UNIVERSITY OF IDAHO BUREAU OF MINING RESEARCH

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An Annotated Bibliography on Mine Fires

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June 1974

Sponsored by the U.S. Bureau of Mines
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FINAL REPORT

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FOREWORD

This report was prepared by the University of Idaho Bureau of Mining Research under USBM Grant No. GO 133129. The grant was initiated under a Bureau of Mines program. It was administered under the technical direction of the Pittsburgh Mining and Safety Research Center with Mr. Donald W. Mitchell acting as the technical project officer. Mr. J. A. Herickes was the contract administrator for the Bureau of Mines.

This report summarizes work completed under the grant during the period 30 June 1973 to 30 April 1974. The report was submitted by the author on 10 May 1974.

DISCLAIMER NOTICE

The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies of the Interior Department's Bureau of Mines or the U.S. Government.

NARRATIVE

In terms of a Research Proposal, supported by a Grant Agreement dated 30 June 1973, the author was commissioned to prepare an annotated bibliography of mine fires.

The main objective was to conduct a comprehensive program of library research and search of official files to prepare a list of articles dealing with actual occurrences of mine fires.

This bibliography as now completed includes an annotated reference from each article or report cited, underlining the cause, extent, methods used, procedural errors made, results achieved, ventilation effects, and lessons learned from the operation of subduing the particular fire.

Actually the bibliography has been extended to cover a wider range of articles and references associated with mine fire prevention, protection, causes, sources, equipment for subduing fires and rescue work, methods of subduing fires and rescue and recovery activities, fire fighting organization, statistics, damage assessments, fire detection, research and testing, and ventilation effects. Accounts of experience gained, lessons learned, seminars and symposia are also listed.

The bibliography was designed to cover published articles on mine fires and fire techniques on a world wide basis, but particularly in the United States, from 1860 to 1974. Unfortunately, the earlier records are fragmentary because there was then no statutory provision for reporting fires to the Bureau of Mines. Similarly, the records of fires in the various state jurisdictions were difficult to trace or secure within the time and cost frame of the project.

In compiling the bibliography there was no logical opportunity of adopting a chronological order, or an alphabetic order by author, or by title. Therefore, the entries are compiled in a simple numerical order by "item." This allows for the critical selection of a particular reference by Item Number from the index. For this reason, the General Index has been compiled with particular care. An Index of Actual Mine Fire Reports and an Index of Authors have also been provided, in support of the General Index.

The indicated method of using the bibliography is therefore to refer to one or other (or perhaps to all three) of the Indices in order to locate publications listed in the bibliography by Item Number under the heading sought.

It is to be hoped that this bibliography will become a valuable source of reference material dealing with all aspects of underground fire-fighting. In this way, it could become a valuable tool in the advancement of methods to detect, prevent, and subdue mine fires--not only to save needless destruction of lives and property, but to conserve national wealth.

The author wishes to acknowledge the assistance given by Bureau of Mines Personnel, including Mr. Arthur P. Nelson, Mr. Donald W. Mitchell, Mr. John Nagy, Mr. William R. Park, Mr. John Waxvik, and Mr. William Steadman; by Mr. Woods G. Talman of U.S. Steel Corporation and many others in the United States and Canada; and by Mrs. K. Gold who conscientiously and meticulously conducted the library research and typed the listings.

1. ABADIE, J. Fires in Coal Mines. *Génie Civil*. Part I. Oct. 4, 1902.

   A study of the origin of fires in coal mines, and the most effective methods of controlling them, based upon experience in the Decazeville district, in the department of Aveyron, France. [In French]

2. DAVIDSON, S. and McKENZIE, N. The Mine Fire at Dominion No. 1 Colliery, Glace Bay, N.S. *Canadian Society of Civil Engineers*. Jan., 1905.

   A description of the mine and the disaster, with illustrations and plates.

3. FARMER, G. Gob-Fires, Their Theory and Practice. *Iron & Coal Trades Review*. Sept. 25, 1903.

   Deals with spontaneous combustion, and the problem of gob-fires, their causes, prevention, and means of extinction.

4. FARMER, G. The Problem of Gob-Fires. *Iron & Coal Trades Review*. Sept. 16, 1904.

   Deals with spontaneous combustion, and the problem of gob-fires, their cause, prevention, and extinction. Discussion.

5. KUMMER, W. The Handling of Underground Fires with Milk of Lime. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*. April 9, 1904.

   Describing a method of extinguishing fires behind masonry walls or closed workings by the injection of milk of lime under high pressure. [In German]

6. JEFFRIES, J. The Occurrence of Underground Fires at the Greta Colliery, New South Wales. *Iron & Coal Trades Review.* June 9, 1905.

Gives the writer's opinion of the cause of the fires.

7. BLICK, J. Mine Fires in Pittsburg Region. *Mines & Minerals.* April, 1902.

Gives their history and causes and methods used to subdue them, as gleaned from observation.

8. BRAUNS, H. The Prevention and Extinction of Spontaneous Coal Fires in the Zwickau District. *Glückauf.* May 28, June 4, 11, 1904.

A very complete account of practical methods of handling fires in coal mines. [In German]

9. HERMAN, J. Mine Fires. *Mining Reporter.* Vol. XLVII, No. 12, p. 262. March 19, 1903.

Discusses the causes of fires in various kinds of mines and methods used in overcoming them. Aside from fires caused by contact with flames, mine fires may start from friction or from chemical action...as by copper sulphide oxidising to copper sulphate with evolution of heat...the iron sulphide remaining intact. The presence of iron sulphate increases chemical action.

In a badly broken ore body rich in copper sulphide and slightly damp and several hundred feet thick, the chances of taking up most of the oxygen and retaining the heat evolved are at a maximum.

Whenever the ore body becomes kindled, the timbers catch fire at once and rapidly spread the fire, giving evidence of wood smoke.

Fires resulting from chemical causes are extinguished with great difficulty and become rekindled when more air is admitted if the temperature is high enough to support chemical action, especially if moisture is present.

The products of combustion (CO_2 and SO_2) do not constitute 20% of the total gas volume because much of the oxygen unites with copper sulphide to form copper sulphate or to burn the metallic constituents of the ore without releasing any gas.

A fire caused by chemical causes may be put out by gases very low in oxygen to avoid further evolution of heat by oxidation.

While air containing 12% of CO_2 is sufficient to put out a timber fire, one caused by chemical reactions will not respond unless less than 1% of oxygen is applied.

Various methods have been used to put out mine fires. The simplest is to bulkhead as closely as practicable. When there is sufficient CO_2, SO_2, and N_2 in relation to oxygen the fire will go out provided broken ground does not promote circulation.

Otherwise, to flood the mine with water, but there is a danger of re-kindling when air is later introduced.

A much better way is to generate and introduce gases that do not support combustion. This can be done within the mine by deliberate firing of coal but the heat generated is disadvantageous. A cooled regulated supply of CO_2 and nitrogen is necessary, probably made from sulphuric acid and limestone, or by burning coke or coal with air on surface. Coke produces the larger unit volume which is of the greatest importance but a large excess of air is necessary to avoid forming CO. It is important to avoid introduction of free air or CO to the seat of the fire.

For snuffing fires, the furnaces at Jerome (United Verde) followed by after-coolers produced a gas mixture containing 17% CO_2, 3% O and 80% N but this required constant assaying control. Any oxygen present united with the metals or their sub-oxides. With the type of furnace used, the coke gas produced averaged 19.5% CO_2, 0.5% oxygen, and 80% nitrogen without trace of CO. Coal is just as good.

10. ANON. The Smuggler Union Mine Fire. *Mines & Minerals.* Jan., 1902.

An account from the Inspector's report to the Commissioner of Mines, describing this disaster in Colorado, and discussing the causes which resulted in such large fatalities.

11. LLEWELYN, L.W. Fire at the Cambrian Collieries. *Colliery Guardian.* Aug. 17, 1906.

Abstract of a paper before the So. Wales Inst. of Engrs., describing the character of the explosion and fire, and the methods adopted to combat the poisonous gases and the conflagration.

12. MAYER, J. Fire Fighting with Continuous Ventilation in Gaseous Mines. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* July 7, 1906.

The miners are provided with suits and helmets supplied with air through hose connected to a central supply. [In German]

13. HALL, H. Ignition Points of Wood and Coal. *Colliery Guardian.* July 10, 1908.

Brief discussion on the question of what heat is required to set wood or coal on fire, reporting tests.

14. WALKER, S.F. The Use of Carbon Dioxide in Extinguishing Mine Fires. *Mines & Minerals.* June, 1908.

Explains the methods of generating and using the gas, giving examples of the successful application.

15. SNELLING, W.O. Sulphur Dioxide as an Agent in Fighting Mine Fires. *American Institute of Mining Engineers.* Bulletin, Sept., 1908.

Considers favorably its effectiveness and safety.

16. DEVERS, P.H. Fighting Fire in an Anthracite Coal Mine. *Engineering & Mining Journal.* July 11, 1908.

An account of problems met in fighting a mine fire in the Wyoming Valley, PA.

17. ANON. Report on the Hamstead Colliery Fire. *Colliery Guardian.* Aug. 14, 1908.

Reviews the report of R. A. S. Redmayne on the causes of, and circumstances attending, the underground fire at this colliery near Birmingham, Eng.

18. KUMMER, W. The Causes of, and Protection against, Mine Fires in the North West Bohemian Lignite District. *Oesterreichische Wochenschrift für den öffentlichen Baudienst.*

Illustrates and describes the arrangements for fire protection. [In German]

19. GRAY, F.W. Fighting a Mine Fire at Close Range with Oxygen-Breathing Apparatus. *Mines & Minerals.* Dec., 1908.

Illustrates and describes experience at Sydney No. 1 Mine, Nova Scotia.

20. GARCIA, J.A. Sealing Shafts after Explosion. *Mines & Minerals*. Aug., 1909.

Describes an attempt to extinguish a mine fire by sealing off the shafts at mine No. 18, Dering Coal Co., IL.

21. STOCK, H.H. Sealing Off Summit Hill Mine Fire. *Mines & Minerals*. Aug., 1909.

Illustrates and describes the sinking of a line of shafts removing coal and rock, and filling space with clay to form a barrier.

22. SCHULZ, E. The Production of Carbon Monoxide in Mine Fires. *Glückauf*. Dec. 4, 1909.

Discusses the causes of formation of the gas. [In German]

23. WILLIAMS, R.Y. Mine Recovery with Oxygen Helmets. *Mining World*. April 2, 1910.

Describes the recovery of the fire-sealed area of the Majestic mine.

24. CROSLEY, W. Recollections of Mine Fires. *Mining Magazine*.

Recollections of the Pemberton colliery explosion in 1877, and the Abbontiakoon mine in 1905.

25. ADAMS, T.K. Mine Fires. *Mines & Minerals*. Dec., 1910.

Draws lessons from fires past, and gives precautions necessary.

26. WILSON, H.M. Mine Fires. *Engineering News*. June 1, 1911.

Discusses the causes, serious losses, and preventive measures.

27. ANON. The Price-Pancoast Disaster. *Mines & Minerals*. May, 1911.

An account of a mine fire which caused great loss of life and property, located in Lackawanna County, PA.

28. HARGER, J. Gob Fires in Mines and Their Prevention. *Iron & Coal Trades Review*. Oct. 11, 1912.

Discusses the spontaneous ignition of coal, describes the different kinds of gob fires, and considers their prevention.

29. PICKERING, W.H. Gob Fires in the South Yorkshire Coalfield. *Colliery Guardian*. Jan. 12, 1912.

Explains methods of working the Barnsley seam, discussing the causes and remedies for gob fires.

30. WATSON, T. Some Notes on Dealing with Gob Fires in Highly-Inclined Workings. *Iron & Coal Trades Review*. April 25, 1913.

31. TAYLOR, W.A. Underground Fires. *Iron & Coal Trades Review.* Feb. 28, 1913.

Considers difficulties met with in working seams liable to spontaneous combustion.

32. WILSON, H.M. Fire Protection and Fireproofing in Mines. *Mining and Scientific Press.* May 24, 1913.

Remarks on the heavy loss of life and property through mine fires; and discussion of methods of fireproofing, and related subjects.

33. HARGER, J. The Detection of Gob-Fires. *Institute of Mining Engineers.* Transactions, Vol. XLVI, Part 2.

An account of experiments and explanation of the principle of the method of detection of gob-fires at an early stage.

34. SMITHSON, H.F. Gob Fire at a West Yorkshire Colliery. *Iron & Coal Trades Review.* March 6, 1914.

An account of the fire and discussion of its cause and best method of preventing such fires. Discussion.

35. MORRIS, J. Notes on Gob Fires and Blackdamp. *Iron & Coal Trades Review.* Feb. 20, 1914.

An illustrated account of the writer's experience at Lydbrook Colliery.

36. MORRIS, J. Notes on Gob-Fires and Blackdamp, Etc. *Institute of Mining Engineers.* Transactions, Vol. XLVII. Part I.

Notes on the writer's experience, especially at Lydbrook Colliery.

37. FILLUNGER, A. Mine Fires; Their Origin and Power with Special Regard to Coal and Firedamp Mines. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* Nov. 29, 1913.

Considers chemical and physical causes of fire, spontaneous combustion, intensity, etc. Serial, 1st part. [In German]

38. MIKESELL, H.S. Fire Prevention at Coal Mines. *Coal Age.* July 31, 1915.

Résumé of precautions and rules of action.

39. McCRYSTLE, J. Anticipating Mine Fires. *Colliery Engineer.* Sept., 1915.

Careful plans as to method of action in case of fire.

40. McCRYSTLE, J. Forestalling Underground Fires at the Lansford Collieries. *Coal Age.* June 26, 1915.

Maps are prepared showing resources available in case of fire.

41. ANON. Fireproofing Mine Shafts. *Colliery Engineer.* March, 1915.

Explains a method of lining a mine shaft with cement grout.

42. ANON. Treating a Gob Fire in Northumberland. *Colliery Guardian.* Oct. 29, 1915.

Methods used to combat it.

43. CAIN, J. Sealing Off Mine Fires. *Coal Age.* Dec. 25, 1915.

Care in construction and removal of seals.

44. EVANS, E.C. Carbon Dioxide as an Agent in Extinguishing Mine Fires, with Special Reference to Its Application at the Senghenyddl Colliery. *Institute of Mining Engineers.* Transactions, May, 1916.

With discussion.

45. RICHARDS, W.B. Fighting an Anthracite Mine Fire. *Coal Age.* June 10, 1916.

At No. 9 colliery of Lehigh Coal and Navigation Co.

46. BRIDGES, S.J. Methods of Dealing with Gob Fires. *Iron & Coal Trades Review.* July 20, 1917.

Methods employed.

47. TARLETON, C.H. How a West Virginia Mine Fire Was Placed Under Control. *Coal Age.* Feb. 10, 1917.

Difficulties explained and their solution.

48. VAUGHAN, J.E. and STEART, F.A. Some Notes on Explosions of Fire Damp, and Occurrences of Gob Fires in Natal. *Chemical Metallurgical and Mining Society of South Africa Journal.* June, 1917.

Past experiences in Natal.

49. CABANE, M. Smothering Mine Fires. *Bulletin et comptes rendus de la Société de l'Industrie Minérale.* Series 5, Vol. 14, 3d issue, 1918, pp. 67-77.

Principal features of system developed at Commentry Collieries; arrangement at Decazeville mines designed to deliver dust under pressure; materials used to form dust. [In French]

50. WALSH, J.J. Mine Fires, and the Inert Gas Method by Which They May be Extinguished. *Journal of the American Society of Heating and Ventilating Engineers.* Vol. 25, No. 3, July, 1919, pp. 329-331.

Arrangement consists of ordinary boiler furnace; gases produced by combustion are conducted through cooling tubes, immersed in water, and then forced into mine. Gases used are carbon dioxide and nitrogen.

51. WALSH, J.J. Use of Inert Gas to Extinguish Mine Fire. *Coal Industry.* Vol. 2, No. 7, July, 1919, pp. 266-267.

Applicability in extinguishing crop fires or those at inaccessible points.

52. PRICE, M.W. Fire Prevention in Anthracite Coal Mines. *Coal Age.* Vol. 16, No. 16, Oct., 1919, pp. 651-652.

Necessary equipment for extinguishment of mine fires.

53. NOTEBAERT, F.E. How Gob Fires are Fought and Prevented in Pictou County, Nova Scotia. *Coal Age.* Vol. 18, No. 4, July 22, 1920, pp. 161-165.

Crushed pillars in thick seams cause many gob fires. Should smoke be seen, no time is lost in sealing up and in reopening, care is taken to keep air from the heated area or progress would be rapid from gob-stink to gob-smoke and thence to gob-fire.

54. BAKER, D.J. Illinois Mines Guard Their Timbered Shaft Bottoms by Fusible Plug Sprinklers. *Coal Age.* Vol. 18, No. 15, Oct. 7, 1920, pp. 719-722.

State statutes demand elimination of fire hazards below ground. To secure this protection one operator uses fusible fireplug sprinkler heads on pressure lines containing rain water only.

55. SINNATT, F.S., STERN, H., and BAYLEY, F. Does Fusain Cause Mine and Bin Fires, Spoil Coke and Aid Explosions? *Coal Age.* Vol. 18, No. 8, Aug. 19, 1920, pp. 384-388.

Reprint of booklet entitled "Coal Dust and Fusain," published as Bulletin No. 5 by Lancashire and Cheshire Coal Research Assn., College of Technology, Manchester, England.

56. TRACY, L.D. and LEIGHTON, A. Possibilities of the Geophone in Locating Mine Fire Areas. *Coal Age.* Vol. 17, No. 2, Jan. 8, 1920, pp. 40-42.

Instrument is similar to physician's stethoscope. Advantage claimed over other listening devices is absence of electric battery.

57. McAULIFFE, E. Bad Fire at Kathleen Mine Is Rapidly Extinguished. *Coal Age.* Vol. 20, No. 7, Aug. 18, 1921, pp. 247-251.

Apparently a circuit breaker was cause of accident. Special fire seal hastens recovery.

58. FIELDNER, A.C. and KATZ, S.H. Experiment in the Use of Carbon Tetrachloride and Foamite Firefoam for Extinguishing Mine Fires. *Coal Age.* Vol. 20, No. 1, July 7, 1921, pp. 7-9.

With draft entirely closed off tetrachloride developed deadly quantities of phosgene. Chemical is efficient and where ventilation is good, is also safe. Desirable for electric fires. Foamite is harmless and effective.

59. DICKINSON, C. Methods of Dealing with a Shaft Fire and Netherseal Colliery. *Institution of Mining Engineers.* Transactions, Vol. 60, Pt. 4, April, 1921, pp. 345-349.

Describes method of combating fire.

60. BUNTING, D. Mine Fires Extinguished by Sealing. *American Institute of Mining & Metallurgical Engineers.* Transactions, No. 1090-C, Aug., 1921.

States that in all probability 90 per cent of mine fires may be ascribed to ordinary miner's open lamp and discusses various ways of dealing with a fire.

61. TUEBBEN. Fighting Mine Fires. *Braunkohle.* Vol. 21, No. 19, Aug. 12, 1922, pp. 349-350.

Describes new extinguisher working on compressed CO_2*, and the Torkret process of applying mixtures of cement etc., by spraying, for insulating and fireproofing.* [In German]

62. ASHMEAD, D.C. Putting Out a Mine Fire in a Big Anthracite Shaft. *Coal Age.* Vol. 21, No. 15, Apr. 13, 1922, pp. 613-616.

Extinguishing of recent fire in Hollenback Colliery, Wilkes-Barre, PA.

63. ASHMEAD, D.C. Red Ash Co.'s Mine Fire, Thought to Be Slushed Out, Blazes Up, Threatening Nearby Properties. *Coal Age.* Vol. 21, No. 19, May 11, 1922, pp. 769-772.

Fire travels 6 ft. per day in one direction and 4 ft. in another; stripping to stop fire stopped by union; fire for 5 years believed to be dead.

64. REED, J.W. Mine Fire Prevention and Fighting in Bituminous Coal Mines. *Safety Engineering.* Vol. 62, No. 4, Oct., 1921, pp. 174-176.

Notes on prevention of fires caused by contact between flame and combustible material, and of fires caused by arcing or overheating of electric circuits or equipment.

65. JONES, C.L. The Extinction of Coal Mine Fires by Means of Liquefied Carbon Dioxide. *Coal Industry.* Vol. 6, No. 6, June, 1923, pp. 272-279.

Results of successful large-scale trial of inert-gas methods of extinguishing coal-mine fires; method shows large saving in cost over direct method.

66. JONES, C.L. Carbon Dioxide Succeeds in Fighting Bitner Mine Fire When the Flooding of the Workings Fails. *Coal Age.* Vol. 24, No. 1, July 5, 1923, pp. 3-10, 8 figs.

Describes manner in which fire in Bitner mine, of H. C. Frick Coke Co., Pennsylvania, was extinguished with aid of liquified carbon dioxide; when fire dies, mine atmosphere contracts and sucks in air unless given carbon dioxide which cools mine, and saves fire from necessity of generating its own inert gas.

67. TOMLINSON, J.R. Dealing with a Gob Fire at a South Yorkshire Colliery. *Colliery Guardian.* Vol. 125, No. 3256, May 25, 1923, p. 1250.

Account of method of dealing with fire in goaf.

68. ANON. Further Light on the Use of Carbon Dioxide in Fighting Mine Fires. *Coal Age.* Vol. 24, No. 4, July 26, 1923, pp. 132-134, 2 figs.

Difficult to check fire when rock is hot; clay for surface cracks; cement and paint for stoppings. Account of discussion of paper by Charles L. Jones before W. Va. Coal Min. Inst.

69. KIRST, E. New Movable Fire-Extinguishing Device for Mines. *Braunkohle.* Vol. 22, No. 17, July 28, 1923, pp. 253-265.

Apparatus built by Total Company in Charlottenburg and tested at Technical High School at Charlottenburg; provided with extinguishing power and pressure-gas cylinder for use in coal mines to combat spontaneous co combustion. [In German]

70. ARBOLEDAS, J.S. Sealing-Up Zones of Fire. *Revista Minera, Metalurgica y de Ingenieria.* Vol. 74, Nos. 2867, 2869, 2870 and 2872, Feb. 8, 24, Mar. 1 and 16, 1923, pp. 69-71, 102-104, 117-120 and 145-146, 1 fig.

Deals with coal mines on fire; stopping temporarily; construction and placing of masonry walls, brick walls, etc. Methods of applying walling (1) to air exit first, (2) to exit and entrance simultaneously, or (3) to entrance first. [In Spanish]

71. ANON. Should High Pressure and Small Volumes Be Used in Underground Fire Fighting and How? *Coal Age.* Vol. 23, No. 15, Apr. 12, 1923, pp. 595-600, 5 figs.

Pressure can be regulated by tanks with floats, by reducing valves and by throttles placed in hose valves; ½-in. nozzle with 1½-in. 750 lb. test rubber hose recommended; peril in mixing impure with pure water.

72. TILLSON, B.F. Notes on the Installation of Fire Fighting Equipment in Mines. *American Institute of Mining & Metallurgical Engineers.* Paper read at meeting, Feb. 19-22, 1923.

Methods and apparatus employed by Franklin, NJ, mine of N.J. Zinc Co.

73. ANON. Comments on Suggestions for Mine Fire Control in California Mines. *Pacific Mining News of Engineering and Mining Journal-Press.* Vol. 1, No. 8, Dec., 1922, pp. 230-234.

Discusses suggestions presented to Indus. Accident Commission for their consideration, by a general committee of California mine operators, labor representatives, engineers, etc. See also Mine Fire Control Hearing Comment on Tentative Orders, Pacific Min. News, Vol. 2, No. 1, Jan. 1923, pp. 5-9.

74. TUEBBEN, L. Fire Prevention in Mining. *Glueckauf.* Vol. 59, No. 8, Feb. 24, 1923, pp. 190-193.

Describes Torkret method of fireproof coatings by use of cement gun; Torkret fire extinguishers. [In German]

75. ANON. Mine-Fire Control Safety Orders Issued in California. *Engineering & Mining Journal-Press.* Vol. 115, No. 12, Mar. 24, 1923, pp. 548-549.

Cal. Indus. Accident Commission makes new code of rules to protect men at work. See also comment by T. A. Rickard, p. 524.

76. STORROW, J.T. and GRAHAM, J.I. The Application of Gas Analysis to the Detection of Gob Fires. *Colliery Guardian.* Vol. 128, Nos. 3327 and 3328, Oct. 3 and 10, 1924, pp. 873-874 and 934-935.

Deals with part which careful chemical analysis of underground air samples may play in detection of heatings and following of course of these when they have occurred.

77. DE HART, J.B. Some Notes on the Problem of Gob Fires in Thick, Highly Inclined Seams. *Canadian Institute of Mining & Metallurgy.* Bulletin, No. 142, Feb., 1924, pp. 48-56.

Causes and conditions which are inductive of spontaneous heating of coal; study of particular case of thick steeply inclined seams; possibility of ventilating gob; exclusion of air from gob as equally effective method of fire prevention; other possible methods.

78. VALENTINE, J. Gob Fire at a North Wales Colliery. *Iron & Coal Trades Review.* Vol. 119, No. 2958, Nov. 7, 1924, pp. 739-741, 3 figs.

Account of fire at Vauxhall Colliery, Ruabon. (Abstract) Paper before Nat. Assn. Colliery Mgrs.

79. JONES, C.L. The Functions and Practical Use of Liquefied Carbon Dioxide in Fighting Mine Fires. *Coal Mine Management.* Vol. 3, No. 3, Mar. 1924, pp. 34-35 and 52-57.

Source and purity of CO_2 available; how long it should require for a mine fire to cool; heat generated by a fire, and leakage; heat dissipated; liquefied CO_2 compared with other inert gases; etc. Condensation of paper read at 12th Annual Safety Congress of Nat. Safety Assn.

80. FORSTMANN, R. Elimination of Fires Due to Winches. *Glückauf.* Vol. 60, No. 40, Oct. 4, 1924, pp. 891-896.

Particulars of various devices used in Ruhr district for eliminating fire dangers, using fireproof brake blocks, etc. [In German]

81. WALSH, J.J. Would Ventilate Mine Fire Area With Inert Gas. *Coal Age.* Vol. 25, No. 2, Jan. 10, 1924, p. 55.

Why stopping intake is inadvisable; small fire area if shut in may explode.

82. STRANGE, C.H. Drowning a Mine Fire in Carbon Dioxide. *Coal Age.* Vol. 28, No. 14, Oct. 1, 1925, pp. 453-458, 5 figs.

Sealing inaccessible area has small effect; carbon dioxide speedily quenches fire.

83. ANON. Prompt Efficient Action Saves Men and Mine From Fire. *Coal Age.* Vol. 28, No. 19, Nov. 5, 1925, pp. 634-635, 3 figs.

Flames are attacked first with hand extinguishers and men are withdrawn at mine in Kingston, PA, when fire developed over night; modern equipment is great aid; no casualties.

84. WATSON, J.T. Hydraulic Packing in Coal Mines. *Chemical Engineering & Mining Review.* Vol. 17, No. 198, Mar. 5, 1925, pp. 233-235.

A suggested method for prevention of gob fires in New South Wales coal fields.

85. ANON. Fire Fighting Equipment. *American Mining Congress--Standardization Division.* Bulletin, No. 5, 1925, pp. 76-81 and (discussion) 81-90.

Committee report on recommendation of standards for metal-mine fire-fighting equipment.

86. ANON. The Shutting-off of Gob-Fires in Gassy Seams. *Institution of Mining Engineers.* Transactions, Vol. 69, Pt. 5, Aug. 1925, pp. 428-433.

Limits of inflammability of firedamp, risk of firedamp explosions; minimizing explosions by stone dusting; significance of small explosions behind stoppings; precautions when building stoppings; efficiency of stoppings; prevention of leakage; use of extinctive gas.

87. STORROW, J.T. and GRAHAM, J.I. The Application of Gas Analysis to the Detection of Gob-Fires. *Institution of Mining Engineers.* Transactions, Vol. 68, Pt. 5, Feb. 1925, pp. 408-425 and (discussion) 425-429.

Part which careful chemical analysis of underground air-samples may play in detection of heatings and following of course of these when unhappily they have occurred.

88. PRYDE, G.B. Mine Fires and Methods of Handling. *Mining Congress Journal.* Vol. 12, No. 8, Aug., 1926, pp. 598-599.

Description of fires caused by spontaneous combustion in mines of Union Pacific Coal Co. at Cumberland and Hanna, Wyoming.

89. BANNISTER, H.T. Fire Fighting Organization, Equipment and Methods of the Madison Coal Corporation. *Coal Mine Management.* Vol. 6, No. 9, Sept., 1927, pp. 25-30 and 46.

Review of development of fire-fighting organization in Illinois mines of Madison Coal Corp.; chemical extinguishers, water supply and equipment, underground and surface protection, special rescue cars, use of rock dust, etc.

90. MAN, M. Machine of Large Capacity Used at the Montrambert and La Beraudière Coal Mine for Combating Gob Fires. *Revue de l'Industrie Minérale.* No. 150, Mar. 15, 1927, pp. 109-121.

Principle underlying application of machine is that of quenching fire by injecting mixture of water and flue dust; machine consists of two parts, mixer in which water and dust are agitated by means of compressed air, and diaphragm pump for forcing slurry into area affected by fire. [In French]

91. DUNBAR, F.B. Prevention, Fighting and Sealing Mine Fires. *Mining Congress Journal.* Vol. 13, No. 7, July, 1927, pp. 528-530.

Fires may be prevented by proper supervision and strict discipline; each fire presents its own peculiar problem permitting no fixed rule in fighting; when unsealing, well-thought-out plan should be outlined in writing and strictly adhered to.

92. STEIDLE, E. Safety Appliances and Accessories Used in Mine Fire Fighting and Recovery Operations. *Mining Congress Journal.* Vol. 12, No. 7, July 27, pp. 522-527.

Ventilation and fire fighting becoming complex as workings extend; safety appliances and accessories classified; rock-dust equipment; first-aid supplies listed.

93. DUNCAN, H.S. and SHOEMAKER, A.H. Slime Filling for Extinguishing Mine Fires. *Mining Congress Journal.* Vol. 13, No. 11, Nov., 1927, pp. 834 and 855.

Dry timber can be ignited by caved ground pressure; frequent T's placed in slime lines for flushing; friction lessened by 4-ft. bends; dewatered tailings consisted of 31 per cent solids; principal problem is to avoid escape of slimes.

94. BANNISTER, H.T. The Underground Fire-Fighting Organization of a Coal Mine. *Explosives Engineer.* Vol. 6, No. 2, Feb., 1928, pp. 66-67.

Each rescue car is fully equipped with all small supplies and tools that are ordinarily needed when handling an underground fire; fire drills on bottom are held at regular intervals just the same as those on surface.

95. BLITEK, J. Coal-Mine Fires. *Zeitschrift des Oberschlesischen Berg- und Hüttenmännischen Vereins.* Vol. 67, Nos. 4, 5, and 6, Apr., May, and June, 1928, pp. 227-232, 289-296, and 362-368.

Spontaneous combustion as cause of fires; practical examples of fire fighting in coal mines, giving mine plans and sketches. [In German]

96. BIELENBERG, W. Examination of Explosive Mine Gases and Its Significance for Safety of Operation. *Braunkohle.* Vol. 27, No. 19, May 12, 1928, pp. 413-417.

Extensive quotations from fire-fighting experience of German coal and lignite mines, showing usefulness of analyzing gas samples when fire fighting requires sealing or damming fire area; by such gas analyses it is possible to follow progress of fire and test efficiency of stoppings and seals. [In German]

97. ANON. Preventing and Limiting Coal-Mine Fires. *Safety Engineering.* Vol. 55, No. 3, Mar., 1928, pp. 105-106, 1 fig.

Factors involved in mine fires are numerous including different sources of ignition present, presence of methane, arrangement of mine and its equipment, and, most of all, degree of discipline maintained and mine organization employed; as being of primary importance in preventing serious fires certain measures are proposed, beginning at surface.

98. McCAA, G.S. Fighting Mine Fires. *National Safety News.* Vol. 17, No. 6, June, 1928, pp. 19-21 and 54.

Some effective methods of extinguishing mine fires are described; direct attack with water, chemicals or rock dust; flooding with water, silt or carbon dioxide; sealing so as to eliminate external air and extinguish fire by lack of oxygen for combustion.

99. MONTES DE OCA, G. Fire in the "Aurora" Mine in Teziutlan, Puebla, Started on March 8, 1928. *Boletin Minero.* Vol. 25, No. 5, May 1928, pp. 292-295.

Describes occurrence of fire at mine of Teziutlan Copper Co.; origin ascribed to workman's carelessness in holding lamp too close to inflammable timber; fire was controlled and finally extinguished more than 3 hours after discovery; fatalities resulted from breathing gases; censures management for not ordering all workmen out of mine as soon as fire was discovered. [In Spanish]

100. ANON. Mine Fires. *Boletin Minero*. Vol. 25, No. 5, May, 1928, pp. 288-291.

Upon occurrence of mine fire, effects on working force and on timbering must be considered; gaseous products of combustion; air containing 0.2 per cent carbon monoxide breathed for 2 hours may cause death, although presence is not noticed by victim; carbon dioxide may reach proportion to render air unbreathable; when either gas is detected, special precautions should be taken; means of preventing fires; method of fire fighting; rescue work; crews should drill regularly to learn tasks and use of apparatus.

101. SIMCOCK, E.O. Spontaneous Combustion in Coal Mines. *Fuel in Science and Practice*. March, 1925, pp. 131-134.

Discusses the effect of pyrites on spontaneous combustion of coal in relation to the free oxygen available in terms of air movement.

102. WYNNE, F.H. Coombs Wood Colliery Fire. *Colliery Guardian*. Vol. 138, No. 3580, Aug. 9, 1929, pp. 520-523.

Coal mine in township of Halesowen, 6 mi. southwest of Birmingham; output 3200 ton per week and 380 persons employed below ground; brattice cloth of ventilation system caught fire, Mar. 18, supposedly from candle flame or from discarded cigarette end; steps taken to combat fire; hose pipes installed and ready for use, when fall of roof quenched fire; 8 miners died from breathing carbon monoxide. From Report of Deputy Chief Inspector of Mines.

103. SMART, R.C. Fire Risks at Collieries; Their Detection and Extinction. *Colliery Guardian*. Vol. 139, Nos. 3575 and 3576, July 5 and 12, 1929, pp. 29-32 and 128-130.

July 5: Notes on detection systems by periodic visits of watchmen and by automatic fire alarms, with particular reference to surface plant and buildings; first-aid fire extinguishing appliance; buckets, hand pumps, hoses and chemical extinguishers; foam type is recommended for oils and inflammable liquids, but not for electrical fires. July 12: Fire hydrants and hose; fire engines and fire pumps; sprinkler installations; general notes on prevention precautions.

104. STONE, F.E. Gob-Fires. *Science and Art of Mining.* Vol. 39, No. 18, Mar. 23, 1929, pp. 276-277.

Gob fire implies supply of combustible material in goaf, and supply of air in or passing through goaf; successive indications of gob fire are rise of local temperature, sweating of ground in vicinity, gob stink, and smoke; for extinction, quick attack is essential; filling out, or removal of heated material; sealing off air supply; to hasten extinction, water or inert gas may be poured into area sealed off; details of practice are given.

105. COATESWORTH, D. Prevention of Fires in Mines. *Colliery Guardian.* Vol. 139, Nos. 3595 and 3596, Nov. 22 and 29, pp. 1967-1969 and 2078-2079.

Causes of fires; suggestion as to necessary precautions; methods for dealing with fires; gases; necessity of building stoppings as near to seat of fire as is possible. Abstract of paper entitled "Practical Steps to be Taken to Reduce Number of Fires in Mines and Method of Sealing off a Fire" read before Manchester Geol. and Min. Soc.

106. MAWSON, T.T. Recovery of Underground Workings after an Explosion and Fire at Holditch Colliery, North Staffordshire. *Iron & Coal Trades Review.* Vol. 119, No. 3213, Sept. 27, 1929, pp. 464-468, 5 figs; *Iron & Coal Trades Review.* Vol. 119, No. 3222, Nov. 29, 1929, p. 841.

Origin of fires; erection of stoppings; recovery of seam; conversion of haulage gear from endless rope to direct-rope; rescue teams; repair work undertaken; ordinary work resumed after official inspection. Read before Nat. Assn. Colliery Mgrs.

107. JONES, T.D. Spontaneous Combustion in North Staffordshire. A Record of Analysis of Air-Samples Taken During the Combating of a Gob-Fire. *Colliery Guardian.* Vol. 138, No. 3573, June 21, 1929, pp. 2395-2397 and (discussion) Nos. 3574 and 3599, June 28 and Dec. 20, pp. 2508-2509 and 2365.

Mine in Yard seam, worked by longwall; no heating noticed prior to discovery of fire; results of air analysis supported view that fire was still alive, ratios of carbon monoxide and dioxide to oxygen being abnormally high; advisability of having record of air analysis during combating of fire is clearly shown.

108. ROBERTS, J.H. The Colliery Fireman. *Colliery Engineering.* Vol. 6, No. 59, Jan., 1929, pp. 27-28.

From point of view of safety of workmen coal-mine fireman holds most responsible post in coal mine; qualification of man to hold this post is worthy of serious attention; practical knowledge of ventilation is essential; every fireman should be well trained in rescue and ambulance work; he should be able to read mine plan correctly; fireman should have training in theory of mechanics, electricity, and mechanical and electric machinery.

109. MAIZE, R. Causes and Prevention of Mine Fires. *Coal Mining.* Vol. 6, No. 1, Jan., 1929, pp. 17-24.

Paper deals chiefly with coal-mine fires; classification of fires; electric wires are most prolific cause; open lights; blasting with black powder; fires along outcrop; spontaneous combustion; examples of gob fires in Pennsylvania bituminous mines; experiences in handling fires; best methods of sealing mine fires. Read before Coal Min. Inst. of America.

110. ANON. Underground Fires. *Science and Art of Mining.* Vol. 39, No. 14, Jan. 26, 1929, p. 209.

Summary of principal causes of underground fires and of precautions to be taken to prevent outbreak of fire underground, with particular reference to coal mines.

111. ABADIE, M. Fighting Mine Fires: The Methods Employed and the Results at the Décazeville Mine. *Fuel.* Vol. 7, No. 5, May 1929, pp. 220-224.

Methods now employed may be grouped as preventive and combative; under former, principal roadways are driven through rock, outside seam; or coal face is advanced regularly; following are combative methods: fire is put out temporarily and coal is cooled by copious watering; injection of sludge into affected area; removal of burning coal, after watering and injection of sludge, etc. [In French]

112. MEUSS. Fire Prevention and Combating in Case of Fires at Starting. *Bergbau.* Vol. 43, Nos. 24, 34, and 47, June 12, 1930, pp. 353-357, Aug. 21, pp. 504-507, and Nov. 20, pp. 695-697.

June 12: Chemical and physical principles underlying various extinguishing material and equipment and methods used in early extinction of surface and underground fires in coal mines. Aug. 21: Means to prevent starting of fires and to combat fires at start; impregnation of inflammable building materials with chemical solutions; test made with wood impregnated with solutions with trade name "Cellon-Feuerschutzloesung"; dry fire extinguisher with trade name "Total." Nov. 20: Several kinds of fire-extinguishers are described and their advantages and limitations discussed. [In German]

113. COATESWORTH, D. The Prevention of Fires in Mines and Methods of Dealing with Them. *Institution of Mining Engineers.* Transactions, Vol. 78, Part 3, 1929, Dec., 1929, pp. 145-153 and (discussion) 153-157. Vol. 78, Part 5, Feb., 1930, pp. 261-262.

Causes of fires; suggestion as to necessary precautions; methods for dealing with fires; gases; necessity of building stoppings as near to seat of fire as is possible.

114. BERRY, R.L. Fire Prevention in Coal Mines. *Colliery Guardian.* Vol. 145, No. 3746, Oct. 14, 1932, p. 713.

Practice at group of coal mines in Wales. Before Nat. Fire Brigades' Assn.

115. KIRST, E. Versuche zur Hemmung der Flammen von Schlagwetter und Kohlenstaubexplosionen mit Hilfe inerter Gase. *Colliery Guardian.* Vol. 144, No. 3729, June 17, 1932, p. 1152.

Tests to reduce flames from ventilating-air and coal-dust explosions with aid of inert gases, particulary, carbon dioxide. [In German]

116. NAYLOR, A.E. Description of Underground Fire at Shirebrook Colliery. *Colliery Guardian.* Vol. 145, No. 3747, Oct. 21, 1932, pp. 762-763.

Account of fire originating in ignition of smoldering sludge on core and windings of overheated transformer in underground substation.

117. MASON, T.N. and TIDESWELL, F.V. Gob-Fires. *Colliery Guardian.* Vol. 146, No. 3761, Jan. 27, 1933, pp. 150-152.

Part I - Explosions in Sealed-Off Areas in Non-gassy Seams; first series of experimental studies, dealing with coal-fires in goaf, fires in roadside coal packs and fires in roadside dirt packs; Part II - Revival of Heatings by Leakage of Air; details of experiments supplementing those described in Part I.

118. GLAESER, O.A. Guarding Against Mine Fires. *Engineering & Mining Journal.* Vol. 134, No. 2, Feb., 1933, pp. 74-77.

Review of mine fire disasters; causes of metal mine fires; insurance rates; classification of methods for fire prevention and protection in underground workings; discussion of elements of fire prevention, fire safety, fire fighting, and organization.

119. MILLS, F.P. Underground Fires. *Iron & Coal Trades Review.* Vol. 128, No. 3438 and 3456, Jan. 19, 1934, pp. 95-96 and (discussion) May 25, p. 836.

Results of experience gained in dealing with underground fires during last 20 yrs; author deals only with means by which fires were subdued; omitting reference to precautionary measures to avoid such conflagrations; chief causes of fires are reviewed. Before Nat. Assn. Colliery Mgrs.

120. MASON, T.N. and TIDESWELL, F.V. Experimental Gob-Fire Explosion. *Colliery Guardian.* Vol. 149, No. 3838, July 20, 1934, pp. 97-100.

Continuation of work described in S.M.R.B. papers No. 75 and 76; purpose was to observe sequence of events during slow heating up of coal in leaky roadside pack, and to record changes in composition of atmosphere in goaf immediately after sealing off; precuations are suggested. Before Instn. Min. Engrs.

121. DAVIDSON, D. Tests of Seals and Pumps for Combating Mine Fires. *Colliery Guardian.* Vol. 148, No. 3818, Mar. 2, 1934, pp. 391-392.

Sandbags and sandbag stoppings; water from pressure mains and pump pipes; portable fire pumps; description of experiments in firefighting.

122. RYBA, G. Mine Fires and Explosions. *Montanistische Rundschau.* Vol. 26, No. 7, Apr. 1, 1934, pp. 1-7.

Author's viewpoints based on experiences since 1897 in mine-rescue practice and equipment; firedamp and coal-dust explosions; account of explosion in Nelson lignite mine in Czechoslovakia on Jan. 3, 1934 with loss of life of 142; study of possible causes. [In German]

123. HOCHSTETTER, C. Ursachen, Verhuetung und Bekaempfung von Grubenbraenden im Schyltaler Steinkohlenrevier von Petroseni-Lupeni (Siebenbuergen). *Berg- und Huettenmaennisches Jahrbuch.* Vol. 82, No. 2, June 25, 1934, pp. 55-68.

Causes, prevention and extinguishing of mine fires in Schyl valley coal district of Petroseni-Lupeni, Roumania, brief account of geology of district, mining conditions, stowage, and ventilation; analysis of causes of fire; results of experiences. [In German]

124. FISHER, O. Underground Fire Fighting at Fryston Colliery. *Iron & Coal Trades Review.* Vol. 130, No. 3494, 3497, 3501, 3502, 3508 and 3509, Feb. 15, 1935, pp. 290-292 and (discussion) Mar. 8, pp. 410-411, Apr. 5, pp. 580-581, Apr. 12, pp. 627-628, May 24, pp. 892-893 and May 31, p. 938.

Description of system for dealing with underground fires, in which compressed air main from surface can be rapidly exhausted and filled with water, which may be directed by means of valves at pit bottom, to particular district involved. Before Nat. Assn. Colliery Mgrs.

125. ANON. Underground Fires, Their Cause, Prevention and Cure. *Colliery Guardian.* Vol. 150, No. 3865 and 3866, Jan. 25, 1935, pp. 160-162 and Feb. 1, pp. 207-209.

Addresses before Midland Counties Instn. Min. Engrs., by A. NAYLOR, C. H. HEATHCOTE, J. HUNTER, G. L. BROWN, N. D. TODD, P. BEAUMONT AND H. E. MITTON.

126. EDWARDS, J. Dealing with Sudden Fire Outbreak Underground. *Iron & Coal Trades Review.* Vol. 132, No. 3540, Jan. 3, 1936, pp. 1-3.

Fire described and discussed occurred at mine of Pooley Hall Colliery Co. July 12, 1934; by carefully organized team work, conflagration was rapidly overcome. Before Nat. Assn. Colliery Mgrs.

127. TIMOC, T. Underground Fires in Coal Mines of Jiu Basin in Roumania. *Revue de l'Industrie Minérale.* No. 372, June 15, 1936, pp. 576-579.

Investigation of cause of fires and means of combating them. Before Congrès Int. des Mines, de la Métallurgie et de la Géologie Appliquée. Paris, 1935. [In French]

128. VERSEL. Causes and Combating of Underground Fires. *Revue de l'Industrie Minérale.* No. 372, June 15, 1936, pp. 565-575.

Method employed at Blanzy coal mine described. [In French]

129. MORGAN, C.E. Serious Fire and Subsequent Heatings which Occurred in Workings in Coleford Highdelf Seam, Forest of Dean. *Colliery Guardian.* Vol. 152, No. 3925, 3926, 3927 and 3932, Mar. 27, 1936, pp. 584-587, Apr. 3, pp. 634-635 (discussion) 637-638 and further discussion May 8, pp. 868-869.

History, treatment, and causes of fire in main intake and haulage road; heatings in main road and in gob-side pillars.

130. HUMPHRYS, H.J. Underground Fires in Yorkshire. *Iron & Coal Trades Review.* Vol. 131, No. 3538 and 3539, Dec. 20, 1935, pp. 1021-1023 and Dec. 27, pp. 1069-1071 and Vol. 123, No. 3547, Feb. 21, 1936, pp. 365-366.

Description of recent occurrences and methods of attack; spontaneous combustion; electricity; shot firing; friction. Before Nat. Assn. of Colliery Mgrs.

131. VAN HETTINGA TROMP, H. Principles Governing Protection Against Fires in Underground Mines. *Revue de l'Industrie Minérale.* No. 372, June 15, 1936, pp. 580-589.

Investigation of cause and prevention of fires in coal and metal mines. Bibliography. Before Congrès Int. des Mines, de la Métallurgie et de la Géologie Appliqué, Paris, 1935. [In French]

132. SCHULTZE-RHONHOF. Account of Work Carried Out in Experimental Mine. *Bergbau.* Vol. 50, No. 16, Aug. 5, 1937, pp. 263-265.

Investigation of cause, propagation and prevention of coal mine fires. [In German]

133. CABOLET, P. Fire Barriers of Logs and Loam. *Glueckauf.* Vol. 73, No. 22, May 29, 1937, pp. 511-513.

Fire barriers of logs and loam employed in some German coal mines; illustrated description of construction system employing old mine timbers; advantages over usual sandbag barriers pointed out. [In German]

134. CABOLET, P. Extinguishing a Fire in Stowage Installations of Coal Mine with Aid of Carbon Dioxide. *Glueckauf.* Vol. 73, No. 17, Apr. 24, 1937, pp. 383-384.

Method employed at mine in Bochum, Germany, in which fire was successfully combated by use of carbon dioxide under high pressure and low temperature. [In German]

135. FLEISCHER, O. Recent Experiences and Investigations of Mine Fires in Upper Silesia. *Glueckauf*. Vol. 73, No. 6, Feb. 6, 1937, pp. 131-137.

Results of mine air analysis; use of micromanometer.

136. GORDON, H.C.M. Notes on Coal Mine Fires. *Canadian Institute of Mining & Metallurgy*. Transaction, Vol. 40, 1937, pp. 311-318.

Main causes of fire hazard in underground workings of coal mines: open lights igniting gas, wood, or coal itself; explosives igniting gas or coal; spontaneous combustion; electric sparks or short circuits; frictional heat; explosions of gas or coal dust igniting wood or coal; discussion of preventive measures; examples of fires occurring in recent years, in mines of Pictou field in Nova Scotia.

For a discussion of the paper, see Transactions, Vol. 41, 1938, pp. 220-225 or Bulletin, No. 314, June, 1938.

137. SCOTT, G.S. and JONES, G.W. Significance of Low-Temperature Oxidation Products in Anthracite Mine Fire Studies. *Industrial and Engineering Chemistry*. Vol. 29, No. 7, July, 1937, pp. 822-826.

U.S. Bureau of Mines has investigated means for detecting incipient heating underground, and for determining trend of heating, once fire is known to exist; apparatus used; tests on anthracite to determine amount of oxidation and composition of oxidation products. Bibliography.

138. CABOLET, P. Combating of Gob Fire at Hannover Mine 1/2. *Glueckauf*. Vol. 74, No. 17, Apr. 30, 1938, pp. 371-375.

Combating of gob fire at Hannover mine 1/2 which occurred July 3, 1937; fire was extinguished without loss of coal reserves and without interruption of neighboring mine workings; fire barriers of logs and loam were employed in roadways and sand barriers on stowage slope. [In German]

139. FERRARI, B. Origin of Coal Mine Fires Based on Study of Coal Petrography. *Glueckauf*. Vol. 74, No. 36, Sept. 10, 1938, pp. 765-774.

Investigation of inflammability of different coal constituents; results of observation of mine fires; conclusions and preventive measures. [In German]

140. MEYER, B. and MEYER, F.W. Method of Sealing Off Coal Mines Fires. *Mechanization*. Vol. 2, No. 8, Aug., 1938, pp. 10-12.

Method adopted at large mine in Illinois relieves men of hazard of working in smoke; it involves sealing off entire panel with two emergency stoppings; temporary 3 by 3 ft. opening is left in first stopping to provide exit for smoke during construction of second stopping; sketches and explanation of method are given.

141. ATKINSON, F.S. Simple Method of Making Stoppings and Roadways More Nearly Airtight. *Colliery Guardian*. Vol. 156, No. 4020 and 4022, Jan. 14, 1938, p. 91 and Jan. 28, pp. 167-168.

Notes on practice in Doncaster coal field in South Yorkshire, in connection with work to isolate areas subject to spontaneous heating of coal; properties of dry and wet sand; sand dams; advantages of steel sheeting in sand dams, over sand and bricks or stone packing to blanket heated area. Before Midland Inst. Min. Engrs.

142. BLAIR, J.S. Colliery Fire Fighting Systems and Fire Jet Characteristics. *Colliery Guardian*. Vol. 158, No. 4086, 4087 and 4089, Apr. 21, 1939, pp. 691-694, Apr. 28, pp. 743-746 and May 12, pp. 829-831.

Contention of author is that high pressure water system is more satisfactory and economical than low pressure; characteristics of water jets; friction loss in hose and in pipe lines; high pressure system; alternative schemes; manual pumps, fire extinguishers; sand and stone dust; costs of fire fighting systems.

143. MASON, T.N. and TIDESWELL, F.V. Detection of Gob-Fires. *Colliery Guardian*. Vol. 15, No. 4039, July 21, 1939, pp. 95-97.

Description of experimental gob fire chamber; methods of detection studied were by smell and by analysis of return air; it is concluded that gob stink is more useful warning than air analysis, since it is detectable before critical condition is reached in gob pack.

144. KATTWINKEL, R. Explosive Characteristics of Mine Fire Gases. *Glueckauf*. Vol. 75, No. 14, Apr. 8, 1939, pp. 302-305.

Review of literature and results of systematic ignition tests carried out with methane-carbon dioxide and methane-nitrogen-air mixtures, in order to determine amount of inert gas addition required to make gas-air mixtures containing methane non-inflammable; carbon dioxide has greater inhibiting power than nitrogen because of its greater heat capacity. [In German]

145. HUTCHISON, G.C. Fighting Underground Fire. *Colliery Guardian*. Vol. 158, No. 4091, May 26, 1939, pp. 917-919.

Description of locus and treatment of underground fire which occurred in waste of abandoned section in Lower Jersey seam, midway between two neighboring collieries; after unsuccessful use of water for two days, method *adopted was to seal off area and try to fill it completely with mixture of sand and limestone dust; details of equipment and procedure.*

146. ASHLEY, T. and HORSLEY, J.A.B. Fire at Dumbreck Colliery, Stirlingshire. *Colliery Engineering.* Vol. 15, No. 178, Dec., 1938, pp. 431-435 and Vol. 16, No. 179, Jan., 1939, pp. 31-34.

Publication comprises two special reports concerning causes of and circumstances attending colliery fire; colliery briefly described and electric system discussed with reference to event. Eng. Soc. Lib. NY.

147. SKOCHINSKY, A.A. and MAKAROV, S.Z. Study of Selective Sorption. *Izvestiya Academiyi Nauk SSSR - Oteleniye Technicheskikh Nauk.* No. 1, 1939, pp. 21-38 and No. 2, pp. 5-22.

Experimental study of selective sorption and its application to development of chemical methods for combating mine fires due to spontaneous combustion of coal. Bibliography. [In Russian]

148. NOETZOLD, E. and TSCHAUNER, F. Observations Made on Combating Constantly Recurring Coal Mine Fire. *Glueckauf.* Vol. 76, No. 25, June 22, 1940, pp. 345-350.

Observations made on combating constantly recurring coal mine fire which caused alarm because of its vicinity to mine airways; it was decided to dig out fire, but because of locus, only extensive forcing back was possible, as result of which surrounding sections of field could be brought to mined section. [In German]

149. MAYER, F. Fire Tests in Mines. *Glueckauf.* Vol. 76, No. 4, Jan. 27, 1940, pp. 53-58.

Results of large scale experiments to investigate hazards involved; waste gases of fire form mixtures similar to producer gas, which, under certain conditions, are inflammable when mixed with air; most important properties of such gas mixtures and their behavior in shut-off zone of fire are described. [In German]

150. BLAIR, J.S. Colliery Fire Fighting Systems and Fire Jet Characteristics. *South Wales Institute of Engineers.* Proceedings, Vol. 55, No. 4, Jan. 11, 1940, pp. 369-370.

151. BREDEN-BRUCH, E. Brief Illustrated Description of Auer Mine Air Tester Combined with Auer Smoke Tube as Aid for Commander of Mine Rescue Squad. *Glueckauf.* Vol. 76, No. 10, Mar. 9, 1940, pp. 145-146.

[In German]

152. LUYKEN, F. Account of Fire at Consolidation Coal Mine in Germany on Mar. 29, 1938. *Glueckauf.* Vol. 75, No. 36, Sept. 9, 1939, pp. 761-768.

Origin of fire and means employed for combating it; ventilating conditions; conclusions and lessons learned from this fire. [In German]

153. BREDENBRUCH, E. Fighting Mine Fires with Rock Dust Sludge. *Colliery Engineering.* Vol. 17, No. 195, May, 1940, p. 140.

Method employed in Ruhr coal mines consists in applying to fire, sludge of rock dust and water which smothers conflagration, cools surrounding material, seals cracks and fissures, and permeates fine coal with incombustible material; particulars of fire extinguished by this method using 700 to 800 tons of dust during period of 2 mo.

154. BREDENBRUCH, E. Fire Fighting in Ruhr Coal Mines. *Glueckauf*. Vol. 75, No. 37, Sept. 16, 1939, pp. 781-6.

Protective methods and equipment discussed. [In German]

155. CABOLET, P. Origin and Prevention of Mine Fires Due to Spontaneous Combustion of Coal. *Glueckauf*. Vol. 75, No. 50, 51 and 52, Dec. 16, 1939, pp. 953-962, Dec. 23, pp. 971-975 and Dec. 30, pp. 984-987.

Investigation based on practical examples; spontaneous combusion during mining under various conditions discussed; means of preventing combustion; detection and extinguishing of fire. [In German]

156. KAISER, H.O. Instructions for Fire Fighting Underground. *Glueckauf*. Vol. 76, No. 26, June 29, 1940, p. 364.

List of rules, compiled by German coal mining company, presented. [In German]

157. SCOTT, G.S. and JONES, G.W. Application of Chemistry in Combatting Anthracite Mine Fires. *American Institute of Mining & Metallurgical Engineers.* Technical Publications, No. 1424, Meeting, Oct., 1941, 11 p.

Factors involved in heating and cooling; effect of oxidation on composition of coal; relationship between temperature and composition of mine fire atmosphere; explosive gas mixtures; calculations of leakage from sealed area; after sealed area has been opened, close inspection is necessary to prevent residual heat and increase in oxygen from causing recurrence. Bibliography.

158. CAMUS, J. and COUTURE, P. Use of Liquid Carbon Anhydride for Combating Mine Fires. *Revue de l'Industrie Minérale*. No. 456, Jan.-Feb., 1941, pp. 1-6.

Illustrated description of method employed in Ruhr coal mines; advantages of method. [In French]

159. CABOLET, P. Shutting Down and Re-opening of Section in Coal Mine in Bochum, Germany, in Which Fire and Explosion Occurred. *Glueckauf*. Vol. 76, No. 41, Oct. 12, 1940, pp. 533-561.

Causes of fire, its effect on ventilating system, and means employed in combating it; reasons for re-opening of section after 3½ years and account of how work was carried out. [In German]

160. ROSE, H.C. and SKINNER, E.C. Small Mine Fires Extinguished with Carbon Dioxide at Operations of Pittsburgh Coal Company. *Coal Age*. Vol. 46, No. 3, Mar. 1941, p. 59.

Notes on system in use at all mines of company where Cardox is used as blasting agent; shells may be held in hands and played over fire like hose or, where fire can not be approached, shells may be thrown on fire; examples of fires extinguished by Cardox.

161. BERGHOFF, F. Experiments in Fire Fighting with Limestone Dust Sludge. *Glueckauf*. Vol. 76, No. 41, Oct. 12, 1940, pp. 561-563.

Illustrated description of mixing car and liquid sticky mixture developed by author for rapid and sure extinction of mine fires directly on spot; development prompted by article by E. BREDENBRUCH, May, 1940, on fighting mine fires with rock dust sludge. [In German]

162. MUELLER, E. Description of Aerodynamical Method of Keeping and Controlling Air Tightness of Fire Barrier. *Glueckauf.* Vol. 77, No. 20, May 17, 1941, pp. 305-306.

Method consists of building inclosure in front of barrier in which air pressure is kept same as pressure of gases behind barrier; ventilators in ducts are used. [In German]

163. ANON. Dry Ice Utilized to Complete Fire Extinguishment. *Coal Age.* Vol. 47, No. 9, Sept., 1942, p. 51.

Brief description of use of frozen carbon dioxide at mine of Alden Coal Co., in Luzerne County, PA introduced through air locks by men wearing breathing apparatus and carrying life lines to assume orientation in fog from condensed moisture, dry ice made atmosphere incombustible; this is said to be first use of dry ice in fighting mine fire in anthracite region, perhaps first time used in world except where Cardox tubes have been utilized.

164. MIRFIN, L.H. Firedamp Ignition at Kiveton Park Collieries. *Iron & Coal Trades Review.* Vol. 145, Nos. 3869, 3873, 3902, Apr. 24, 1942, pp. 1-4, May 22, pp. 159-160, Dec. 11, pp. 1289-1290.

On Jan 12, 1942, it was reported that fire had occurred in Goose Carr District in Barnesley Seam at Kiveton Park Collieries; this district is worked by hand; no electricity or compressed air being used, and haulage being by ponies; description of circumstances; discussion of possible causes of ignition.

165. ASH, S.H., JONES, W.C., and FELEGY, E.W. New Wrinkles in Fighting Anthracite Fire Developed at Hazle Brook Mine. *Coal Age.* Vol. 47, No. 11 and 12, Nov., 1942, pp. 72-73 and Dec., pp. 95-96.

Description of conditions; after fire started, limestone dust was applied to keep air away from burning anthracite, to choke flame, and to neutralize acidity of mine water; chemical control prevented hydrogen, created by heating of anthracite and by water gas reaction between water and carbon in coal, from exploding; archway built to act as fire stopping; slush introduced through boreholes. Before Am. Inst. Min. & Met. Engrs.

166. HORNSBY, W. Rock-Dust Fighting Overcomes Elkhorn-Seam Mine Fire After Men Are Stricken by Recirculation. *Coal Age.* Vol. 47, No. 5, Mar., 1942, pp. 48-50.

At drift mine of Utilities Elkhorn Coal Company at Martin, KY, fire broke out Nov. 1, 1941, when mine was idle; use of rock dust brought fire under control and mae it possible to confine it to small area by sealing; operations were resumed in less than one week, as against 90 days or more if whole mine had been sealed.

167. LAWSON, W. and COOPE, C.M. Underground Fire at Old Boston Colliery. *Iron & Coal Trades Review.* Vol. 144, No. 3868, Apr. 17, 1942, pp. 356-358.

Fire occurred in Wigan Nine Feet Seam, Haydock, Lanshire, at 7:30 p.m. on Oct. 3, 1941; description of occurrence, sealing off, and precautions in reopening. Before Yorkshire Branch Nat. Assn. Colliery Mgrs.

168. TRIGG, R. Underground Fire Fighting at Collieries. *Colliery Guardian.* Vol. 144, No. 4245, May 8, 1942, pp. 451-452.

Review of various methods of fire fighting underground; details of mains water supply scheme; outline of necessary organization and personnel. From paper before Manchester Geol. & Min. Soc.

169. BAKER, J.S. Fire Prevention Planning for Mines. *Engineering & Mining Journal*. Vol. 143, No. 4, Apr., 1942, p. 53.

Brief correspondence item, citing three cases where recommendations were made to correct conditions where possible, or to install fire prevention and fire fighting apparatus where situations could not be corrected.

170. FELLMAN, C.M. Fires in Lake Superior Iron Mines. *National Safety Council - Lake Superior Mining Section*. Proceedings, June 26-27, 1941, pp. 96-112.

Brief review of history of fires which have occurred during last 10 years, with their causes; description of recent fire prevention measures which have been adopted to meet changing underground conditions; information submitted by ten different companies.

171. ANON. Fires and Explosions. *Coal Age*. Vol. 48, No. 10, Oct., 1943, pp. 68-73.

Analytical discussion of causes and prevention; costs of fires and explosions; good ventilation; dust elimination and control; fire fighting equipment; preventing electrical fires; shaft wiring; transformers; trolley wires; electric light bulbs.

172. ASHURST, T. Layout of Colliery Workings in Seam Liable to Spontaneous Combustion. *Iron & Coal Trades Review*. Vol. 145, No. 3904, Dec. 25, 1942, pp. 1359-1361.

Outline of working of seams where trouble with spontaneous combustion occurred; description of system where each panel of work can be isolated without affecting any other workings in district; it is essential to start right at shaft, and, if at all

possible, seam should be worked from downcast shaft to enable main haulages to be used as intake airways. Before S. Wales Branch, Nat. Assn. Colliery Mgrs.

173. RILEY, W. Organization and Conduct of Fire-Fighting in Mines. *Iron & Coal Trades Review.* Vol. 147, Nos. 3951, 3952, 3955, Nov. 19, 1943, pp. 787-788, Nov. 26, pp. 833-835, Dec. 17, pp. 945-946, 957.

Importance of correct procedure and selection of personnel; quick action on fire may avert serious damages; extinguishers; only special types safe to use on electrical fires; use of compressed air mains for water; portable fire pumps; duties of officers; checking persons entering or leaving mine; procedure following discovery of fire; mine maps; special equipment and clothing. Before Yorkshire Branch, Nat. Assn. Colliery Mgrs.

174. WILLETT, H.L. Prevention of Spontaneous Combustion at Bullcroft Main Colliery. *Colliery Guardian.* Vol. 166, No. 4289, 4293, 4296, 4297, Mar. 12, 1943, pp. 305-311, Apr. 9, pp. 429-431, Apr. 30, pp. 543-544, May 7, pp. 572-574.

Account of underground investigations in coal mine at Carcroft, Doncaster, which have already resulted in reduction of spontaneous combustion in Barnsley seam; comparison of roadway conditions with ordinary gateside packing and with special inert gateside packing; organization and duties of fire gang of about 50 workmen; ventilation; proposed system of pneumatic stowing. Before Midland Inst. Min. Engrs.

175. JONES, T.D. Spontaneous Combustion in Coal Mines. *Colliery Guardian.* Vol. 166, No. 4291 and 4292, Mar. 26, 1943, pp. 365-368 and Apr. 2, pp. 419-422.

Report on research work; air analysis as means of detecting spontaneous heatings under modern mining conditions; appeal is made for formation of committee *of mining engineers and mining research investigators for further investigation of method. Before North Staffordshire branch of Nat. Assn. Colliery Mgrs.*

176. WILLETT, H.L. Spontaneous Combustion of Coal in Mines. *Colliery Guardian.* Vol. 167, No. 4317, 4318, Sept. 24, 1943, pp. 345-348, Oct. 1, pp. 373-378.

Causes of spontaneous combustion; prevention; value of equalizing ventilating pressure on old workings and sealed areas; production of extinctive atmosphere in sealed off area; leakage of air produced by subjecting old roads to high differences of ventilating pressure; treatment of heatings. Before Shffield Univ. Min. Soc.

177. UNSWORTH, L. Underground Fire at Wigan Junction Colliery. *Iron & Coal Trades Review.* Vol. 147, No. 3943, 3944, 3945, 3946, 3948, Sept. 24, 1943, pp. 461-463, Oct. 1, pp. 506-508, Oct. 8, pp. 547-549, Oct. 15, pp. 587-588 and Oct. 29, pp. 675-678.

Fire believed to have started Sept. 7, 1942, when no one was in pit; method of treatment, sealing and re-opening. Before Lancashire branch, Nat. Assn. Colliery Mgrs.

178. ATKINSON, F.S. Use of Steel Doors in Fire Stoppings. *Colliery Guardian.* Vol. 166, No. 4297-4302, May 7, 1943, pp. 545-547, June 11, pp. 703-706, Vol. 167, No. 4307, July 16, p. 80.

Account of sealing off underground fire, experience gained in use of steel doors, and discussion of use of carbon dioxide, known commercially as "dry ice." Before Midland Inst. Min. Engrs.

179. EDMOND, F., PICKERING, B.H., HUDSPETH, H.M., and PRICE, H. Sealing-Off Fires Underground. *Institution of Mining Engineers.* Transactions, Vol. 103, Pt. 9, June, 1944, pp. 477-521.

Memorandum of Committee; open fires; gob fires; function of stoppings; conditions necessitating erection of stoppings; stone dusting and stone dust barriers; siting of stoppings; sealing-off a fire area; possibilities of explosion behind stoppings and effect; balancing of pressure; barometric effects; mine air and gas analysis; oxygen content behind stoppings; organization; recommendations. Bibliography.

180. PRICE, H. Extinguishing Mine Fire by Blast. *Colliery Guardian.* Vol. 170, No. 4396, March 29, 1945, pp. 387-391, Vol. 171, No. 4416, August 17, pp. 201-203.

Referring to Memorandum of Committee on Sealing-Off Fires Underground from Instn. Min. Engrs. - Trans. June, 1944. Further suggestion is submitted regarding proposed method of snuffing fire out by detonation of charge of high explosive; propagating artificial explosion; precautions; of dangerous gases present in area sealed off in consequence of fire, oxygen is most dangerous. Before Manchester Geol. & Min. Soc.

181. BRUSSET, G.A. Putting Out Fire at Greenhill Mine. *Coal Age.* Vol. 50, No. 3, March, 1945, pp. 97-102.

Greenhill mine is situated at Blairmore, Alberta. Oct. 25, 1943, smoke was discovered by fire-bosses on their regular weekly inspection of airways; fire had started on outcrop at top of old raise filled with dirt; direct fire fighting; checking fire; smothering fire, after Nov. 15; it has been possible, by methods including use of dry ice, rock dust, and hydraulic flushing, to first slow down and then kill underground fire within period of 6 mo.

182. NICHOLAS, R.H. Prevention of Mine Fires. *Coal Mining.* Vol. 22, No. 12, Dec., 1945, pp. 7-9.

Summary of work of subcommittee on preparation of haulage roads, for prevention of fires from electrical origin; headings for haulage roads; timbering; grading; drainage; roadbed. Before Coal Min. Inst. America.

183. NICHOLSON, R.P. Recent Mine Fires in Acadia No. 7 Colliery. *Canadian Institute of Mining & Metallurgy.* Transactions, Vol. 49, 1946, pp. 407-412. (Bulletin No. 413, Sept., 1946.)

Mining in Pictou coal field has, from early times, been accompanied by underground fires and explosions; some have entailed little damage; many have resulted in heavy losses in both life and material; consequences of fire in Cage pit in 1880; experiences since opening of Acadia No. 7 in 1936.

184. BROWN, G.L. Emergency Work in Mines with Aerophor Breathing Apparatus. *Colliery Guardian.* Vol. 173, No. 4465, July 26, 1946, pp. 111-114.

Fire occurred at conveyor gear-head and progressed quickly along belt; local brigade failed to overcome fire; stopping in intake roadway was built in fresh air; one in return was erected by rescue teams of five to six men each wearing Aerophor apparatus charged with 5½ lb. of liquid air for two-hour periods of work; procedure; reopening mine. Before Superintendents of Mine Rescue Stations.

185. DAWSON, A.B. Efficient Sealing of Underground Fire. *Colliery Guardian.*

Account of difficulties in dealing with old underground fire in Main Band seam at William Pitt, Whitehaven; sealing operations had been carried out in 1924, 1939, 1941 and 1945; completion of final stoppings; injection of cement; effectiveness of stoppings; sampling of air at stoppings, to determine quantity of gas leaking through. Before England Inst. Min. & Mech. Engrs.

186. VENTER, J., Introduction to Study of Underground Fires in Coal Mines; DUMONT, E. and DUFOUR, D., Fires and Their Prevention in Mine at Marihaye; BEBELMAN, J., Underground Fires Abroad; STASSEN, M., Carbon Monoxide Intoxication, Detection of Gas and Treatment of Ailments Caused by Gas; LECLERC, E., Detection of Atmospheric Carbon Monoxide; DESSALE, E. and BROUHON, A., Underground Fires Due to Various Causes; SCHYNS, J., Respirators and Extinguishers; VENTER, J., Fires in Liege Basin; DENOEL, C., Life Saving Stations in Belgian Coal Mines; VENTER, J., Conclusions; WATHIEW, N., Employment of Heat Insulation in Combating Fires. *Revue Universelle des Mines.* Vol. 89, No. 8, 1946, pp. 285-378. [In French]

Underground fires in coal mines.

187. ROBINSON, C.A. New Mine Fires Are Again Threatening Hocking Valley Coal Field. *Coal Mining.* Vol. 23, No. 12, Dec., 1946, pp. 15-17.

In Ohio's Hocking Valley coal fields, where great coal mine fires have been raging continuously for last 62 yr., new fire roaring into its third month is threatening vast new damage; Ohio coal operators are fearful that new fire not only will render useless barriers built to protect reserves from older fires, but if not extinguished or isolated, will destroy in next 50 yr. another $60,000,000 worth of coal.

188. YOURT, G.R. Preparations for, and Early Action in, Preservation of Life at Time of Mine Fire. *Canadian Institute of Mining & Metallurgy.* Transactions, Vol. 50, 1947, pp. 577-588 (Bulletin, No. 427, Nov., 1947).

Suggested preparations to be carried out in advance, so that loss of life might be prevented should fire occur; actual organized procedure to be followed for preservation of life if and when fire occurs.

189. NEATH, G. Fighting Underground Fires. *Iron & Coal Trades Review.* Vol. 156, No. 4184, May 21, 1948, pp. 1061-1062.

Application of foam extinguishers; experience of fire at Griff colliery. Before Worcester Branch of Nat. Assn. Colliery Mgrs.

190. PARK, W. Fire Extinguishers - Their Application to Underground Fire Fighting. *Colliery Guardian.*

Extinguishers available include soda acid, chemical foam, water and compressed air or carbon dioxide, dry powder, and carbon dioxide types; comparison of types; foam and fires involving electric equipment at potential; organization of fire fighting personnel procedure in event of fire. Before Mine Rescue Station Superintendents' Conference.

191. BAILEY, F.J. New Developments in Underground Fire Fighting Equipment. *Illinois Mining Institute.* Proceedings, 1947, pp. 17-23 (discussion) 23-24.

In coal mines, greatest difficulty is getting to fire quickly; in development of new mine fire car, two types of extinguishing agent used are sealing or covering material (called fire coat) and carbon dioxide; sealing material consists of two water solutions of inorganic compounds, stored in separate tanks and mixed as discharged through special nozzle.

192. KEIR, J. Underground Fires. *Iron & Coal Trades Review.* Vol. 155, No. 4158, 4159, 4161, Nov. 21, 1947, pp. 985-989, Nov. 28, pp. 1057-1060, and Dec. 12, p. 1163.

Account of some experiences of underground fires which occurred in Wemyss district of Fife, Scotland; their probable origin; methods adopted to deal with them. Before Scottish Branch, Nat. Assn. Colliery Mgrs.

193. SIMOMOS, I. Fires in Lignite Mines. *Texnika Xponika.* Vol. 23, No. 259-264, Jan.-June, 1946, pp. 41-47.

Causes, protective measures and methods of fighting fires; most frequent cause is spontaneous combustion; rules to be observed in order to avert fires. [In Greek]

194. KNEVITT, L.T. Further Notes on Underground Mine Fire Prevention at South Mine, Broken Hill. *Australasian Institute of Mining & Metallurgy.* Proceedings, No. 142, June 30, 1946, pp. 127-150.

Paper considered as supplementary to that by R. P. HOOPER, Mar. 31, 1929 issue; description of mine; ventilation; organization and training of fire fighting squads; fire fighting and rescue equipment; fire alarms.

195. ANON. How Andes Copper Plans for Fire Prevention. *Engineering & Mining Journal.* Vol. 148, No. 12, Dec., 1947, pp. 68-69.

System in use at copper mine at Potrerillos, Chile; emergency map of each level is carried by all mine supervisors and safety men; in case of fire, corresponding map and instruction sheet is consulted immediately.

196. ANON. Use of Air-Mover with Rock Dust Extinguishes Timber Fires. *Mining World.* Vol. 9, No. 12, Nov., 1947, p. 32.

Notes on experimental work by U.S. Bureau of Mines at St. Elmo mine in Coeur d'Alene mining district, Idaho; results were satisfactory and mine operators are considering installation of rock dusting equipment in all underground electric stations.

197. HANSFORD, J.H. Conveyor Belt Fires in Bituminous Coal Mines. *Coal Mining.* Vol. 26, No. 1, Jan., 1949, pp. 19-21.

Paper based on experience in WV. Findings in connection with four belt fires resulting from electrical sources, and four which were result of mechanical difficulties; methods of fighting fires was, if possible, to get on top of fire with rock dust or rock dust plus water, if latter was available.

198. BLAIR, J.S. Fire-Fighting Systems for Collieries. *Engineering*. Vol. 166, No. 4319, 4320, Nov. 5, 1948, pp. 433-436, Nov. 12, pp. 457-459.

High pressure and low pressure systems considered; certain principles common to both dealt with: description of, and calculations for both systems; charts included.

199. NEATH, G. Foam Extinguishers for Underground Fires. *Colliery Guardian*. Vol. 178, No. 4605, Apr. 14, 1949, pp. 495-496.

History of practical application of foam on underground fire at Griff No. 4 pit, Warwickshire area, West Midlands Div.; demonstration at Warwickshire Central Rescue Station; fierce wood fires, built in open, were attacked with two and 10 gal. foam extinguishers; results proved that one or two of two gal. size would be capable of extinguishing small fire or of keeping larger fire in check; usefulness of small model foam generator demonstrated.

200. BASSETT, T.B. Gob Fires in Longwall Workings. *Colliery Guardian*. Vol. 177, No. 4578, Oct. 8, 1948, pp. 471-476, No. 4581, Oct. 28, p. 599.

Underground roadside heatings may be detected by slight increase in temperature, but definitely by peculiar heating smell; this may be timber or coal smell, or both; experienced person can easily detect one from other; methods of dealing with roadside heating and how to prevent them; sealing off areas affected; discussion of two cases of spontaneous combustion that occurred during recent years at collieries in South Wales area.

201. ANON. Proper Fire Protection for Coal Mines. *Coal Mining.* Vol. 25, No. 11, Nov., 1948, pp. 10-13.

Classification of fires, as established by National Board of Fire Underwriters; combustible materials which continue to burn, even though flames are extinguished, require different media than flammable liquids, greases, etc., or energized electrical fires; characteristics of approved hand fire extinguishers; description of some track mounted, trackless, and combination track and trackless mounted units.

202. HOGG, G.W. Recovery Work After Underground Fire. *Iron & Coal Trades Review.* Vol. 158, No. 4223, Feb. 18, 1949, pp. 347-349.

Detailed description of difficulties encountered and overcome in recovery of large area of coal, at Pootkee Colliery in Jharia coalfield in India, which had been sealed off due to outbreak of fire about 4 yr. previously. Before Assn. Colliery Engrs. in India.

203. DOHMEN, F. Prompt Detection and Damming of Coal Mine Fires. *Colliery Engineering.* Vol. 27, No. 312, Feb., 1950, pp. 78-79.

It is shown how fires can be detected by drill holes and by tapping samples of gas from these holes in time to isolate fires without loss or difficulty; reference to fire in Lothringen coal mine in 1933 which was sealed off, and of precautionary measures undertaken 11 years later when working in same seam approached fire area; diagrams.

204. ANON. Providing for Safe Removal of Men from Section of Mine in Case of Fire. *Coal Mining.* Vol. 26, No. 11, Nov., 1949, pp. 11-14, 19.

Using Pittsburgh coal mine with map of workings as example, author describes preparations made for possible fire and procedure to be followed.

205. SNELL, W.D. Colonial Mine Fire. *Coal Age.* Vol. 56, No. 9, 10, Sept. 1951, p. 110, 112, Oct. p. 110, 112-113.

Account of effective planning and efficient fire fighting in combatting fire discovered in belt heading of 5¼ mile long belt conveyor system at Colonial mine, Fayette County, PA; details on fire fighting and obstacles encountered; roof fall and carbon monoxide; sealing fire; advancing against fire; operations in parallel entry; timbering.

206. LANDALE, N.S. and GUTHRIE, E.M. Dealing with Fire in Winding Shaft. *Iron & Coal Trades Review.* Vol. 162, No. 4338, June 1, 1951, pp. 1245-1250.

Fire in Dora shaft of Little Raith colliery near Cowdenheath described; sealing off opening to shaft with sand; cement injection for sealing off 18 ft. of shaft head; permanent sealing; air samples taken daily; study of ventilation circuits; schematic drawings; graphs. Before Scottish Branch, Nat. Assn. Colliery Managers.

207. WILCOX, W., ROBERTSON, W.M., TIDESWELL, F.V., and JONES, S. Ignition of Conveyor Belts by Frictional Heating. *Colliery Guardian.* Vol. 183, No. 4717, July 26, 1951, pp. 113-117.

Record of experiments made at Whitfield Colliery, Great Britain, in Germany and at Dutch State Mines; most common causes of ignition were defective rollers and bearings conducive to heating and ignition of coal dust or of belt itself after stopping, and belt slip at driving head; suggestions for reducing ignition hazard. Bibliography.

208. WILCOX, W. and ROBERTSON, W.M. Sealing and Reopening District. *Colliery Guardian.* Vol. 182, No. 4700, Mar. 29, 1951, pp. 381-386, No. 4702, Apr. 12, pp. 475-476.

Steps taken to seal off and reopen Old Whitfield District, after devastating conveyor belt fire 2,350 yd. from downcast shaft bottom; discussion of changes in composition of air from behind return stopping; preparations for recovery; use of airlock system and practice of inspection in advance proved successful; plan. Before North Staffordshire Inst. Min. Eng.

209. PARK, W. and JENKINS, C. Sealing Off Underground Fire. *Iron & Coal Trades Review.* Vol. 162, No. 4333, Apr. 27, 1951, pp. 963-972.

Serious outbreak of fire occurred at Newlands colliery on Mar. 7, 1947; discovery of fire; exploration by rescue teams; possible causes of fire discussed; photographs, schematic drawings. Before S. Wales Branch of Nat. Assn. Colliery Managers.

210. ANON. S.M.R.E. Fire Research. *Colliery Guardian.* Vol. 182, No. 4700, Mar. 29, 1951, pp. 389-390.

Demonstration of fire research at Safety in Mines Research Establishment of Ministry of Fuel and Power at Buxton; ease of ignition of fine coal dust; ignition of coal dust on heated surface, heating by friction, smoldering developing into flaming, development of fires in underground roadway, burning of conveyor belting and its extinguishing, fire danger associated with leakage of compressed air; coal dust explosion spread prevented by limestone dust.

211. ROANTREE, W.B. Work in High Air Temperatures in Fire in Mysore Mine, Kolar Gold Field. *Institution of Mining & Metallurgy.* Bulletin No. 538, Sept., 1951, pp. 513-539, No. 540, Nov., pp. 61-78.

Investigation of effects of high air temperatures on teams engaged in fire fighting underground in Proto apparatus; medical findings on completion of task classified by severity of shift; it is concluded that temperature up to 115 F. dry bulb and 109 F. wet bulb may be permissible for average, fresh, trained Proto team for 20 min.

212. SCHWARZ, K. and BUSKUEHL, H. Cause of Fire in Pneumatic Conveyor Operating in Ruhr Coal Mine. *Glueckauf*. Vol. 87, No. 47-48, Nov. 24, 1951, pp. 1110-1112.

Investigation revealed that fire was caused by excessive heat of motor driving conveyor; safety device did not work properly so that air supply to and discharge from motor was throttled; illustrations. [In German]

213. LEHMANN, G. Fire Fighting and Prevention in Mines. *Glueckauf*. Vol. 87, No. 19-20, 35-36, May 12, 1951, pp. 439-447, Sept. 1, pp. 817-831.

Detection and initial protective measures; regulations in Saar mines following two explosions during war; fire extinguishers; types of fires in mines; illustrations. See also English translation in S. African Min. & Eng. J. Vol. 63, No. 3086, Apr. 5, 1952, p. 215. [In German]

214. ANON. Coal Fire-Fighting Projects Save Reserves. *Mechanization*. Vol. 16, No. 6, June, 1952, p. 128.

Method of fighting coal mine fires in West; underground coal fire fighting project of Skull Creek in Colorado completed through excavation of trench around fire area, filling of trench with clay and compacting it; problem of isolation of 40 fires still burning in Colorado, Wyoming and New Mexico; methods of surface sealing and flushing silt into burning workings through boreholes.

215. BULLOUGH, W. Controlling and Sealing Spontaneous Heating in Winding-Shaft. *Colliery Guardian*. Vol. 184, No. 4762, June 5, 1952, pp. 665-669.

Rawdon colliery at Moira, South Derbyshire Coalfield was sunk in 1820; heating occurred in Main Coal at depth of 721-741½ ft; fighting fire by means of limestone dust mixed in water and injected through drill holes into fire zone; shaft repairs, rearrangement of ventilation; sealing-off fire zone; provisions for future injections; diagrams.

216. ANON. Fighting Fire with Flood. *Coal Age.* Vol. 57, No. 3, Mar., 1952, pp. 96-98.

Fighting fire in Lehigh Navigation Coal Co's mine No. 4 at Lansford, KY; flooding as best method of attack; experience in building dams, circulating water and recovering section; planning for flooding and strict control minimize ravages of fire; plans, sections.

217. WYANT, G.D. Fire Fighting Equipment and Facilities at Indianola Mine. *Mining Congress Journal.* Vol. 38, No. 3, Mar., 1952, pp. 29-31.

Indianola Mine is located 15 mi. northeast of Pittsburgh in Allegheny Valley; layout of mine; drainage and fire fighting system, consists of 4 in. pipe connections installed in bottom of 12 in. discharge column, from which 21,000 ft. of 4 in. pipe line was laid among all of main haulage roads and into working sections; details on system and its operation.

218. BARCLAY, J.T. and WALKER, D.N. Fire Hazards. *Colliery Guardian.* Vol. 185, No. 4778, Sept. 25, 1952, pp. 372-375.

Analysis of fires and casualties caused thereby during period from 1940 to 1950; apart from spontaneous combustion, conveyor fires formed most numerous and serious group; methods of dealing with fire risk at driving units and at rollers or idlers; special dangers on conveyors reviewed; installation of non-inflammable conveyor; automatic thermal control and prevention of fires beneath bottom rollers are recommended; other causes of fire reviewed.

219. RICHFORD, E. Fire Prevention and Protection at Collieries, with Particular Reference to Trunk-conveyor Systems. *Iron & Coal Trades Review.* Vol. 164, No. 4376, Feb. 22, 1952, pp. 409-415.

Summary relating to primary causes of 70 conveyor fires; results of investigation at East Midlands colliery; prevention of initial fire outbreak, provision to limit or deal with fire, and safeguards for faceworkers; fire prevention safety devices for conveyors; diagrams.

220. ANON. Portable Fire Extinguishers for Use Underground. *Great Britain National Coal Board.* Information Bulletin No. M5(51)7 (supersedes No. MS(50)2), 4 p.

Places where portable fire extinguishers should be installed; types of portable extinguishers used underground, types for various underground fire risks.

221. TALLIS, J.R. and CROOK, S.R. Underground Fires in Two Anthracite Mines. *Institution of Mining Engineers.* Transactions, Vol. 111, Pt. 12, Sept. 1952, pp. 960-978.

Incidents at Abercrave Colliery and at Cwmllynfell Colliery, Great Britain; results of study show, that in case of anthracite mines presence of actual fire is more reliably indicated by presence of carbon monoxide than by CO/O_2 absorbed ratio; data on analysis of air samples.

222. POTTER, N.M. Underground Heatings and Fires. *Iron & Coal Trades Review.* Vol. 164, No. 4381, 4382, Mar. 28, 1952, pp. 691-696, Apr. 4, pp. 761-766.

Gas analysis in its relation to detection and control of heatings and fires in coal mines; risk of explosion during mine fires; development of heating; effect of ventilation; pyrites as factor of heating; behavior of carbon monoxide; detection of heating by gas analysis alone; friction fires; gas analysis during sealing and reopening of sealed district; layout of district; graphs.

223. ANON. For Safety's Sake. *South African Mining & Engineering Journal*. Vol. 62, No. 3077, Feb. 2, 1952, p. 989.

New Lifesaving cylinder tested in West Virginia; in case of fire, explosion or other accidents cylinder would be lowered into mine through ventilator escapeway and bring men out at rate of 50 per hr; method of drilling ventilator escapeways.

224. MOROZOV, M.N. Combatting Spontaneous Combustion of Coal by Shaft Sinking Using Caissons. *Ugol*. No. 4, Apr., 1951, pp. 20-24.

Experience with shaft sinking in Moscow basin; methods of combatting underground fires; need for preliminary geologic study; diagrams. [In Russian]

225. HOUSTON, H.R. Causes and Prevention of Fires Underground. *Iron & Coal Trades Review*. Vol. 167, No. 4451, July 31, 1953, pp. 247-252.

Actual instances of underground fires; methods of fire prevention; combatting fire in damp pit; outbreak of fire in gassy seam; ignition of firedamp by brushing shot; handling of fire and reasons for action taken.

226. ANON. Clamshell Wallops Coal Mine Fire. *Excavating Engineer*. Vol. 47, No. 2, Feb., 1953, pp. 26-29.

Five month struggle with coal mine fire in Pittsburgh, PA, which endangered multi-million dollar Bedford Dwellings Project; limits of fire were determined by drilling 8-in. holes down to 44 ft.; with fire subdued, exposed portion of coal bed which has not yet ignited, was protected from future fires by concrete wall.

227. FROST, L. Fire in Dominion No. 16 Colliery, New Waterford, Nova Scotia. *Canadian Mining & Metallurgy.* Bulletin, Vol. 46, No. 494, June, 1953, pp. 360-367.

Diary of consecutive operations connected with combatting blaze cause by shot which blew out and ignited small gas feeder at face; use of stonedust and fire extinguishers, installation of fire stoppings; plans, diagrams.

228. SHEPHERD, W.C.F. and JONES, S. Investigations into Underground Fires. *Great Britain. Safety in Mines Research Establishment.* Report No. 43, July, 1952.

New hazards from fire due to increased mechanization; smoldering of coal dust; spread of fire and its prevention; fire risks with hydraulic coupling and leaking compressed air pipes.

229. MIKHEEV, G.F. Samovozgoranie Ves'ma Tonkikh Plastov Ugolya. *Ugol.* No. 3, Mar., 1951, pp. 20-21.

Self-ignition of very thin coal seams; self-ignition of lignite of 0.4-0.7 m. thickness in Moscow coal basin; geologic and petrographic characteristics of coal; character of underground fires; sealing off fires; analyses of mine atmosphere for detection of carbon monoxide; plans. [In Russian]

230. WOOD, W.A. Testing Underground Fire Hydrants. *Colliery Guardian.* Vol. 186, No. 4794, Jan. 15, 1953, pp. 93-95.

New method of testing hydrants to show that water is present in sufficient volume and at adequate pressure; checking supply to pipe line; tests in East Midlands; British Fire Fighting regulations.

231. YOPES, P.F. Fire-Retarding Paints and Compounds for Use on Mine Timbers. *Coal Mining.* Vol. 30, No. 6, May, 1953, pp. 22-26.

Consideration of fire retardants from point of view of underground practice; applications and functions of fire retardant coatings, and their types; test work of Bureau of Mines summarized; water emulsion, synthetic resin phosphate type coatings recommended for most underground and surface applications.

232. KLINGER, M.K. Suitable Measures for Reducing Fire Hazard in Mine Timber. *Colliery Engineering.* Vol. 29, No. 346, Dec., 1952, p. 524.

Experiments at underground test station in Dortmund, Germany, in order to ascertain influence of specific surface of timber and its inflammability and to determine action and efficiency of certain fireproofing materials.

233. DAVIES, J.W. Anthracite Stripping in Burning Areas. *Mining Congress Journal.* Vol. 40, No. 6, June, 1954, pp. 67-70.

How incandescent rock, burning coal and drill hole temperatures above 1500 F were overcome to recover 925,000 tons of anthracite; procedure and equipment used by Shen-Penn Production Co., in stripping burning areas near Shenandoah, PA; drilling problems, use of special explosive developed for hot ground; dust and flying rock problem.

234. CURZON, G.E., and EISNER, H.S. Assessment of Hazard Caused by Arsenious Fumes from Impregnated Timber in Underground Fires. *Great Britain. Safety in Mines Research Establishment.* Report No. 78, Aug., 1953, 15 p.

Possible health hazard produced by liberation of arsenious fumes in underground fire involving timber impregnated with arsenic-containing preservative; account of laboratory and large-scale experiments to compare arsenic hazard with that concurrently arising from carbon monoxide; it is concluded that, with certain qualifications, hazard is negligible.

235. BREDENBRUCH, E. Combating Mine Fires. *Glueckauf.* Vol. 90, No. 29-30, July 17, 1954, pp. 769-779.

Preliminary measures allowing quick action in case of fire; extinguishing and sealing fires; control of sealed fires by means of gas analysis. [In German]

236. ANON. Care and Maintenance of Canvas Hose Used for Fire Fighting. *Great Britain National Coal Board.* Information Bulletin No. 53/87, 5 p.

Deterioriation of canvas type fire hose left stored in rolls ready to run out for immediate use found to be due to acid attack and microbiological attack; construction of hose; examination and maintenance; proofing of existing stocks.

237. BENNETT, A.J. Colliery Fire-Fighting Organization. *Colliery Guardian.* Vol. 187, No. 4844, Dec. 31, 1953, pp. 827-829.

Organization and training of personnel; equipment necessary for fire fighting; fire fighting plans; inspection and maintenance of fire fighting equipment; communications.

238. EISNER, H.S. and SMITH, P.B. Convection Effects from Underground Fires: Backing of Smoke Against Ventilation. *Great Britain. Safety in Mines Research Establishment.* Report No. 96, July, 1954, 12 p, 5 supp. plates.

Phenomenon of smoke and hot air backing against ventilation; study in Buxton underground roadway 200 ft. long with cross-section area of 56 sq. ft.; experiments with model; simple method of advancing towards fire; it is suggested that transverse screen would be useful for fire fighting. See also Colliery Guardian, Vol. 189, No. 4879, Sept. 2, 1954, pp. 311-315.

239. EISNER, H.S. Detection of Heatings and Fires in Coal Mines. *Great Britain. Safety in Mines Research Establishment.* Report No. 63, Feb., 1953, 41 p.

Conditions that affect fire detection underground; distinction between 'heating' and 'fire' detectors; existing heat detectors are described and possible new methods outlined; diagrams.

240. SMITH, P.B. Inflammability of Brattice Cloth. *Great Britain. Safety in Mines Research Establishment.* Report No. 81, Oct., 1953, 12 p., 8 supp. plates.

Types of brattice cloth that are used underground, or in process of development; test for inflammability; some cloths are highly inflammable when new; others become so when worn; P V C-coated cloths can be made very flame resistant, and they retain this property under conditions of severe treatment.

241. EISNER, H.S. and SHEPHERD, W.C.F. Recent Research on Mine Fires. *Colliery Guardian.* Vol. 189, No. 4873, 4874, July 22, 1954, pp. 95-98, July 29, pp. 127-132.

Problem of fires in timber logged roadways; fireproofing of timber; conveyor belting; ignition risk of ventilation hose; accumulations of coal dust, smoldering; dangers of friction; risks from electrical equipment; detection of heat by stench agents; warning and action in event of fire; methods of fire fighting.

242. GUIDER, W. Fire-Resistant Coatings for Pit Timber. *Colliery Guardian.* Vol. 188, No. 4854, Mar. 11, 1954, pp. 313-317.

Investigations made to render timber difficult to ignite, in which fire resistant paints, cement coatings and similar substances were examined, and coating of sand, limestone dust and sodium silicate solution was finally recommended; tests carried out in experimental tunnel are described and costs compared.

243. ANON. Use of Fire Resistant Timber in Mines. *Great Britain. National Coal Board.* Information Bulletin, No. 54/106.

Standard of resistance to fire; impregnation and surface treatment processes; most effective salts and principal types of coating.

244. BLAIR, J.S. Colliery Fire-Fighting. *Iron & Coal Trades Review.* Vol. 169, No. 4525, Dec. 31, 1954, pp. 1543-1556.

Principles of fire jets, water flow, and general fire fighting considerations above and below ground, in light of British National Coal Board's recommendations.

245. GLOVER, H.G. Divisional Mobile Laboratory. *Colliery Guardian.* Vol. 189, No. 4887, Oct. 28, 1954, pp. 533-536.

Laboratory, recently made by National Coal Board for use in North-Western Division Great Britain, will be used at pithead at time of underground fire, etc., and, in addition to housing scientific equipment for gas analysis, will provide accommodation and equipment for technical computing staff.

246. KLINGER, K. Experiments With Mine Fires Conducted on Large Scale to Test Measures Designed to Prevent Underground Fires. *Glueckauf.* Vol. 91, No. 13-14, Mar. 26, 1955, pp. 329-337.

Installation of fireproof zones, fire protected zones, and zones equipped with sprinkler systems. [In German]

247. BUDRYK, W. Reversibility of Air Flow During Underground Fires. *Archiwum Gornictwa i Hutnictwa.* Vol. 2, No. 2, 1954, pp. 125-170.

Methods used to prevent reversibility of air flow during underground fires. [In Polish with French summary]

248. BARCZYK, S. Reversion of Main Flow of Air During Fire in Ascendant Air. *Archiwum Gornictwa i Hutnictwa*. Warsaw, Vol. 2, No. 4, 1954, pp. 489-512.

[In Polish with French summary]

249. OLPINSKI, W. Dependence of Reciprocal Relations Between Air and Coal Upon Temperature. *Archiwum Gornictwa i Hutnictwa*. Vol. 2, No. 2, 1954, pp. 191-200.

Problem of coal oxidation and underground fire hazard. [In Polish with French summary]

250. MORGAN, W.P. Mine Fire Protection. *Canadian Mining Journal*. Vol. 76, No. 9, Sept., 1955, pp. 83-86.

Prevention of fires due to stray electric currents, sparks from oxygen acetylene torches, oxidation of sulphides, cigarette butts, friction, and spontaneous combustion.

251. JARVIS, J.I. Mock Fire at East Malartic Mines. *Canadian Mining Journal*. Vol. 76, No. 6, June, 1955, pp. 62-65.

Program of annual exercise and evacuation of mine at East Malartic, Quebec.

252. MORRIS, W. Fighting Persistent Mine Fire. *Canadian Mining & Metallurgical Bulletin*. Vol. 49, No. 527, Mar., 1956, pp. 161-166.

Fighting underground fire that occurred in 1950 at Foothills mine, Coalspur District, Alberta; section of Val d'OR seam and formation of cracks formed situation ideal for heating; risk of explosion, problems of fighting fire, and immediate steps to be taken.

253. EISNER, H.S. and SMITH, P.B. Fire Fighting in Underground Roadways: Experiments with Foam Plugs. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 130, June, 1956, 24 p.

Method consists of fitting fabric net across roadway; outby side of net is continuously sprayed with dilute solution of wetting agent; ventilation current through wetted net forms bubbles on side of net next to fire, foam is driven down roadway by ventilation until it reaches either fire itself or length of burnt out roadway sufficiently hot to convert water content of foam into steam.

254. JONES, S. Ignition Hazard From Leaks of Compressed Air. *Great Britain. Safety in Mines Research Establishment.* Report No. 137, Oct., 1956, 12 p.

Hazards of generation, transmission, and use of compressed air; examples of fires associated with leaks; heating may occur and produce sparks if air as it leaks causes vibration of rubber patch ineffectively bound onto hose; rubber alone softens and disintegrates before reaching its ignition temperature.

255. KLINGER, K. Large-Scale Mine Fire Experiments to Test Methods of Arresting Open Roadway Fires. *Great Britain. Safety in Mines Research Establishment.* Paper No. 25, 1954.

Installation and maintenance of fireproof zones.

256. BREDENBRUCH, E. Eine Flammenschutzkleidung fuer den Bergbau. *Glueckauf.* Vol. 92, No. 37-38, Sept. 15, 1956, pp. 1089-1094.

Protective clothing designed to protect against fires due to dust and firedamp explosions in mines. [In German]

257. HERMES, J.H., SLOTBOOM, J.G. and KIRKELS, P.A.H. Study of Fire Which Happened in Compressed Air Locomotive During Filling Up. *Revue de l'Industrie Minérale*. Vol. 38, No. 649, Dec., 1956, pp. 763-770.

Accident occurred due to conflagration of oil which accumulated in compressed air cylinders. [In French]

258. STASSEN, J. and VENTER, J. Underground Fires in Coal Mines. *Revue Universelle des Mines*. Vol. 12, No. 11, Nov., 1956, pp. 585-596.

Preventive measures and methods of combatting fires. [In French]

259. ANON. Fire Control for Today's Mining. *Coal Age*. Vol. 62, No. 7, July, 1957, pp. 66-70.

Experience of Pittsburgh Coal Co. with installation of fire prevention equipment, establishment of definite fire fighting procedures and continuous training of men and officials in steps to be taken in event of underground fire.

260. HATTERSLEY, R. Powder Couplings and Fire Hazard. *Colliery Guardian*. Vol. 195, No. 5051, Dec. 19, 1957, pp. 753-755.

Heating of fluid coupling using powdered iron as transmission medium has been investigated under various conditions of operation in coal mines and it is shown that such coupling is unlikely to cause fire, provided it is fitted with fusible plugs which will completely release powder in event of temperature of coupling rising above predetermined figure.

261. KLINGER, K. Prevention of Initiation and Propagation of Fires. *Revue de l'Industrie Minérale.* Vol. 38, No. 649, Dec., 1956, pp. 760-762.

Results of experiments conducted at Rescue Station of Essen with air ducts and portable air conditioners, one of which caused underground fire. [In French]

262. ANON. Protection and Means of Combatting Mine Fires. *Annales des Mines de Belgique.* Vol. 56, No. 3, Mar., 1957, pp. 193-232.

Statistics on fires in coal mines of Ruhr Basin; equipment for fighting fire with water, fire extinguishers, spreading foam, installation of fireproof zones, and suppression of fire by cutting off air supply; fireproof clothes, masks, and mine rescue service. [In French]

263. GRUMBRECHT, K. Some New Ideas on Efficiency of Fire Extinguishing Powders in Combatting Mine Fires. *Revue de l'Industrie Minérale.* Vol. 38, No. 649, Dec., 1956, pp. 757-759.

[In French]

264. POLACK, S.P. Research on Method of Testing Fire Resistance of Conveyor Belts. *Revue de l'Industrie Minérale.* Vol. 38, No. 649, Dec., 1956, pp. 789-796.

[In French]

265. COWARD, H.F. Research on Spontaneous Combustion of Coal in Mines, Review. *Great Britain. Safety in Mines Research Establishment.* Report, No. 142, Sept., 1957, 80 p.

Sources of spontaneous heating in coal; rates of oxidation of various coals and of their components;

chemistry of oxidation of coal at mine temperatures; laboratory methods of comparing inflammabilities of coals; experimental gob fires; recognition of incipient heatings in mines; prevention of heatings in mines; suppression of heatings and reopening of sealed-off areas.

266. WILLETT, H.L. Spontaneous Combustion in Yorkshire Coalfield. *Colliery Guardian.* Vol. 195, No. 5036, Sept. 5, 1957, pp. 281-287.

Incidence of spontaneous combustion; early theories on spontaneous combustion due to oxidation of coal; variation in characteristics of Barnsley seam and variations of strata above; influence of Dunsil seam; mining factors, means of detecting spontaneous combustion, and methods of treating heatings.

267. PARISI, C.W. Fire-Fighting Equipment in Modern Coal Mining. *Coal Mining Institute of America.* Proceedings, Dec., 1956, pp. 93-100.

Fire drills for all sectional men as well as all key personnel should be conducted in working sections of mine, primarily to train men in proper procedure to follow in event of fire in their section and include use of all available fire fighting units in extinguishing mock fire; three case histories considered.

268. COLES, G. and POTTER, N.M. Inflatable Air Seals for Mine Roadways. *Colliery Guardian.* Vol. 196, No. 5059, Feb. 13, 1958, pp. 187-190.

Stoppings are erected in mine workings to prevent access of air to fire or heating, provide explosionproof barrier, minimize changes in composition of atmosphere, control degassing of sections of mine workings, seal off abandoned workings, and to effect temporary diversion of ventilation; development and applications of inflatable stopping.

269. WHITTAKER, J.S. Mine Fire Hazards and Fire Fighting Equipment. *Mining Congress Journal.* Vol. 44, No. 4, Apr., 1958, pp. 81-82.

Preventing occurrence of fires, maintenance of equipment, training of employees, and procedures employed; development and use of a-c equipment from fire standpoint.

270. LONG, V.D. and MURRAY, W.L. Theoretical Considerations of Pre-Reaction Zone of Coal-Dust Flame. *Great Britain. Safety in Mines Research Establishment.* Report No. 145, July, 1958, 32 p.

Heat transfer processes involved in pre-reaction zone of stationary, laminar, premixed, coal dust flame and conditions which are necessary for establishment of temperature homogeneity between dust and surrounding air, in contradistinction to gas flames; importance of radiation is demonstrated.

271. CAW, J.M. Control of Air Pressures as Aid to Fight Mine Fires. *Institution of Mining & Metallurgy.* Transactions, Vol. 66, Pt. 8, No. 606, 1956-57, pp. 377-400, Vol. 67, Pt. 3, No. 613, 1957-58, pp. 115-126.

Behavior of pressures measured across mine fire seals and use to which these can be put; cheap and effective method of improving seals by reducing pressure across them requires erection of additional seal in front of one (or group) to be improved, to form chamber; air pressure within chamber is then adjusted artificially to approach that of fire zone.

272. HALLER, F.J. and MICHELS, F.G. Fighting Mine Fires with CO_2. *Mining Congress Journal.* Vol. 43, No. 11, Nov., 1957, pp. 53-55.

Use of carbon dioxide gas in conjunction with carbon dioxide as dry ice permitted almost immediate control and extinguishing of fire at Michigan iron mine.

273. BENT, H.C. Fire Prevention at Noranda Mines. *Canadian Mining Journal.* Vol. 78, No. 9, Sept., 1957, pp. 114-120.

Fires are caused by explosions of dust arising from blasting of heavy pyrites, oxidation of ore and backfill, electric failures, burning, and welding operations; preventive measures; fire fighting methods and equipment; safety of working force.

274. THOUSEAU, G. Study of Inflammability of High-Volatile Coal from Provence. *Revue de l'Industrie Minérale.* Vol. 41, No. 4, Apr., 1959, pp. 364-372.

Study of inflammability of high-volatile coal from Provence with igniter and in large heading; coal contains 40% of volatile matter; its inflammability was compared with coal containing 14-16% volatile matter; part played by combustion of volatile matter, and influence of fineness of dust are not same as during test in large gallery. [In French]

275. LINACRE, E.T. Practical Aspects of Foam-Plug Method of Fighting Large Mine-Airway Fires. *Great Britain. Safety in Mines Research Establishment.* Report No. 171, Feb., 1959, 24 p.

Mass of light foam is created at net stretched across roadway on upwind side of fire; foam is formed by mine ventilation from foam agent solution which is sprayed over net; ventilation moves foam to fire, where water contained in foam cools and reduces fire zone.

276. PATERSON, D.T. Recovery Work at Michael Colliery. *Iron & Coal Trades Review.* Vol. 178, No. 4732, Jan. 30, 1959, pp. 251-259.

Procedure of sealing off and subsequent recovery operations undertaken at coal mine in Great Britain resulting from fire caused by ignition from conveyor belt.

277. COULSHED, A.J.G. Some Aspects of Fire Seals. *Iron & Coal Trades Review.* Vol. 178, No. 4730, Jan. 16, 1959, pp. 155-158.

Technical aspects of building fire seals, with some practical notes for guidance on construction of good quality seals; adoption of fire seal, incorporating use of pressure chamber to effectively balance differences in ventilating pressure between intake and return is proposed.

278. CLARKE, W. Spontaneous Heating at Roslin Colliery. *Iron & Coal Trades Review.* Vol. 179, No. 4760, Oct. 9, 1959, p. 519.

Usual procedure adopted when spontaneous combustion occurs in coal seam is to isolate area; in instance cited, where fire in highly inclined working is approaching closer to winding shafts, attempt has been made to isolate shafts from fire; some factors that influenced subsequent sealing off measures.

279. LECLERCQ, J., FIEVEZ, V. and DEGEYTER, O. Ignition of Oil Due to Damage of Electric Cables. *Annales des Mines de Belgique.* No. 1, Jan. 2, 1959, pp. 56-77.

Influence of heat on ignition of oil; influence of shock pressure; esperiments in combatting fire caused by ignition of oil. [In French]

280. FORDER, A.L.A. and DEACON, D.D. Notes on Underground Fire at Rand Leases: Dec., 1956. *Association of Mine Managers of South Africa.* Papers & Discussions, 1956-1957-1958, pp. 535-559.

Elements of organization, administration and delegation of responsibility that were found necessary in coping with outbreak; mining layout and methods, occurrence and preliminary action in fighting fire itself, and *observations on conduct of fire-fighting operations; most serious handicaps in fighting fire were steep dips and narrow slope widths in old area; fire burnt out area of 800,000 sq. ft.*

281. BURT, H. and LAWRIE, J. Dealing with Underground Fire at Argyll Colliery. *Colliery Guardian.* Vol. 199, No. 5148, 5149, Dec. 17, 1959, pp. 593-598, Dec. 24, pp. 623-628.

Method of working, ventilation, and pumping; details of underground fire and fighting action; choice of sites and construction of seals; materials used for construction of seals.

282. FURUYA, T. Studies on Spontaneous Underground Combustion of Coal. *Revue de l'Industrie Minérale.* Vol. 42, No. 10, Oct., 1960, pp. 820-830.

Experience in Japan suggests that incidence of spontaneous combustion increases with greater depth in mining operations; plastic film found effective in preventing air leakage across waste; detection of gas content and temperature uses; experimentation on oxidation of coal. [In French with English summary]

283. LINACRE, E.T. Formation and Movement of Foam Plugs for Mine Firefighting. *Great Britain. Safety in Mines Research Establishment.* Report No. 182, Aug., 1959, 47 p.

There is upper airspeed limit for adequate filling of roadway with foam, limit being 300 fpm for one net design; spraying rate is of secondary importance in ensuring adequate filling, as long as volume ratio of airflow and sprayed water is no more than critical amount, found to be 2000 in one set of conditions; foam did not move satisfactorily in roadways rising more steeply than 1 in 10 or dipping more steeply than 1 in 5.

284. LINACRE, E.T. and JONES, D.H. Heat-Protection of Timber by Silicate-Based Coatings. *Great Britain. Safety in Mines Research Establishment.* Report No. 178, Nov., 1959, 18 p.

Procedure for assessing heat protection conferred on timber by compounds of sodium silicate, limestone dust, and sand, in conditions resembling those in large mine roadway fire; heat protection provided was little affected by omitting sand from coating compound or varying amount of moisture in timber and coating; coating provided useful protection of specimen boards in experimental fire.

285. RAE, D. Ignition of Gas by Impact of Light Alloys on Oxide-Coated Surfaces. *Great Britain. Safety in Mines Research Establishment.* Report No. 177, Nov., 1959, 37 p.

Ignition probability from impact of alloy-capped cylinder of given mass depends mainly on height from which it is allowed to fall freely; relative incendivities of different alloys are compared by comparison of heights of fall which, for specified mass, give 50% ignitions; titanium gives gas ignitions as readily as magnesium, but sparking phenomena are different.

286. BARNARD, W.O., Jr. Mine Fires in Northern West Virginia. *Mining Congress Journal.* Vol. 46, No. 3, Mar., 1960, pp. 66-68.

Incidence of fires found to increase in last decade; major causes are electrical short circuit on equipment, falls on power lines, belt fires and gob lines or outcrop fires; most fires occur in Pittsburgh seam due to head coal situation; direct and indirect methods of fire fighting.

287. YACHMENEV, V.I. Some Factors Influencing Formation of Underground Fires. *Ugol.* Vol. 34, No. 9, Sept., 1959, pp. 53-55.

Problem of self-ignition of lignite in mines of Chelyabinsk basin; methods of mining are main factor contributing to fires; retreat system of mining is recommended as well as increase of rate of mining not less than two or three times, as means of reducing fire hazard. [In Russian]

288. ANON. Prevention of Accidents Due to Fires Underground in Coal Mines. *International Labor Office, Geneva.* 1959, 48 p.

General operating precautions for incombustible or fire resistant construction, combustible and flammable materials, machinery and plant, conveyor haulage, diesel locomotive haulage, cutting burners, welding appliances and blowlamps, and naked light mines, organization for prevention, detection and fighting of fires, provisions applicable to mines liable to spontaneous combustion.

289. NAGY, F., MURPHY, E.M. and MITCHELL, D.W. Controlling Fires in Mines with High-Expansion Foam. *Mining Engineering.* Vol. 12, No. 9, Sept., 1960, pp. 993-996.

Results of controlling experimental fires showed that high expansion foam containing at least 0.2 oz. of water per cu. ft. of foam is effective; ammonium lauryl sulphate has many desirable qualities as foaming agent; where heat, roof falls, and smoke prevent direct approach to fire, somewhat more involved procedure of using foam plug may be effective.

290. LITWINISZYN, J. Flows in Pipe Networks from Point of View of Theory of Random Processes. *Archiwum Mechaniki Stosowanej.* Vol. 11, No. 4, 1959, pp. 421-440.

Study of smoking process in network by means of probabilistic method based on Chapman-Kolmogozov equation; determination of degree of danger in connection with underground fires during which smoke appears in ventilation network of mine. [In English]

291. WEAVER, H.F. Analysis of Causes of Mine Fires and Ignitions. *Coal Age.* Vol. 65, No. 12, Dec., 1960, pp. 83-84.

Analysis by United States Bureau of Mines, indicate that of 209 ignitions investigated 35% were caused by electricity followed by sparks, explosives and open flame; of 395 underground fires investigated, 64% were caused by electricity followed by belt fires, spontaneous ignition, and explosives.

292. BYLO, Z. and RACHTAN, M. Autoxidation Effect as Method of Determining Liability of Coals to Spontaneous Ignition. *Academie Polonaise des Sciences.* Bulletin, Serie des Sciences Techniques. Vol. 9, No. 4, 1961, pp. 239-245.

Liability of coals to low temperature oxidation in mining conditions determined by reactivity to nitration with diluted HNO_3; prompt and precise determination of self inflammability by means of simplified and inexpensive apparatus.

293. CRIDDLE, S.J. CO/O_2 Ratio and Spontaneous Combustion. *Colliery Guardian.* Vol. 202, No. 5224, June 1, 1961, pp. 664-666.

To use CO/O_2 ratio as indication of temperature of oxidation, it is necessary to examine gases issuing from affected area before dilution; in case of sealed area where it is normal practice for sampling pipes to be placed in stoppings, air samples may be considered to be representative of gases issuing from heating; effect of lowering of ratio by dilution on detection of spontaneous combustion.

294. ANON. Control of Spontaneous Combustion in Mines. *Iron & Coal Trades Review.* Vol. 183, No. 4865, Oct. 12, 1961, pp. 785-788.

Development of polychloroprene latex as sealant included long-term storage and accelerated aging *tests and achievement of proper physical and spraying characteristics; material has good film forming properties and is non-inflammable; conditions and application of sealant under ordinary and emergency conditions; results of tests; leakage through ventilation doors, surface airlocks, and aircrossings can be prevented by application of sealant.*

295. KITAGAWA, T. Detection of Incipient Underground Fires. *Revue de l'Industrie Minérale.* Vol. 43, No. 1, Jan., 1961, pp. 34-48.

CO detector tube for colorimetric process can be used to reveal contents of 10^{-3} *to* 10^{-4}*% carbon monoxide; it can also reveal traces of ethylene of* 10^{-4} *to* 10^{-5}*%.*

296. ANON. Developments in Sealing Mine Roadways. *Iron & Coal Trades Review.* Vol. 182, No. 4847, June 9, 1961, pp. 1233-1234.

Synthetic rubber spray, of chloroprene group, has been developed as sealing fluid; sealant can be applied with splatter spray of type used for applying under-body seal to car; film has air-retaining properties roughly equal to those of natural rubber inner tube of car; plastic inflatable seal has been developed to reduce flow of air into fire area.

297. PARISI, C.W. Fighting Fire with Foam at Montour No. 4 Mine. *Mining Engineering.* Vol. 13, No. 2, Feb., 1961, pp. 190-191.

Foam plug proved itself to be capable of controlling coal mine in western Pennsylvania; intermittent operation of foam fire generator enabled fire fighters to attack fire directly with water; use of foam generator during sealing operations permitted some seals to be constructed within 200 ft. of fire.

298. CAREY, B.W. Fighting Underground Mine Fires with Foam Producing Detergents. *Mining Congress Journal.* Vol. 47, No. 1, Jan., 1961, pp. 40-42.

Foam plug technique consists of filling mine entry or tunnel tight to back with soap bubbles; these bubbles are moved to fire area by mine ventilating air currents; when foam reaches fire area it tends to quench fire in four ways; it reduces volume of air feeding flames, cools fire area by evaporation, dilutes oxygen, and serves as radiation shield.

299. ANON. Fire-Resistant Fluids...What 100% Users Have Found. *Coal Age.* Vol. 66, No. 8, Aug., 1961, pp. 55-56, 58.

Based on mine experience with emulsion-type fire resistant hydraulic fluid, operators report that fluids give equal or better production, no pump problems, lower consumption of hydraulic fluid and lower cost of fluid per ton; little or no water need be added to systems, hydraulic system should be free of suction-line leaks and dirt; no hydraulic system should be operated at 200 F.

300. BYLO, Z., and RACHTAN, M. Nitration Ability as Characteristic Distinguishing Self-Inflammable Coals from Those Non-Liable to Spontaneous Ignition. *Academic Polonaise des Sciences.* Bulletin. Series des Sciences Techniques. Vol. 8, No. 7, 1960, pp. 391-398.

Coals with tendency to spontaneous ignition react with dilute HNO_3 *identically as sulphocoals; ability to nitration reaction may be utilized for determination of self-ignition indexes; nitration product can be quantitatively determined by thermal, photometric and polarographic method.*

301. RAUK, J., DZIUNIKOWSKI, K. and LABUS, H. New Agent in Active Firefighting. *Przeglad Gorniczy.* Vol. 16, No. 10, Oct., 1960, pp. 487-494.

Experiments with extinguishing fire using water-glass; waterglass spray forms at 170 C foam on surface of burning material which prevents supply of oxygen; no steam is formed which usually impairs visibility. [In Polish]

302. MATUSZEWSKI, J. Operations in Case of Fire in Intake Ventilation Shaft. *Przeglad Gorniczy.* Vol. 16, No. 5, May, 1960, pp. 244-251.

Possibility of reversing ventilation and examples of systems designed to combat underground fire, depending on number of air intake shafts. [In Polish]

303. BYLO, Z. and RACHTAN, M. Role of Sulphonic Groups in Formation of Catalysts of Spontaneous Ignition of Coals. *Academie Polonaise des Sciences.* Bulletin. Series des Sciences Techniques. Vol. 8, No. 8, 1960, pp. 467-475.

Presence of sulphonic compounds leads, in oxidizing medium, to formation of polyphenolredoxy systems, which catalyze process of self-heating of coals.

304. ANON. What You Can Expect from Fire-Resistant Fluids. *Coal Age.* Vol. 66, No. 6, June, 1961, pp. 98-99.

Present status of water-in-oil emulsions used in underground machinery equipped with hydraulic power; future possibilities; operating and economic advantages or disadvantages; shipping procedures; emulsion types and costs.

305. BYLO, Z. Problem of Pyrite and Sulphonic Group in Process of Self-Ignition of Coals. *Archiwum Gornictwa.* Vol. 5, No. 1, 1960, pp. 99-115.

Formation of sulphuric acid causes sulphonation of coals making them more or less inclined to spontaneous ignition. [In Polish]

306. GRUMBRECHT, K. and BOTH, W. State of Further Development of Underground Fire Extinguishers. *Glueckauf*. Vol. 96, No. 23, Nov. 5, 1960, pp. 1461-1467.

Experiments with 80 kg fire extinguisher and portable extinguishers using new kind of extinguishing powder, adequate for fighting glowing and open flames; requirements for construction and testing of 10 kg powder fire extinguisher. [In German]

307. KRAJ, W. Determination of Optimum Distribution of Probability for Appearance of Smoke Source in Ventilation Network. *Academie Polonaise des Sciences*. Bulletin, Series des Sciences Techniques. Vol. 9, No. 10, 1961, pp. 581-586.

Computation method for determination of probability of safety concerning appearance of smoke source in case of known relative imminence of fire in ventilation network; practical applications to safety problems in mines.

308. SOBKO, V.A., SMIRNOV, V.N. and CHESNOKOV, N.I. Experience with Use of Mass Caving Method Under Conditions of Self-Igniting Ore and Enclosing Rocks. *Gornyl Zhurnal*. Vol. 136, No. 7, July, 1960, pp. 31-36.

Mineralized and barren cherty-carbonaceous rocks are able to ignite within time period of 70 to 100 days; self-ignition is prevented by independent ventilation of caved-in blocks and by sprinkling with water of areas where heat is generated. [In Russian]

309. MUZYCZUK, J. Accurate Determination of Amount of Carbon Monoxide in Mine Air. *Archiwum Gornictwa*. Vol. 7, No. 2, 1962, pp. 201-211.

Accurate determination of amount of carbon monoxide in mine air is means of early detection of underground fires of endogenetic nature; equipment and method for determination of concentrations of between 4×10^{-4} *to* 5×10^{-2} *vol %.* [In Polish with German summary]

310. ANON. Gob Fires...Control or Extinguishment. *Coal Age.* Vol. 67, No. 4, Apr., 1962, pp. 118-122.

Localized spontaneous heating in Illinois coal mine has occurred in areas where gob has been less than 2 yr. old; geological chemical and physical factors favorable for occurrences of hot spots, criteria for recognizing spontaneous heating and heating control; studies on coal oxidation and spontaneous combustion.

311. AJTAY, Z. and CSABAY, A. Means and Method of Sensing and Control of Incipient Mine Fires Using Electric Equipment. *Hungarian Research Institute for Mining.* Publication 3-4, 1959-60, pp. 135-139.

Design and underground installation of thermistors; suggestions concerning practical utilization of thermistors. [In German]

312. RESKA, P. Investigation of Tendency of Coal to Self-Ignition in Lignite Mine. *Berg- und Huettenmaennische Monatshefte.* Vol. 107, No. 3, Mar., 1962, pp. 49-53.

Study of problem is supported by microscopic examination, and is examined from physical-chemical, and mining engineering points of view. [In German]

313. SOBKO, V.A., PEPELEV, G.I., DOROSHENKO, V.M., CHERNORUTSKII, E.T., and NOVIKOV, K.P. Improved Variance of Combined System of Mining Thick Deposits of Self-Igniting Ores. *Gornyl Zhurnal.* No. 2, Feb., 1962, pp. 13-17.

Underground fire hazard is reduced by introduction of block-caving; height of blocks equals thickness of ore body; new system replaces sublevel stoping and slicing; mineralization is associated with zones of fracturing in carbonaceous and cherty slates. [In Polish]

314. JONES, C.R.L. Aspects of Fire Prevention in Main Airways. *Mining Engineer.* No. 30, Mar., 1963, pp. 496-504.

Thermal conditions which might occur in fire in main roadway are examined in terms of thermal conditions of Brit. Standard 476 - Surface Spread of Flame Test; deductions are made regarding standard of impregnation coverboards by which their use would not add to any danger of poisoning arising from advent of source of fire.

315. LASEK, T. and BYSTRON, H. Combating Fires in Polish Coal Mines. *Berg- und Huettenmaennische Monatshefte.* Vol. 108, No. 8, Aug., 1963, pp. 314-322.

Characteristics of endogenetic and exogenetic fires; statistics on types of fires in Polish coal mines during period between 1947 and 1962; protection of personnel from fire. [In German]

316. ANON. Control of Spontaneous Heatings Underground by Latex Sealants. *Mining Journal.* Vol. 259, No. 6621, July 13, 1962, p. 35, 37.

Developments in Czechoslovakia and Great Britain in use of latex sealants for control and treatment of spontaneous underground heatings; high speed insulation method utilizes light metal fabric which is strung across whole width of roadway; neoprene is sprayed on screen; inflatable membrane developed in Great Britain is light in weight, easily manageable, and capable of being erected in 5-10 min. by team of 4 men; laminate of polyvinyl chloride and woven-glass fiber was selected.

317. BUDZAK, P.M. and EADIE, G.R. Controlling Mine Gob Fires. *Mining Congress Journal.* Vol. 48, No. 7, July, 1962, pp. 39-42.

Orient No. 3 mine in Jefferson County, IL, has experienced several instances of spontaneous heating; indications of heating in gob include haze, moisture *condensation, bituminous odor and presence of CO in airways; 7 of areas where spontaneous heating has occurred have been controlled by sealing with masonry stoppings and flooding with carbon dioxide; literature review on causes of "hot spots"; results of chemical and physical analyses of Orient coal. 17 refs.*

318. BOTH, W. Early Detection of Underground Fires by Means of Meters. *Glueckauf.* Vol. 98, No. 24, Nov. 21, 1962, pp. 1406-1414.

Details of method using carbon monoxide detectors and experience with detection of open and concealed fires; recommendations concerned with installation and control of carbon monoxide recorders and affiliated alarm system. [In German]

319. BYSTRON, H. Depression of Main Fan During Fire in Ascending Flow of Air. *Przeglad Gorniczy.* Vol. 18, No. 2, Feb., 1962, pp. 113-122.

Theory of phenomenon of fire based on Budryk's system of ventilation circuit with emphasis on lateral inflow of air; effect of barriers on ventilation circuit during fires. [In Polish]

320. MUELLER, E. Reduction of Fire Hazard, Breakdowns, and Wear of Band by Controlling Tension in Underground Conveyors. *Bergbauwissenschaften.* Vol. 10, No. 17-18, Sept. 25, 1963, pp. 409-417.

Formulas are derived for calculation of initial tension by combination of laws for rope friction and for expansion of textile belts; absolute sliding safety when conveyor belt is locked fast, sliding safety when upper belt is locked fast, and sliding when starting conveyor; comparison of screw belt tightener and gravity belt tightener; diagram for final temperatures by sliding of belt. [In German]

321. CHAKRABORTY, R.N., ALI, H., and BAGCHI, S. Disappearance of Carbon Monoxide in Coal Mines. *Journal of Mines, Metals, & Fuels.* Vol. 10, No. 11, Nov., 1962, pp. 7-10, 30.

Investigation of 2 Indian coals of different rank shows that cause for CO disappearance should be attributed to bacterial action and not to chemical action; bacteria which live on CO are fairly stable and found everywhere; unless these bacteria are killed by some sterilizing agent, they can multiply and thrive over coal surface for years; CO as indicator of underground fire can disappear quite fast if mine is wet and suitable for growth and preservation of such bacteria.

322. LINACRE, E.T. and RHODES, A.C. Extinction of Experimental Fires with Foam Plugs. *Great Britain. Safety in Mines Research Establishment.* Report 213, Feb., 1963, 36 p.

Foam plug method of firefighting has been studied using 9 fires, of up to 2½ tons of wood, in ventilated tunnel; in each fire, observations were made of extent of visible combustion, fire temperatures and fume composition, during extinction of fire by foam plug; effectiveness of foam plugs in extinguishing fires depends particularly on pattern and material of fire, and degree to which foam fills roadway.

323. ANON. Extinguishing Agents for Fire-Fighting Today. *Coal Age.* Vol. 68, No. 12, Dec., 1963, pp. 94-95, 97.

Development of such dry-chemical extinguishing agents as potassium bicarbonate-base and monoammonium phosphate and improved equipment for discharging them onto fires; one of novel uses of dry-chemical fire equipment in coal mines is installation of new low-cost automatic sodium bicarbonate-base dry-chemical system over number of hydraulic car spotters; automatic system consists of 30 lb. sodium bicarbonate-base dry-chemical extinguisher mounted over pump and motor of spotter.

324. ANON. Fernhill Colliery Fire - Nitrogen Used for First Time Underground. *Colliery Engineering.* Vol. 40, No. 471, May, 1963, pp. 190-191.

Nitrogen was used to control fire in coal mine in Wales; more than 2550 tons of liquid nitrogen - 85 million cu. ft. of free gas - were delivered in 1150 loads; within few days of installation flow reached 60,000 cu. ft./hr. and was maintained throughout emergency; to get nitrogen to seat of fire, use was made of existing air pipeline.

325. ANON. Fire, Explosions and Recovery, Federal No. 1 Mine. *Coal Age.* Vol. 68, No. 11, Nov., 1963, pp. 78-85, 92-95.

Fire was discovered in West Virginia mine on Dec. 25, 1962, and was followed by number of explosions; mine was recovered and returned to production Sept. 3, 1963, covering 18,000 acres and averaging 8500 tpd of Pittsburgh coal, operation was served by 7 active shafts; recovery included initial attempt to seal workings abandoned as result of explosions, after which it was decided to seal on surface; new sealing technique, using mineral rock wool placed through boreholes was adopted as method of sealing off workings.

326. ANON. Fire-Resistant Fluids Survey No. 2. *Coal Age.* Vol. 68, No. 8, Aug., 1963, pp. 59-61.

1963 survey reveals that more education is needed, that standard hydraulic systems must be redesigned to be compatible with fire-resistant fluids, that temperature and filtering are among major operating problems, and that new equipment warranties do not recognize fire-resistant fluids as acceptable hydraulic fluid; fire-resistant fluids can and should be used because of their inherent safety features; list of fire-resistant fluid manufacturers.

327. CHAKRABORTY, R.N. and BAGCHI, S. Interpretation of Gas Analysis Results for Reopening Sealed-Off District and Detecting Spontaneous Heating. *Journal of Mines, Metals, & Fuels.* Vol. 10, No. 4, Apr., 1962, pp. 8-10.

Procedures for reopening district sealed off due to fire and detection of spontaneous heating; accurate analysis of carbon monoxide and oxygen contents can be of great value in detecting heating in coal mine at very early stage.

328. GREGOIRE, M. and THIMUS, A. Fire Dams. *Annales des Mines de Belgique.* No. 11, Nov., 1962, pp. 1133-1138.

Purpose of dams and isolation from fire; purpose and means of taking samples of atmosphere; selection of dam site; construction of dams in gassy and non-gassy environment; technique of opening and sealing dams; construction of dams in case of emergency.

329. STENUIT, R. Combating Underground Fires in Poland. *Annales des Mines de Belgique.* No. 4, Apr., 1963, pp. 447-458.

Experience with placing partitions and auxiliary ventilators to ensure stability of ventilation in case of underground fire in cases of rising, descending, diagonal or dependent air currents; principle of method of balance of fire pressures by means of auxiliary ventilator. From document No. 344 published by Polish National Institute of Mines, in May, 2962. [In French]

330. KOZDROJ, M. Method of Determining Indices of Fire Hazard in Coal Mines. *Przeglad Gorniczy.* Vol. 18, No. 12, Dec., 1962, pp. 709-712.

New suggested method is based on mathematical statistics; coal mines can be classified according to fire hazard and safety of miners. [In Polish]

331. KOROTKOV, Y.M., ALEKSEEV, I.S. and SURCOV, A.V. Experience With Suppression of Self-Heating in Fractured Coal Pillar Using Lime Slurry. *Ugol.* No. 12, 1962, pp. 35-36.

Coal bed is 3.6 m. thick and dips at 34°; pillar is 10 m. along strike and 25 m. down dip; self-heating of coal in pillar resulted in temperature increase to 35-42 C; after infusion of 5-10% lime slurry through 250 mm. diam. drill holes temperature reduced to 25-22 C. [In Russian]

332. LIU, C.T. Pressure Distribution on Cone in Transverse Air Flow. *Academic Polonaise des Sciences.* Bulletin. Series des Sciences Techniques. Vol. 10, No. 6, 1962, pp. 369-373. Plate.

Phenomenon of fires of coal dumps and waste heaps is connected with air filtration inside porous mass; this depends on air flow past cone shaped coal dump; investigation of pressure distribution produced by uniform steady-state air flow normal to axis of cone; experimental measurements carried out on model of waste heap with 120° apex angle in horizontal air current.

333. BEZHETSKII, A.E. Perfection of Measures Designed to Prevent and Combat Underground Breeding Fires. *Ugol.* No. 11, Nov., 1962, pp. 46-48.

Prevention of underground fires by pumping slime slurry into goaf; pumping of carbon dioxide into abandoned workings is suggested; same method is designed to combat fires in Kuznetsk basin. [In Russian]

334. BYLO, Z. Spontaneous Ignition of Coals in Light of Studies in Model Systems. *Academic Polonaise des Sciences.* Bulletin, Series des Sciences Techniques, Vol. 10, No. 5, 1962, pp. 301-307.

In laboratory investigation influence of products of oxidation of pyrite admixtures on process of spontaneous *ignition of coals is becoming more and more evident; wet oxidation of pyrite is considered of high importance; reported experimental data seem to confirm assumption that sulfuric acid and ferrous sulfate enhance inflammability of coals under natural conditions.*

335. LLEWELLYN, D.J. and EVANS, R.A. Steps Taken to Seal Off and Re-Open District After Fire. *Mining Engineer.* Feb. 29, 1963, pp. 427-438.

Measures taken at Wyndham coal mine, England after ignition; procedure for sealing off and reopening; with use of methane drainage and monitoring system using wholly physical methods of analysis, reopening went according to plan; district, sealing off very large volume of gas, was cleared in 48 hr.

336. BYSTRON, H. Theory of Direction of Air Flow During Underground Fire. *Przeglad Gorniczy.* Vol. 18, No. 4, Apr., 1962, pp. 214-236.

Phenomena accompanying descending or ascending ventilation using blast fan or exhaust fan are analyzed; new criteria for calculations of ventilation circuit are suggested. [In Polish]

337. BYSTRON, H. Effect of Specific Gravity of Mine Air on Direction of Flow in Ventilation Circuits. *Przeglad Gorniczy.* Vol. 18, No. 11, Nov., 1962, pp. 627-644.

Dependence of specific gravity of air on distance from underground fire, and rate of air flow on volume of air flowing per unit of time. [In Polish]

338. KRUPINSKI, B. Effect of Layout of Mine. *Archiwum Gornictwa.* Vol. 7, No. 3, 1962, pp. 227-241.

Weekly output of coal mine is 7000 tons; number of employees is 6200, including 4500 people working underground; analysis of events accompanying underground fire and recommendations to improve situation and layout of underground workings. [In Polish with German summary]

339. DREKOFF, K. Determination of Explosibility of Gases Generated by Underground Fire. *Bergbau-Archiv.* Vol. 24, No. 1, Mar., 1963, pp. 35-47.

Explosive gases consist of variable amount of combustible component, air, and nitrogen; method of determining characteristic values of explosibility when composition of gas is known. [In German]

340. NAKANO, K., ISHIHAMA, W., MATSUKUMA, K., IWASAKI, T., and NABEYA, H. On Control of Mine Fire with High-Expansion Foam Plugs. *Mining & Metallurgical Institute of Japan.* Journal, Vol. 79, No. 895, Jan., 1963, pp. 1-4.

Studies of high expansion-foam plugs show that conversion efficiency is only slightly affected by spraying rate; conversion efficiency is reduced by unduly low air speed, but in small model roadway condition it would normally be 70%; effect of air speed on wetness of foam plug. [In Japanese]

341. MICHAEL, D.H. Fire Resistant Fluids. *West Virginia Coal Mining Institute.* Proceedings, 1962, pp. 92-101.

Water-in-oil emulsions are fire resistant, have lower operating temperatures, promote more efficient pump operation and can be used in mining coal more efficiently at lower cost; they are less efficient than conventional oils under conditions of high temperatures, excessive dirt and air leaks; advantages and disadvantages of buying emulsions as concentrate and in premixed state; differences between typical chemical emulsion and mechanical type emulsion with respect to inversion, water separation, viscosity characteristics, leakage characteristics, water content, cost and wear.

342. ANON. Safety in Mines Research, 1962. *Great Britain. Safety in Mines Research Establishment.* Annual Report, 1963, 72 p.

Development in fields of explosives and blasting devices, explosion hazard, fire hazard, investigation of mining incidents, rescue apparatuses, dust measurement and pneumoconiosis hazard, engineering and metallurgical research, examination of mine equipment, and testing services.

343. DARLOW, A.E. and BALDRY, T. Controlling and Preventing Outbreaks of Spontaneous Combustion. *Colliery Guardian.* Vol. 209, No. 5385, July 3, 1964, pp. 22-24.

Development of method using hardstem, processed form of gypsum to control frequent roadside fires at Arley coal mine, Great Britain by isolating cavity; hardstem is available with various setting times; mechanical mixing tank was developed for continuous mixing at rate of 6 bags of hardstem to 8 gal. of water; development of method for preparing foaming cement and foaming hardstem.

344. HODGES, D.J. and HINSLEY, F.B. Influence of Moisture on Spontaneous Heating of Coal. *Mining Engineer.* No. 40, Jan., 1964, pp. 211-224.

Laboratory experiments have shown that there are 2 important sources of moisture which must be considered; these are moisture associated with oxygen or air and inherent moisture in coal; some of coals tested fired spontaneously in stream of moist oxygen under conditions of heat transfer resembling those found in practice; importance of moisture in percolating gases is shown by experimental results.

345. BYSTRON, H. Depression of Principal Fan at Time of Fire in Ascending Air Current. *Annales des Mines de Belgique.* No. 5, May, 1963, pp. 602-613.

During mine fire which lasted over one year, author checked personal theory derived from Budryk's *fundamental equation demonstrating possibility to reduce lowering of pressure of main fan if dam of very high resistance has previously been constructed at entrance of fire channel; theory and its application confirm Budryk's fundamental principle.* [In French]

346. BUECHER, H. Open Mine Fires Due to Ignition and Recommendations for Their Prevention. *Glueckauf.* Vol. 100, No. 16, July 29, 1964, pp. 968-977.

Characteristics and magnitude of open mine fires; causes of ignition and their frequency; underground sites where fire presents most hazards; examples of underground fires and measures for prevention of fires. [In German]

347. HODGES, D.J. Spontaneous Combustion. *Colliery Guardian.* Vol. 207, No. 5354, Nov. 28, 1963, pp. 678-682.

Series of laboratory tests were designed to investigate importance of inherent moisture of coal, and humidity of air, on spontaneous heating; it is mutually supplementing effects of these 2 factors which may lead to development of suitable conditions for occurrence of spontaneous combustion; humidity of air entering heating must have important effect on its development especially in initial stages; cooling will take place if water vapor pressure in air is less than that at coal surface.

348. BRACHT, G. and GEBERT, F. Determination of Small Amounts of Hydrogen in Gases Produced During Mine Fires. *Bergbau-Archiv.* Vol. 25, No. 3, June, 1964, pp. 61-62.

Study of ignition limits for methane and hydrogen-air mixtures; design of apparatus for determining amount of hydrogen in underground atmosphere generated by fire. [In German]

349. VAUGHAN-THOMAS, T. Use of Nitrogen in Controlling Underground Fire at Fernhill Colliery. *Mining Engineer.* No. 42, Mar., 1964, pp. 311-336.

Following unsuccessful attempt to control fire at Fernhill mine, Great Britain, by sealing area, nitrogen was introduced by means of existing pipe column into fire heading; explosibility of atmosphere behind seal was controlled; recovery operations are described in 2 phases; use of nitrogen gas assisted materially in control of fire, made recovery operations safer and enabled production of coal to continue while fire was being sealed off.

350. BYSTRON, H. Notes Concerning Problems of Underground Fire in Ascending Current of Air. *Przeglad Gorniczy.* Vol. 19, No. 3, Mar., 1963, pp. 122-125.

Notes concerning problems of underground fire in ascending current of air; critical aspects of problem of stopping fan during underground fire and effect of stopping on combatting fire. [In Polish]

351. RYMARSKI, W. Effect of Preparatory Workings and Productive Workings on Starting Endogenetic Fires. *Przeglad Gorniczy.* Vol. 19, No. 7-8, July-Aug., 1963, pp. 278-284.

Analysis of causes of mine fires in 1952-1961 in 10 mines of Dabrowa basin; methods are suggested to prevent underground fires. [In Polish]

352. KRUPINSKI, B. Effect of Mine Layout on Fire Hazard from Standpoint of Analyzing Causes of Fire at Makoszowy Mine. *Przeglad Gorniczy.* Vol. 19, No. 3, Mar., 1963, pp. 103-109.

Details on underground fire are examined and conclusion is made that greatest error was in using very long escapeways, driving cross-cuts at various levels, and not appropriate layout of mining operations. [In Polish]

353. JARON, S., KRUK, F., OLPINSKI, W. and WOLNA, M. Results of Testing Ionization Sensing Element for Early Detection of Exogenetic Fires. *Biuletyn Glownego Instytutu Gornictwa.* (Supp. to *Przeglad Gorniczy*, Vol. 19, May, 1963). No. 1, 1963, pp. 1-6.

Testing of apparatus under laboratory conditions; testing of sensing elements in ventilation ducts at various velocities of air flow and testing of sensing elements underground. [In Polish]

354. MACIEJASZ, Z. Stopping of Fan During Underground Fire. *Przeglad Gorniczy.* Vol. 19, No. 3, Mar., 1963 (received Nov., 1963). pp. 113-122.

Conditions requiring stopping or reducing speed of fan during underground fires are examined along with cases when such stopping resulted in complications in ventilation system; cases when stopping is required; characteristics of fires in ascending and descending flows of ventilation air. [In Polish]

355. ANON. Foam Generator For Fighting Underground Fires. *Mining & Chemical Engineering Review.* Vol. 56, No. 3, Dec. 16, 1963, pp. 33-34.

Foam generator has been developed to provide source of water for fighting fires underground; high-expansion foam has 4-fold effect on fire; 3.1% solution of detergent in water is supplied to generator at rate of 75 gpm; it is sprayed on 1/8 in. mesh cotton fabric screen, through which air is blown at rate of 12-15,000 cfm, using 4 compressed-air operated fans; within 8 min. foam generator will push foam 800 ft. along level 9 ft. by 8 ft. drive.

356. CZAN-MIN, J. Instable Air-Flow in Mine Ventilation Network during Underground Fires. *Academic Polonaise des Sciences.* Bulletin, Series des Sciences Techniques, Vol. 11, No. 9, 1963, pp. 519-524.

Analysis of underground fires shows that most victims succumb to toxic gases carried by air flows in aspiratory shafts or in ducts of fresh air; thus, investigations on air flows in mines during underground fires are of utmost importance for work safety; instable air flow in nonramified duct with varying cross-section and inclination investigated.

357. ROSZKOWSKI, J. Analysis of Effect of Some Mining Engineering Factors on Possibility of Spontaneous Fires in Coal Mines. *Archiwum Gornictwa.* Vol. 8, No. 4, 1963, pp. 367-380.

Index of fire frequency in given coal seam is derived; using this index, studies were performed on effect of mining factors on frequency in occurrence of underground fires; statistical analysis of effect of fan depression on spontaneous fires and effect of coal bed thickness and level at which mining operations are conducted on fires in coal mines. [In Polish with Russian and German summaries]

358. HOFBAUER, I. and SEBOR, G. Application of Chemistry to Safety in Mines. *International Mining Congress.* 3rd, Salzburg, Austria, 1963.

Experience with chemical means of combating and preventing fires in coal mines of Czechoslovakia; this includes injection of calcium chloride with clay into deep drill-holes, coating of timber with sodium silicate and clay paste, use of fire extinguishers spraying sodium silicate and calcium chloride solutions, spraying rubber latex for sealing off air vents, and construction of nitrogen filled forebays in front of fire barriers; asphalt and rubber mixtures are used for waterproofing.

359. TOKARSKI, Z. and BIALEK, S. Mining of Coal Bed 302 in Coal Mine Komuna Paryska Below Coal Bed 301 in Which Underground Fire Developed. *Przeglad Gorniczy.* Vol. 20, No. 6, June, 1964, pp. 276-282.

There is a possibility to mine coal under conditions of depressed ventilation with special attention to safety measures concerning lighting and control of air composition. [In Polish]

360. BREDENBRUCH, E. Essential Points in Prevention, Finding and Suppression of Fires in Coal Mines. *International Mining Congress.* 3rd, Salzburg, Austria, 1963.

West German experience with fires in coal mines with emphasis on factors promoting spontaneous combustion occurring during or after recovery of supports from abandoned workings, during roof falls in coal faces or running-out of coal, in case seam is not completely worked at points of disturbances, when coal is left in goaf, when there is clod mixed with small coal bands at certain distance from face in roof or accompanying bed at smaller distance from seam in roof, and when pillars are not mined.

361. WANG, T.S. First Industrial Trials of Fighting Underground Fires by Combustion Gases at Tchegan Colliery. *International Mining Congress.* 3rd, Salzburg, Austria, 1963.

Fire arose in June, 1959 on first working level of third seam at coal Mine No. 1 of Tchegan Div.; 100,000 cu. m. of combustion gases consisting of N_2 *and* CO_2 *were forced in, thus causing decrease of CO content to 0.03%; when rescue teams entered area of fire temperature of air was 21 C and no CO was discovered.*

362. ANON. How Osage No. 3 Fire Was Fought With Foam. *Coal Age.* Vol. 70, No. 7, July, 1965, pp. 96-98.

Foam made possible extinguishment of fire at Osage No. 3 mine, Christopher Coal Co., in probably record time for serious conflagration in Pittsburgh seam in northern West Virginia; fire was discovered at 6:15 PM, Apr. 27, 1965; mine was released for production at 1:04 AM, May 6; in meantime, foam generators had been efficiently deployed *to bring fire under control and to cool debris during loading-out phases; chronology of water and foam application and construction of foam-guiding installations.*

363. SINHA, K.N. Investigation on Mine Fire in Indian Mine. *International Mining Congress.* 3rd, Salzburg, Austria, 1963.

Fire in mine producing about 5000 tpd of coal was combated by sealing off entire area after attempts to fight fire by digging out with quenching isolation of fire area by temporary stoppings did not succeed; fire fighting operations included also flooding of mine which created additional problem of landslides.

364. ALEKSEEV, I.S. Suppression of Spontaneous Heating of Coal in Pillar by Infusion of Lime Milk. *Ugol.* No. 10, Oct., 1964, pp. 46-48.

Experience gained in Kuznetsk basin with infusion of lime milk resulted in decrease of temperature and carbon dioxide content in drill holes. [In Russian]

365. KOZDROJ, M. Distribution of Probabilities Concerning Number of Fires During Definite Time Interval. *Archiwum Gornictwa.* Vol. 8, No. 4, 1963, pp. 381-394.

Use of method based on mathematical statistics taking into account all factors affecting generation of fire; fire hazard in various mines is evaluated by comparison of definite probabilities; results of statistical studies during 6 yr. period in 8 coal mines where 2937 fires occurred; it is concluded that frequency in occurrence of underground fires mainly follows Poly principle which is complex version of Poisson process. [In Polish with Russian and German summaries]

366. CUDMORE, J.F. Spontaneous Combustion of Greta Seam - New South Wales. *Colliery Guardian.* Vol. 209, No. 5399, Oct. 9, 1964, pp. 487-489.

Spontaneous heatings are very prevalent in mines working thick Greta seam near Cessnock; infrared spectra showed presence of higher hydrocarbons in firestink; tests under adiabatic conditions revealed that evaporation of water plays vital role in process of spontaneous combustion; linear relationship between CO/O_2 percentage and temperature was established for Greta coal; by extrapolation close relationship was found between laboratory results and actual values for CO/O_2 percentage obtained by routine sampling and analysis of gases.

367. MACIEJASZ, Z. Early Detection of Endogenetic Fires as Demonstrated by Recent Studies and Practice in Polish Coal Mines. *Przeglad Gorniczy*. Vol. 20, No. 7-8, July-Aug., 1964, pp. 323-330.

Theoretical principles of early detection of fires by analyzing composition of air and by using hydrogen peroxide method; experience gained with underground use of these methods. [In Polish]

368. ROSZKOWSKI, J. Effect of Technical Factors on Generation of Spontaneous Underground Fires from Point of View of Statistical Studies. *Archiwum Gornictwa*. Vol. 8, No. 3, 1963 pp. 283-296.

Method of accumulating statistical data on underground fires and use of computer for analysis of these data; type of punched card suitable for recording data on underground fires. [In Polish]

369. PURSALL, B.R. and GHOSH, S.K. Early Detection of Spontaneous Heatings Using Chromatographic Gas Analysis. *Mining Engineer*. No. 57, June, 1965, pp. 511-526.

Use of integrating amplifier is illustrated; field study of nature of gases from mines affected by spontaneous heating, and illustrated by chromatograms, show that unsaturated hydrocarbons ethylene, propylene and acetylene are produced in that order as heating progresses in intensity and that appearance of each gas can be correlated with increase in CO/O_2 deficiency ratio above normal.

370. RATUSHKOV, M.I., MAEVSKAYA, V.M., RAPOTSEVICH, A.P. and LYURAI, L.L. Experience with Fighting Fires in Coal Mines by Means of Inert Gases. *Ugol.* No. 6, June, 1965, pp. 63-64.

Method consists in using gases generated by combustion of liquid fuel and containing not more than 1 to 2% oxygen; these gases are injected into area affected by underground fire; inert gases consist of 12.5 to 14% carbon dioxide, nitrogen, traces of carbon monoxide, and oxygen; this mixture of gases is generated in portable plant at rate of 500 cu. m./hr. [In Russian]

371. KUKUCZKA, A. Utilization of Neutralized Gases Generated by Fire for Acceleration of Underground Fire Extinguishing. *Przeglad Gorniczy.* Vol. 20, No. 9, Sept., 1964, pp. 428-431.

Method involves continuous flow of refrigerated neutralized gases through fire zone; physicochemical principles of method; calculation of necessary amount of gas and selection of neutral gas. [In Polish]

372. KUKUCZKA, A. Use of Damping Chambers to Accelerate Extinguishing of Underground Fires. *Przeglad Gorniczy.* Vol. 20, No. 12, Dec., 1964, pp. 596-599.

Chambers are installed between fire dams and are designed to equalize depression between intake and outlet fire dams, thus preventing progress of fire. [In Polish]

373. RANDALL, T.H. Pumpability of Fire-Resistant Hydraulic Fluids. *Coal Age.* Vol. 70, No. 9, Sept., 1965, pp. 100-104, 106.

Field experience indicates that fire protection fluids have different flow characteristics than petroleum oils and that low-temperature pumpability is critical with water-in-oil emulsions; tests of representative fire protection fluids show that primary property of these fluids affecting pumpability is viscosity of fluid as flowing in hydraulic system; pour point is not adequate *indicator of low-temperature pumpability of fire protection fluids; low-temperature pumpability is improved by reducing pump-inlet-system resistance.*

374. KUEHLTHAU, K.R. and NEIL, R.M. Rigid Foam for Ventilation Control. *Mining Congress Journal.* Vol. 51, No. 11, Nov., 1965, pp. 47-50.

Smoldering fires in caved footwall slates of three iron mines operated by Hanna Mining Co. can burn with as little as 5% oxygen in atmosphere; they can be controlled only by air sealing or filling with glacial surface material; urethane foam has been successfully used to obtain quickly placed, tight seal.

375. HULANICKI, S. and GLOWIAK, B. Method of Dynamic Self-Ignition Temperature Determination of Air-Dust Clouds. *Archiwum Gornictwa.* Vol. 11, No. 1, 1966, pp. 87-98.

Dynamic self-ignition temperature, in case of air-dust clouds, is not constant value but it is included between lower dynamic self-ignition temperature and upper dynamic self-ignition temperature; investigation of influence of dust concentration in cloud, of intensity of cloud flow, ash and water contents, as well as area of dust particles on dynamic self-ignition temperature. [In Polish with Russian and German summaries]

376. LARSH, R.J., ALSTON, G.L., and WILLIAMS, J.R. Three Ways to Fight Mine Fires. *Coal Age.* Vol. 72, No. 2, Feb., 1967, pp. 127-131.

Types, applications and uses of dry chemicals, high-expansion foams and low-expansion foams; emphasis is on selection of foam agents which are compatible with other fire-extinguishing agents, such as dry chemicals; it also is pointed out that coal companies should take advantage of engineering, technical services and chemical facilities of manufacturers of fire-protection equipment and agents.

377. ROBERTS, A.F. and KENNEDY, M. Modelling of Mine Roadway Fires. *Great Britain. Safety in Mines Research Establishment.* Report 239, Dec., 1965, 19 p.

Paper discusses propagation of fires along wood lining of mine roadway; propagation of such fires is studied experimentally by means of two small-scale ventilated ducts lined with refractory material; equations derived from heat conduction theory, which give approximate temperature distributions downwind of mine fires, are given; experimental data are compared with these theoretical temperature distributions; agreement is good.

378. BOTH, W. Experience With Carbon-Monoxide Recorders in Early Tracing of Fires in Underground Coal Mines. *Glueckauf.* Vol. 104, No. 3, Feb. 1, 1968, pp. 135-138.

Installation of CO-content recorders, equipped with automatic warning device, has helped West German coal mining industry in early tracing of fires; fires can start through friction of minute particles of coal, by spontaneous combustion of coal, or other reasons. [In German]

379. RUDENKO, K.P. Self-Ignition of Coals of Various Ranks in Donets Basin. *Izvestiya Vysshikh Uchebnykh Zavedenii, Gornyl Zhurnal.* No. 2, 1967, pp. 58-59.

Analysis of over 500 underground fires indicates that self-ignition depends on geological and mining factors and that metamorphic rank should not be used as criterion indicating degree of self-ignition hazard. [In Russian]

380. BYKOV, L.N., ZAKHAROV, E.I. and KLIMANOV, A.M. Dependence of Endogenetic Fires on Petrographic Composition of Coal Bed. *Izvestiya Vysshikh Uchebnykh Zavedenii, Gornyl Zhurnal.* No. 1, 1967, pp. 59-60.

Study of coal beds of Moscow basin reveals that clarain coal fractures more easily than coal of other petrographic types; fracturing makes easy access for oxygen to coal bed, thus increasing hazard of self-ignition. [In Russian]

381. VERMEULEN, C.G.J. Procedures in Case of Fire at Harmony Gold Mine. *Association of Mine Managers of South Africa.* Papers & Discussions, 1966-1967, pp. 39-67.

Detailed "Fire Procedure Manual" as set up by management of deep gold-, pyrites-, and uranium ore mine in South Africa.

382. WILDE, D.G. and ROBERTS, A.F. Fire-Retardant Coatings for Mine Timber. Effect of Coating Thickness. *Mining Engineering.* No. 99, Dec., 1968, pp. 123-130.

Fire risk in timbered mine roadways can be reduced by giving timber fire-retardant treatment; impregnation of timber by suitable salts provides best means of treatment, but surface coatings are only form of treatment that can be applied to standing timber; main variable affecting performance of coating, within control of user, is its thickness; it is recommended that, in mines, coatings of sodium silicate/limestone compound should be 1.02 mm (0.040 in.) thick if applied to hardwood and 3.2 mm. (0.125 in.) thick if applied to softwood.

383. JAMISON, W.B. Zeroing in on Mine-Fire Problem. *Coal Age.* Vol. 74, No. 4, Apr., 1969, pp. 104-112.

Coal-mine fires can be classified usefully as to types of fuel, origin and location; fuel may be coal, rubber, wood or other combustible material (only nonflammable hydraulic oils are permitted for underground use); electrical failures, causing arc, can start fires, so does spontaneous heating of coal; fire extinguishing agents are discussed and their effectiveness compared; protection techniques of attended and unattended equipment and fire fighting equipment are described; future trends in fire protection are discussed.

384. BHATTACLARYYA, K.K., HODGES, D.J. and HINSLEY, F.B. Influence of Humidity on Initial Stages of Spontaneous Heating of Coal. *Mining Engineer.* No. 101, Feb., 1969, pp. 274-284.

Authors describe laboratory investigation of thermal changes which occur in coal and humid atmosphere; heat changes in four coals were measured calorimetrically in isothermal conditions, most at temperature of 30 C and at several humidities; results show that simple oxidation of coal at any humid condition at 30 C does not cause serious heating of coal in normal circumstances; it is established, however, that heat produced during sorption of water vapor by coal is of particular importance to self-ignition of coal; implication of results in actual problem is also discussed.

385. ROBERTS, A.F. and BLACKWELL, J.R. Possibility of Occurrence of Fuel-Rich Mine Fires. *Mining Engineer.* No. 108, Sept., 1969, pp. 699-709.

Study has been made of characteristics of fires that propagate along timber linings of mine roadways; small-scale experiments demonstrated possibility of fires of exceptional severity, with characteristics very different from those so far observed in large-scale fires; furthermore, analysis of data from small-scale experiments indicated that these characteristics could develop in full-scale mine roadway; experiments in roadway of 45 sq. ft. cross-section confirmed this prediction; practical implications of studies are considered. 14 refs.

386. MERTENS, H. and GROSSENBACK, O. Circular Rule for Determining Numerical Index of Mine Fires. *Glueckauf.* Vol. 105, No. 26, Dec. 25, 1969, pp. 1351-1353.

In assessing changes in state of a mine fire, a numerical index based on volumetric ratio of oxygen-, to carbon monoxide content in fire smoke gives good results. Circular rule permitting quick assessment of that index and of lower explosion limit of fire smoke has been developed and is described. [In German]

387. PARK, W.R. Procedures Following Mine Fires and Explosions. *Mining Environmental Conference, University of Missouri.* Proceedings, Rolla, MO, Apr. 16-18, 1969, pp. 154-163.

Well organized, orderly recovery operations following mine fires and explosions do not occur just by chance. Such organization has resulted from thoughtful preparation and effort by those in authority at a mine in developing procedures to be followed in the event of a fire or explosion. Although recovery operations following such occurrences may be different at each mine, there are many general rules and practices that should be followed, and that are discussed.

388. GHOS, A.J. and BANERJEE, B.D. Use of the Carbon-Hydrogen Ratio of the Fuel Burnt as an Index in the Investigation of Explosions and Underground Fires in Coal Mines. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

The systematic studies of the causes and nature of underground explosions and fires in mines often need assessment of the gaseous atmospheres of the affected area. Approach is proposed in which the carbon hydrogen ratio of the actual fuel participated, may be usefully exmployed to distinguish the nature of explosion, i.e, to locate the cause to the commonly occurring but comparatively less violent firedamp or to less frequently occurring but more violent coal dust explosions. The index, which may act as guideline for such assessment may be calculated from the analysis of the gaseous products.

389. SINHA, K.N. Some Aspects of the Problems of Mine Fires in India. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

The existence of a large number of small coal mines, thick coal seams, proximity of coal seams, gentle gradient of the seams and shallow depth of workings create and aggravate the problem of mine fire in India. Report on a number of investigations carried out by Central Mining Research Station to prevent occurrence of fires.

390. BALTARETU, R., NITA, S., and IUSAN, V. Causes of Spontaneous Combustion of Coal in Basin of Jiu Valley. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Bituminous coal deposit of Jiu Valley consists of twenty seams of different petrographic and chemical characteristics, with medium frequency of underground fires. In order to reduce hazard of fires, objective (natural) and subjective (mining method) causes were analyzed and tailored to specific local conditions, fire preventing techniques have been worked out. [In French]

391. BALTARETU, R. and TOMUS, I. Investigation of Parameters of Mine Ventilation that Favor Spontaneous Coal Combustion in Thick Seams. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Mining of between 25 and 30 m. thick coal seam in Jiu Valley basin is characterized by high frequency of underground fires. Paper analyzes those parameters of mine ventilating system (pressure drop, air leaks, influence of gob areas, etc.) evaluation of which is essential for development of preventive measures. [In French]

392. SCHMIDT, W. Behavior of Open Fires in Coal Mines and Their Effect on Downcast Ventilated Mine Workings. *12th International Conference on Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Generally open fires spread more slowly in cases of descending-, as against ascending ventilation. Possibility of reversal of direction of air flow has to be considered and can be minimized by increase of pressure drop produced by fan. On the other hand even brief main-fan shut-off invariably produces air flow reversal. [In German]

393. GRUMBRECHT, K. Behavior of Large-Area, Organic, Air-Tight Stoppings in Mine Roadways When Exposed to Fire. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Air-tight stoppings in roadways help decreasing strong air-currents in worked-out areas, thus reducing hazards of spontaneous combustion of coal as well as methane emission. Various synthetic, organic foam materials have been tested insofar as their fire resistance was concerned. Test results are discussed. [In German]

394. ROWELL, W. Michael Colliery, Containing a Fire and Making Preparations for Recovery, 9th September to 31st December, 1967. *Mining Engineering.* (London), Vol. 129, No. 110, Nov., 1969, pp. 49-65.

Michael coal mine, located on shore of Firth of Forth in county Fife, Scotland was producing prior to fire 16,000 tons/week of coal from five seams. Paper deals with the methods of fighting the fire, the subsequent containment of the fire and the action taken with a view to recovering part of the mine.

395. BALTARETU, R., NITA, S., and COCULESCU, G. Efficacy of Ventilating Air Current Reversal as Means for Fighting Underground Fires. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Paper analyzes three cases of severe fires in main, incoming air entries (two in gassy mines and one in copper ore mine). In each instance reversal of main fan has produced within 5 to 10 min. reversal of ventilating air flow. Effect on fire fighting operation is reported. [In French]

396. LINDENAU, N.I. and MAEVSKAJA, V.M. Analysis of Hazard of Spontaneous Ignition of Coal in Underground Workings as Function of Mine Ventilation. *12th International Conference of Mine-Safety Research Establishment.* Sept. 11-15, 1967, Dortmund, West Germany.

Paper reviews dynamics of spontaneous combustion of coal and examines influence of stray air currents (ventilation losses) on promoting spontaneous combustion of coal in seams and gob. [In Russian with English abstract]

397. STENUIT, R. Should the Flow of Ventilating Air be Reversed in Case of Underground Fire. *Annales des Mines de Belgique.* No. 11, Nov., 1969, pp. 1265-1269.

The disastrous fire of Aug. 8, 1956 at Marcinelle, Belgium (262 fatalities) led to investigations by specially created permanent committee that recommended installation in every mine shaft of a sprinkler system with capacity of 50 liter/sec. of water for each square m. of cross section. Author answers title question affirmatively if fire is located in downcast shaft or main air entries, and negatively if fire started in upcast shaft or any other part of mine. 13 refs. [In French]

398. BHATTACHARYYA, K.K. Effect of Humidity on the Oxidation of Coal and its Spontaneous Heating. *Journal of Mines, Metals, and Fuels.* Vol. 18, No. 1, Jan., 1970, pp. 5-11, 18.

The author investigates the influence of humidity on the rate of heat release in coals during oxidation, and discusses the results in the light of the spontaneous heating of coal. Experimental conditions have been chosen to avoid any effect of either sorption or desorption of water vapor on or from the coal. The study shows that the presence of moisture in both coal and air alters the rate of heat release due to oxidation in various ways depending on the nature of the coal. The results, however, do not indicate that oxidation effect alone can cause any serious heating of coal under normal ventilation practice. 25 refs.

399. HAUSMAN, A. Application of the "Budryk Method" to the Ventilation of an Underground-Coal-Mine Section. *Annales des Mines de Belgique.* June 6, 1970, pp. 839-852.

Title method is a means of representing a mine ventilating system in a simple, graphic form that help detecting splits in the system where, under normal conditions, the direction of ventilating air current is unstable, i.e., likely to be reversed. Furthermore, it enables, in case of a fire, to point out stabilizing steps to be undertaken, as well as to indicate potential hazards of a firedamp explosion during construction of fire-doors (stoppings). A point-in-case (actual fire) is described. [In French and Flemish]

400. KUKUCZKA, A., MARCINKIEWICZ, A. and JANICKI, A. Automatic Prevention of Accidents by Reversal of Ventilating Air Current in Case of Fire in the Incoming Air Stream. *Przeglad Gorniczy.* Vol. 26, No. 6, June, 1970, pp. 271-276.

Measures to be undertaken to automatically set in motion local reversal of incoming ventilating air current in case of an underground fire are discussed. Example of realization of title technique in a fully automated experimental coal mine in Poland is described and analyzed. [In Polish]

401. CHAMBERLAIN, E.A.C., HALL, D.A. and THIRLAWAY, J.T. Ambient Temperature Oxidation of Coal in Relation to the Early Detection of Spontaneous Heating. *Mining Engineering.* London. Vol. 130, No. 121, Oct., 1970, pp. 1-15.

The early detection of spontaneous heating of coal becomes of utmost importance so that prompt remedial actions can be taken. Paper describes work undertaken in British National Coal Board laboratories using a non-isothermal dynamic method to determine the gaseous products of coal oxidation at temperatures from 30 to 200 C or more. Many of the gases which are liberated in the oxidation process are always present in mine air, and it is the initial increase in their concentration which is the first sign of heating. The results show that carbon monoxide is the most sensitive detector, but other gases - hydrogen, ethylene, propylene - may be useful in indicating what temperatures have been reached. 7 refs.

402. WARNER, E.M. Fire Suppression Systems for Underground Face Machinery. *Coal Age.* Vol. 76, No. 1, Jan., 1971, pp. 54-60.

The Coal Mine Health and Safety Act of 1969 has dictated, among other safety requirements, the built-in fire suppression system on hydraulically operated or underground equipment, wherever fire-resistant hydraulic fluids are not used. Paper reviews history of mine fires, associated with coal face machinery between 1960-1969, discusses the fire suppression systems on cutters, shuttle cars, continuous miners loader and face drills. A prototype foam fire suppression system, developed by Joy Mfg. Co. is described.

403. TASHIRO, J., KONO, M. and TAKAKUWA, I. Early Detection of Spontaneous Combustion of Coal by the Ratio of Alkanes. *Mining & Metallurgical Institute of Japan Journal.* Vol. 87, No. 999, May, 1971, pp. 395-400.

The CO/O_2 deficiency ratio, CO content and alkane content are used for the indicators of spontaneous heating underground. Paper describes the development of a novel method, that of the alkanes ratio. The reliability of the new method was proved by laboratory experiments and on the site tests. When coal temperature rises slightly the ratio of alkanes increases sensitively. Therefore, the ratio may become an excellent indicator of spontaneous combustion of coal. 8 refs. [In Japanese with English abstract]

404. OTSUKA, K. and MIYAKOSHI, H. Studies on Surface Reaction of Coal. The Adsorption in the O_2-CH_4-N_2 Atmosphere. *Mining & Metallurgical Institute of Japan Journal.* Vol. 87, No. 1001, July, 1971, pp. 521-525.

In earlier papers about gas adsorption on coal, the authors have shown the heats of adsorption and the activation energies for diffusion in the range of temperatures 24 to about 75 C. In this paper, they carried out the mixed gas adsorption experiments to discover if the atmosphere in mines might influence the spontaneous combustion of coal. In a mixed gas atmosphere the temperature influences the adsorption process *that at higher temperatures is controlled by physical phenomena, whereas at lower temperatures it is added to chemical reaction with considerable velocity. 10 refs.* [In Japanese with English abstract]

405. EXTERNBRINK, W. and LEWER, H. Reduced Hazard of Spontaneous Ignition of Coal by Application of Calcium Chloride-Montan Powder. *Glueckauf.* Vol. 107, No. 17, Aug. 19, 1971, pp. 652-653.

Article reports on experience acquired in West German bituminous coal mines, in treatment of roadway walls, loose coal, etc., by binding of coal dust with title material consisting of mixture of hygroscopic $CaCl_2$ *with surfactants. Not only the hazard of underground fires has been significantly reduced but, moreover, content of carbon monoxide in gob areas, abandoned roadways, etc., was found to be much lower than that prior to treatment. 9 refs.* [In German]

406. GILL, F.S. and BROWNING, E.J. *Spontaneous Combustion in Coal Mines.* Vol. 219, No. 2, Feb. 3, 1971, pp. 79-85, Mar., pp. 134-138, 143-144.

Paper was written to be used as a handbook on spontaneous combustion in coal mines. It includes sections on detection, methods of combating and precautions to prevent the occurrence of spontaneous heatings underground. The authors have outlined the risk caused by mining operations and have included examples of typical heatings and places of high outbreak risks. Included in the section on combating heatings is an outline of pressure balancing of districts and descriptions of the various sealants in use in British mines. There is a section on carbon monoxide poisoning together with a table showing safe duration times for men working in the products of combustion. 10 refs.

407. TASHIRO, J., KONO, M. and TAKAKUWA, I. Influence of Moisture on the Spontaneous Heating of Coal. *Mining & Metallurgical Institute of Japan Journal.* Vol. 87, No. 996, Mar., 1971, pp. 161-166.

Paper describes a series of laboratory experiments carried out to investigate title phenomenon that led to following conclusions - the spontaneous ignition point is found to be lowest when the moisture content is zero, and it progressively increases with the increase of the moisture content of coal; the relation between the moisture and the rate of temperature rise is expressed by the phrase that the more, the lower. The highest rate of temperature rise is shown by dry coal. 16 refs. [In Japanese with English abstract]

408. TRUTWIN, W. Assessment of Natural Ventilating Pressure (NVP) Caused by an Underground Fire. *Archiwum Gornictwa.* Vol. 16, No. 2, 1971, pp. 173-185.

Paper attempts to assess the magnitude of NVP due to a fire in an inclined or vertical airway through which hot fire fumes are flowing, in relation to the velocity of air flowing into the fire; the fire temperature, and the geometry of airway's cross section. Developed in paper formulas are illustrated in three examples. 3 refs. [In Polish with English abstract]

409. OTKIDACH, V.V. Assessment of Temperature Field During Fires in Mines with Horizontal Galleries. *Izvestiya Vysshikh Uchebnykh Zavedenii, Gornyi Zhurnal.* No. 3, 1971, pp. 73-76.

A calculation method is proposed for determination of temperature field of upper strata in mines where fire is taking place. The velocity of heat transfer is main determining factor in these calculations assisted by the Green function method. [In Russian]

410. NAUDE, D.E. Remote Reading Thermistor Sensors for Telemetering Temperatures During Mine Fires. *Mine Ventilating Society of South Africa Journal.* Vol. 24, No. 8, Aug., 1971, pp. 122-125.

Article describes an instrument using thermistors, developed by the South African mining industry for measuring temperatures at a number of remote points, in the range between 20 and 120 C. for the purpose of detecting and fighting underground fires.

411. SCOTT, J.J., MAROVELLI, R.L. and YANCIK, J. Status Report on the Bureau's Fires and Explosions Program. *Coal Age*. Vol. 77, No. 7, July, 1972, pp. 92-99.

Title report on work in preventing fires and explosions in underground coal mines in this country discusses research on elements of the fires and explosions programs such as: ignition, flame propagation, and extinguishment. Mine fire control and secondary problems, fire and explosion hazards caused by abandoned oil wells, as well as European mining research cooperative work are also described.

412. CHAPMAN, D.M. and HARTLEY, A. Sealing, Remote Sampling and Reopening Following an Ignition and Fire at Thurcroft Main Colliery. *Mining Engineer*. London, No. 141, June, 1972, pp. 431-445.

The paper gives an account of the problems encountered in the sealing of a district following an ignition of methane and subsequent fire in the Haigh Moor seam at Thurcroft Main Colliery. The authors describe a system of remote sampling installed under emergency conditions, which enable the effects of measures taken to control the fire to be monitored at the surface. Details are given of the stages in ventilating the sealed area with the stoppings in position and the final reopening and recovery of the district. 12 refs.

413. ROBINSON, G., MORGAN, G.D., and ADAMS, E.G. Fire at Ogilvie Colliery. *Mining Engineer*. London, Vol. 144, Sept., 1972, pp. 573-590.

A major underground fire tests to the full the resources and organization at any colliery. When the fire occurs during a period when the least number of staff is available to organize and deal with it, the emergency becomes more acute. The incident which is discussed deals with a major fire which could not be fought off or sealed off by conventional underground methods. The control of the fire and interpretations of the gas analysis are discussed with special reference to research on fuel-rich fires which have been carried out by the British Safety in Mines Research Establishment (SMRE) in recent years.

414. ANON. Symposium on the Prevention of Spontaneous Combustion. *Proceedings of the Symposium on the Prevention of Spontaneous Combustion.* Symposium, Harrogate, England. Nov. 3-5, 1970. Institution of Mining Engineers, London, England, 1971, 265 p.

Proceedings contains 17 papers relating the measures undertaken in various coal mining regions of the United Kingdom for prevention of the spontaneous combustion of coal, underground, as well as a paper on recent developments in the continuous monitoring of mine air for the detection of title hazard and a summary of the proceedings. Minutes of discussions are included.

415. WILDE, D.G. Fire-Retardant Treatments for Mine Timber. *Mining Engineer.* London, No. 138, Mar., 1972, pp. 281-288.

The manner and extent of use of timber as a lining for mine roadways has led to the adoption of some form of fire-retardant treatments in appropriate cases. Impregnated fire-retardant treatments for timber cause increased evolution of the non-flammable proportion of the volatile products when wood is decomposed by heat. They also cause an increase in the proportion of charcoal that remains after the evolution of volatile products has ceased. Fire-retardant surface coatings for timber reduce the heat that is transferred to wood from flames near the surface of the solid and inhibit the mixing of the flammable volatile products of decomposition with air. 20 refs.

416. ANON. Saga on Underground Fire Protection. *Coal Mining and Processing.* Vol. 10, No. 2, Feb., 1973, 6 p. between p. 24 and 50.

Fire protection requirements under the Federal Coal Mine Health & Safety Act of 1969 have received strong opposition from the industry, but they also have served to stimulate development of new and improved methods, systems, and equipment such as underground fire detection, water and foam systems, fire resistant hydraulic fluids, and detection on belt conveyor lines. List of particular U.S. companies from which certain types of fire protection equipment are available is enclosed.

417. BOTH, W. Extinguishing of Open Mine Fires. *Glueckauf*. Vol. 108, No. 25, Dec. 7, 1972, pp. 1195-1200.

Causes for initiation of open fires in underground coal mines and their propagation are discussed. Apparatus and installations for their extinguishing (sprinkler systems, portable fire extinguishers; and automatic extinguishing systems) are described. Experience acquired in extinguishing open mine fires in West German Ruhr coal mining region is discussed and conclusions are drawn. 18 refs. [In German]

418. CHAMBERLAIN, E.A.C. and HALL, D.A. Liability of Coals to Spontaneous Combustion. *Colliery Guardian*. Vol. 221, No. 2, Feb., 1973, 6 p. between p. 65 and 72.

The oxidation of coal has for long fascinated mining engineers and scientists; the former because of the practical difficulties caused by spontaneous combustion, both underground and in subsequent storage, and the latter because of its complexity and the hope it will lead to a complete model of coal structure and composition. This paper reviews briefly research work carried out by the Scientific Control Organization of the British National Coal Board during the last 3 years in areas of: chemical and physical consideration; practical methods of classifying coals; products of oxidation; practical application for earliest possible detection of spontaneous heating, as well as theoretical considerations. 8 refs.

419. PREGERMAIN, S. Prevention of Underground Fires in Coal Mines, Laboratory Investigation of Coal's Aptitude to Spontaneous Heating. *Industrie Minerale*. St. Etienne, France, No. 1, 1972, Supplement to Aug.-Sept., 1972, Mine, pp. 73-80.

Paper presents results of investigation of title phenomenon in coals of various origin and petrographic structure by three methods developed by V.M. Maciejaxz in Poland; MakNII developed by V.M. Maevskaja in Soviet Union; and author's original method. The first method determining the time necessary for raising the temperature of pulverized coal sample submerged in hydrogen peroxide by 65 C. is particularly suited for investigating a pyritic coal. The second method which utilizes the action of an *air stream on a sample of pulverized coal, heated progressively, analyzes the outgoing gases as function of temperature. The last method measures quantities of oxygen, fixed under pressure of a 15 cm high cover of mercury. Results obtained by either method are shown graphically and discussed. 10 refs.* [In French with English abstract]

420. CHRISTIANSEN, C.R. *Conference on Underground Mining Environment.* Proceedings, Rolla, MO, Oct. 27-29, 1971, 362 p. Publ. by Univ. of Missouri, Rolla, 1971.

Proceedings contains 22 papers that reflect the ever-increasing concern for safety in the mining industry. Among discussed topics are: effects and control of coal dust; detection of hazardous conditions in mines through infrared techniques (loose rock, misfires and spontaneous heating); bolting of coal and salt strata; hydraulic mining; degassing of coal seams; diesel engine exhaust gases underground; fire prevention; noise abatement; emergency communication systems; mine rescue; pneumoconiosis of coal miners; and radiation hazards. Individual papers are provided with bibliographic references.

421. DEACON, T. Rapid Detection and Accurate Location of Underground Fires and the Use of Fire Doors to Provide an Immediately Effective Seal. *Mine Ventilation Society of South Africa Journal.* Vol. 26, No. 2, Feb., 1973, pp. 13-19.

It is recognized in the paper, that there are three actions necessary before an underground fire can be extinguished. The first of these is detection where the existence of a fire must be quickly recognized, the second is accurate pin-pointing of the location of the fire, and the third concerns control in such a way as to reduce the disruption caused and the cost involved to a minimum. It is the object of this paper to discuss the recent work which has been carried out on this subject at Free State Geduld Mines Ltd., where severe block faulting, although imposing substantial constraints on exploration and exploitation, has afforded considerable benefits in the form of natural isolated fault blocks *which facilitates the early detection and more rapid location of underground fires. By means of the recently introduced fire door system, these blocks have the added advantage that they can be completely isolated in a very short time should a fire occur. The underground fires which occurred in the mine on the 29th December, 1971, and the 22nd January, 1972, provided early tests for the fire door system, and also for an improved system for the rapid location of underground fires is described.*

422. CHAMBERLAIN, E.A.C. and HALL, D.A. Ambient Temperature Oxidation of Coal in Relation to the Early Detection of Spontaneous Heating. *Mining Engineer.* London, No. 152, May, 1973, pp. 387-400.

For several years the Extended Service Laboratories of NCB Scientific Control have been carrying out experimental work on the oxidation of coal, with specific reference to the early detection of spontaneous heating, using a non-isothermal dynamic method. The first results of this work covering the oxidation of samples representing all British rank coals at ambient temperatures (20-200 C.) were published. This dealt with the common detector gases and concluded that all the available evidence indicated that carbon monoxide would be the most useful gas and give the earliest warning of an incipient heating; this has formed the basis of installations for continuous monitoring at a number of pits. In continuation of present work other aspects were investigated such as the use of oxidation inhibitors, the relative liability to oxidation of lithotype and maceral constituents of coal, further work on the products of oxidation, some experiments on the mechanism of the reaction, some comments on the oxidation characteristics of manufactured fuels, and the probable part played in the phenomenon by "active centers." 16 refs.

423. CHAMBERLAIN, E.A.C. and HALL, D.A. Practical Early Detection of Spontaneous Combustion. *Colliery Guardian.* Vol. 22, No. 5, May, 1973, pp. 190-194.

The increasing incidence of spontaneous combustion underground is associated with the conditions brought about by modern intensive methods of mining. A heating that is undiscovered until it is too late to gain control over it *may be very costly or indeed fatal to the pit concerned; but a heating that is identified at an early stage need be no more than a nuisance. The earliest warning of incipient heatings is therefore of utmost interest, and the continuous monitoring techniques described in this paper have been developed specifically for this purpose. 5 refs.*

424. FAGAN, V.A.D. Investigation of Electrical Fuse Igniters at Geduld Proprietary Mines, Ltd., with a View to Reducing the Incidence of Underground Fires. *Association of Mine Managers of South Africa.* Papers and Discussions, 1956-1957, pp. 497-505.

Investigation has shown that one of the most common causes of underground fires on the Witwatersrand is the careless disposal of cheesa sticks before they are completely burnt out. In order to reduce the incidence of underground fires from this cause it was decided to investigate the possibility of evolving a practical type of electrical fuse igniter to replace the cheesa stick. As far as can be ascertained no previous work along these lines has been attempted on the Witwatersrand or elsewhere. The introduction of the electric fuse igniter on several mines of Union Corporation Ltd. has eliminated one of the most common causes of underground fires.

425. HAMILTON, G.B. Underground Fires. *Association of Mine Managers of South Africa.* Papers and Discussions, 1956-1957, pp. 507-531.

Many fires have been extinguished in their early stages by quick action. Each official should know his procedural duties. Presence of a fire should be detected as soon as possible. Fire Patrol instructions listed in six steps. Immediate action procedures listed in six steps. Example of an actual occurrence is used as an example. Discussion contributed by E.V. Hindle, J.C. Hall, M. Barcza, E.W. Thiel. Further notes of above fire on pp. 307-308.

426. FORDER, A.L.A. and DEACON, D.D. Notes on an Underground Fire at Rand Leases: December, 1956. *Association of Mine Managers of South Africa.* Papers and Discussions, 1956-1957, pp. 535-559.

Describes the basic elements of organization, administration, and delegation of responsibility found necessary to cope with this fire. The mine layout is described followed by observations and comments. Report of occurrence of fire and preliminary action taken. The conduct of the fire fighting operations in detail. Statistics. Equipment carried by each Proto truck.

427. TRUTWIN, W. Estimation of the Natural Ventilating Pressure Caused by Fire. *International Journal of Rock Mechanics and Mining Science.* Vol. 9, 1972, pp. 25-36.

Deals with NVP caused by fire in inclined or vertical parts of the airway. NVP caused by fire is defined as difference between NVP during fire and before the outbreak in the particular airway. Formulae and diagrams have been produced.

428. WHILLIER, A. Dynamics of Timber Fires in Mines. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, Nos. 9, 12.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. After a discussion of the factors necessary for the ignition and growth of timber fires in stopes, consideration is given to the mechanism of spreading of such fires. A ventilation parameter R is described which enables an assessment of fire situations to be made quantitatively. This parameter is then used to evaluate the benefits that result from the application of various fire-retardant treatments to the timber, and also to explain the mechanism of water and foam in extinguishing fires. A consideration of the costs of fire protection indicates that it is not feasible to apply retardant treatment to all timber but that a suitable strategy in the use of fire protection methods could bring about a substantial reduction in the fire hazard at an acceptable cost.

429. GREIG, J.D. Some Chemical Aspects of Timber Fires in Gold Mines. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 10.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. The chemical processes involved in the ignition and combustion of timber are reviewed and the significance of various ways and means of combating and preventing mine fires are discussed against this background. The analysis of the return air from the fire zones, the minimum oxygen levels necessary to support the burning of timber, fuel-rich fires, timber treatment to postpone the ignition of timber, the occurrence of hydrogen and differences between sound and decayed timber are considered. The fire hazard due to plastics is also discussed.

430. VAN DER WALT, N.T., BOUT, B.J. and NEWINGTON, T.J. Automatic Fire Detection. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, Nos. 11, 12.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. A reliable fire detection (early warning) system must have detectors (sensors) located throughout the underground area to be protected with a signal transmission (telemetering) system to indicate an alarm at a central point on surface. Sensors should be placed to warn not only the source but also the spread of the fire. Therefore a large number are required. They must be robust and durable, sensitive to all products of combustion over a wide range of concentration with a minimum of false alarms, and independent of variations of ambient conditions not due to the fire.

431. BRYCE, J.N. Difficulties Experienced by Brigadesmen. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 9.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. Brigadesmen should have good temperament -- cool, calm, courageous, not foolhardy, able to think and react sensibly. Need for stringent medical exams and physical capacity test. Initial course of training of 4 days includes Proto, Aerorlon, and AJO apparatus, gases, oxygen purity testing, fire extinguishers, foam, hoses and fittings, *and other aspects. Tendency to claustrophobia shows up when he first wears mouthpiece and goggles. This should disqualify him. A brigadesman's efficiency is impaired approximately 50% due to weight of breathing apparatus, the restriction on breathing, and by poor visibility.*

Since apparatus has a limited operating time the team must leave enough oxygen to retreat to a fresh air base.

British Standard tables are given to show the effective safe period of operation for a range of wet bulb and dry bulb temperatures in partly saturated atmospheres; and for range of temperatures in fully saturated conditions.

432. DU TOIT BURGER, T. Water Barriers as a Means of Fire Fighting. *Mine Ventilation Society of South Africa.* Vol. 26, No. 10.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. The main methods for fighting fires are:

(1) direct fire fighting
(2) indirect fire fighting
(3) ventilation control, and
(4) sealing

Other methods that may also be considered are flooding and the use of an inert gas.

Of all these mentioned the use of water, without any doubt, is still the best means to fight a fire. Where a fire is readily accessible the use of water in sufficient quantities is the answer. This method is mostly used by Proto members applying water directly on the fire by means of hoses or spray nozzles. However, this is not always a feasible proposition.

These notes chiefly deal with water barriers as a means of fire fighting. Spray lines or water barriers must not be considered as the first line of defence. Once the fire area has been sealed off or the air quantity to the fire area has been drastically reduced, then water barriers can be considered, to prevent the spread or to retard the progress of the fire.

It is not the amount of "solid" water which is sprayed into the atmosphere that will prevent a fire from spreading, but:

(a) *the actual cooling down of the air or gases.*
(b) *the cooling down of the surrounding rock and*
(c) *the degree of wetness of the timber, etc.*

Water evaporation or steam must be aimed at which increases in volume ten thousand fold and in turn will reduce the air volume and reduce the oxygen content of the surrounding atmosphere.

433. JACOBS, J.C. Zoning and Preplanning. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 11.

Paper presented at a Symposium of Mine Fires in Gold Mines, May 3, 1973. See Item #671. Zoning and Preplanning as a means of fire fighting, is done with the object to extinguish, seal or contain a fire with the maximum safety and minimum delay. Due to varying conditions in mines, it is not possible to produce a single set of standard procedures to cater for all cases. Each case must be dealt with on its own merits.

The scope of this paper is therefore not to cover the subject in detail but to mention some aspects as an introduction to the subject for discussion.

434. STROH, R.M. Sealing as a Means of Fire Fighting. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 9.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973. See Item #671. The key objectives with each underground fire can be listed as follows:

(1) *To extinguish the fire as rapidly as possible and thereby minimise production as well as equipment losses.*

(2) *To ensure that persons are not unnecessarily exposed to the inherent dangers of an underground fire.*

With these objectives in mind, sealing can justifiably be classified as a means of fire fighting. In fact, there are few occasions that sealing of a well established fire will not most effectively satisfy the key objectives. Discusses aspects of when, how to seal; how much leakage can be tolerated; safety features; when to unseal.

435. LLOYD, P.J.D. and GREIG, J.D. The Use of High-Expansion Fire-Fighting Foams. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 10.

Paper presented at a Symposium on Mine Fires in Gold Mines, May 3, 1973, See Item #671. Fire-fighting, high-expansion foams have been used in the Industry with varying degrees of success. If the reasons for the lack of success in some cases could be better understood, and the difficulties that were brought to light could be resolved, then these foams could form a most useful weapon in fighting large fires. They have the potential for rapidly extinguishing fires in inaccessible areas, when operations are being conducted from safe, fresh-air bases, and as such offer unique properties for fighting a fire which is spreading in a narrow stope.

Any fire-fighting weapon which has the potential for preventing medium-sized fires from growing into large ones deserves active study.

High-expansion foams should prove to be a most useful weapon in fighting large, inaccessible fires underground.

Discusses in detail the generation method of application, and its action on mine timbers.

436. BOUT, B.J. Fire Detection. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 158-160.

Whereas humans can detect fires by the senses of smell, sight and temperature detection, the first cannot be reproduced by an instrument. Temperature, optical and ionisation detectors are described. The last is represented to be the only reliable type for underground use. Installation problems are discussed. See Item #670.

437. HEMP, R. Underground Fire Detectors. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 161-168.

Describes the test results of two makes of ionization detectors. Test work is still continuing. See Item #670.

438. SANDYS, M.P.J. Fire Patrolling. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 168-170.

The fire patrol system continues to be the most common method of fire detection in South African mines. Methods of training and organization are discussed. See Item #670.

439. VILJOEN, W. Prevention of Underground Fires on Some of the O.F.S. Gold Mines. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 170-171.

Some companies (in the Orange Free State) appoint Fire Masters to introduce, implement and control methods of preventing underground fires. He must also arrange for the early detection of fires and the installation of fire barriers to keep fire from spreading. The duties are described in some detail. The Fire Master works in close co-operation with mining and ventilation officials with whom the final responsibility for eliminating the fire hazard remains. See Item #670.

440. SMIT, J.G. Monitoring During and After an Underground Fire. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 172-174.

Discusses methods used and reasons for gas, airflow and temperature monitoring during and after an underground fire. Necessary to begin monitoring as quickly as possible after approximate area of fire is determined so that suitable methods can be continuously determined and adjusted. See Item #670.

441. SMIT, J.G. The Use of Foam in Underground Fire Fighting. *Journal of Mine Ventilation Society of South Africa.* Symposium on Underground Fires, Feb. 11, 1970, Vol. 23, No. 10, Oct., 1970, pp. 175-179.

Ever-increasing use is being made of foam as a fire-fighting medium in underground mines. But it is not clear as to whether foam should be used for all fires, what circumstances are best applicable for use of foam, the mechanics of fire suppression with foam, and the methods for optimum results and type of equipment to be used. Concludes that foam is useful for inaccessible fires. Otherwise it is no better than water directly applied. See Item #670.

442. MITCHELL, D.W. Fighting Mine Fires. *Society of Mining Engineers.* Transactions, Vol. 223, No. 2, June, 1962, pp. 218-224.

Experience with fighting fires in coal mines; study of 401 recent fires in United States shows that over 60% were of electrical origin and involved mining equipment; about 1/3 of fires were ignited by short circuits in trailing cables; flammable hydraulic fluid contributed to intensity of fire, making control more difficult in 15% of instances; effectiveness of extinguishing agents and techniques.

Coal mining industry lags seriously behind general industry in fire protection and fire fighting methods. Important to extinguish fire in early stage. Research demonstrates that superior extinguishing agents now available, such as detergents, alkali-metal salts and high expansion foam. Choice depends on application. Incidence will increase with greater mechanization unless fire-retardant components are used and protection increased. Experiments with superior extinguishing agents discussed. The need for better planning, drilling, periodic review, and vigilance is underlined to reduce a growing fire menace.

443. FORBES, J.J. and GROVE, G.W. Procedure in Sealing and Unsealing Mine Fires and in Recovery Operations Following Mine Explosions. *United States Bureau of Mines.* Miners' Circular No. 36, May, 1948.

This circular discusses organization, equipment and materials, and procedure in fighting, sealing, and unsealing mine fires, and in recovery operations following explosions; a practice problem for recovery procedure also is *included. Although the data contained in this publication relate primarily to comparatively thin or medium thick coal beds with little if any pitch, it is believed that the procedure for sealing and unsealing mine fires, together with the principles and technique of identifying fire gases, is applicable, with modifications in some cases, to metal mines and coal beds, whether thick or thin and with varying pitches. This circular is a revision of Miners' Circular 36, issued originally in 1929.*

Deals specifically with causes, hazards, rescue, recovery, organization, training, equipment, extinguishing agents, control methods (including sealing, unsealing, flushing, flooding, and gas sampling).

444. ANON. Explosions and Fires in Bituminous-Coal Mines. *United States Bureau of Mines.* Miners' Circular No. 50, March, 1954.

The most hazardous mine fire to combat occurs in a dry dusty bituminous coal mine generating explosive gas. Destruction of life and property demoralizes and disorganizes the operation. Especially hazardous where the mined product (coal) aids in propagating combustion. Heat from the fire liberates volatile constituents that are flammable and explosive. Some disastrous explosions have followed in the wake of a fire. Also many mining supplies such as timber, brattices, insulation, explosives, lubricants and rubber items can become the cause of a fire that eventually spreads to coal face. Analysis of causes yields six main categories - electricity, open flames, explosives, friction, spontaneous combustion, and incendiarism. Most fires are preventable by proper observation and thermometric monitoring of coal faces. Methods of control and extinguishment depend upon conditions encountered, but generally involve direct attack with water, chemicals, rockdust or sand; enclosing by sealing; flooding; flushing with silt; or smothering with inert gases. Detailed descriptions of methods is given.

Firefighting equipment and organization is also detailed. Prevention of mine fires is preferable to control and recovery after their occurrence.

445. ANON. Fires, Gases, and Ventilation in Metal and Nonmetallic Mines. *United States Bureau of Mines.* Miners' Circular No. 55, Jan., 1955.

Explains the causes of fires in metal and non-metallic mines and the measures used to prevent, control, and extinguish them.

Although mine fires are not a major cause of metal- and nonmetallic-mine accidents, there has been great loss of life in some metal- and nonmetallic- mine fires, and in many the property loss has been heavy. Any mine fire in active workings is likely to endanger life, as even a small fire may give off enough noxious gases to expose men in widely separated places to the dangers of suffocation. A small fire can quickly grow into a gravely serious one, and its control and extinguishment may involve large expenditures in labor, materials, and loss of production and even loss of ore where the fire area cannot be reclaimed. The results of mine fires are often more serious than appear at a casual glance. The direct costs of fighting the fire and reclaiming the mine are high for a fire of only moderate extent. Once a fire gets beyond control, the expense mounts rapidly. Such a fire in a timbered drift may cost $10,000 to $50,000; a fire in a timbered shaft may cost a million dollars or more, when all the losses are included, and several fires involving large parts of ore bodies have cost several million dollars each before the fire was finally halted and mining resumed in that region.

The probable property loss from fire may be so small at many mines that protective measures appear of little importance, but because of the ever-present possibility of loss of life from fire in or about a mine, precautions corresponding to the degree of risk should be taken. Although the total number of men killed by mine fires is less than that ascribed to any one of several other causes of mine fatalities, the possibility of killing a large group of men at one time makes it very important to prevent fires and provide for the protection of men against their effects at nearly all mines.

With the increasing use of belt conveyors and electrically operated mobile loaders and shuttle cars with trailing cables, ignitions or incipient fires in metal and nonmetallic mines may increase unless such equipment is properly installed, guarded, maintained, and operated.

Describes notable examples at Granite Mountain Mine, MT; Argonaut Mine, CA; Magma Mine, AZ; Glenn Mine, CA. Causes grouped under the following headings:

> *Electric wiring and equipment; open lights, flame and smoking; welding and cutting; spontaneous combustion;*

explosives and blasting; heating appliances; ignition of dusts, gases, vapors, and liquids; incendiarism; miscellaneous.

Control and extinguishment methods are detailed; also protective clothing, rescue methods, fire-fighting organization, and fire prevention.

446. FENG, K, CHAKRABORTY, R., and COCHRANE, T.S. Spontaneous Combustion - A Coal Mining Hazard. *Canadian Mining & Metallurgical Bulletin.* Vol. 66, No. 738, Oct., 1973, pp. 75-84.

Modern methods of mining coal increase the risk of spontaneous combustion. This hazard could restrict the development of coal as an energy source. Criteria for susceptibility have been sought by identifying significant coal and environmental factors. This work is being extended.

447. STAHL, R.W. and DAVIS, R.T. Firefighting Facilities at Coal Mines. *United States Bureau of Mines.* Information Circular No. 8361, Feb., 1968.

Revision of RI 5363 updated to reflect improvements in fire protection methods at selected coal mines. Suggestions as to recommended fire protection equipment, organization of fire fighting at various locations underground, and methods of evaluating facilities available.

448. MITCHELL, D.W. Explosion-Proof Bulkheads. *United States Bureau of Mines.* Report of Investigations No. 7581. 1971.

Presents practices based on experience and research for sealing abandoned areas of a coal mine, and areas from which pillars extracted. Regulations require such areas to be ventilated or sealed with explosion-proof bulkheads; but bulkheads alone cannot isolate areas in which dangerous gases accumulate. Gas/air leaks through bulkheads must be controlled. Construction and control methods are analyzed vis-a-vis European methods.

449. JEFFREY, H.E. Notes on Fire Prevention and Fire-Fighting with Particular Reference to the Kolar Gold Field. *The Institution of Mining & Metallurgy.* Bulletin No. 531, Vol. 60, Part 5, Feb., 1951, pp. 153-172.

The paper describes the various causes of underground fires and the preventive steps generally taken. It includes a reference to 'preparedness' and stresses the importance of 'mine sectionalization' - that is, the division of the workings into numerous areas or zones each capable of being isolated by doors and seals. A Central Rescue Station is described and examples are given of fire rules and regulations.

Under the heading of 'fire fighting.' In addition to the well-known methods usually employed there are references to mechanical aids, pressure equalization and ventilation control.

Much importance is given to the necessity of securing early information at the outbreak of fire and the accuracy of subsequent information provided by reconnaissance parties.

The general working conditions under which fire-fighting has been carried out are described, together with a note on the observed behavior of men and birds when subjected to various percentages of carbon monoxide.

The paper concludes with short descriptions of actual incidents in the writer's experience, each of which illustrates some pitfalls likely to be encountered in any mine fire, and describes the necessary precautionary measures.

450. JONES, S.A. The Cause, Prevention and Method of Dealing with Underground Fires. *Canadian Mining Institute.* Bulletin, Aug. 1915, pp. 616-625.

Directs attention to the various causes of underground fires, suggests the best methods of extinction, and indicates steps to prevent them.

451. GALLAGHER, J.C. Ionization for Environment Control. *APSEECO.* 18334 Gault Street, Reseda CA, 91335.

Claims the invention of a negative ionization machine that reduces atmospheric static electricity, dust, fungus spores, odors and carbon monoxide over significantly large areas. Would have useful application in underground mines particularly in case of fires and explosions.

452. ABRAMOV, F.A., MOSIN, I.M. and KREMNEV, O.A. Ventilation in Coal Mines at Fire. *Ugol Ukrainy.* Vol. 6, No. 2, 1962, pp. 41-42.

[In Russian]

453. BABOIN, M. Fire in the Plant Combes of the Coal Mine Roche-la Molière. *Annales des Mines Memoires.* Vol. VI, 1934.

[In French]

454. BALTAJTIS, V.J. and MARKOVIC, J.M. Methods to Determine Some Properties of Mine Fires from the Composition of the Fumes. *Izvestija VUZ, Gornyi Zurnal.* Vol. 10, No. 9, 1967, pp. 46-51.

[In Russian]

455. BOTH, W. New Insights for Fighting Open Mine Fires in Ascensional and Descensional Ventilation. *International Congress on Deep Mine Ventilation.* Joachimsthal (CSR), 1968.

[In German]

456. BUDRYK, B. *Fires and Explosions in Mines.* Polish Publishing House for Mining and Metallurgy (WHG), Katowice, 1956.

[In Polish]

457. BYSTRON, H. Theory of the Airflow Direction During a Mine Fire. *Annales des Mines de Belgique.* No. 5, 1965.

[In French]

458. EGOROV, V.A. and KONDRATENKO, I.D. The Concentration of Gases and their Occurrence in Mine Air During Fires, Explosions and Coal and Gas Outbursts. *Ugol Ukrainy.* No. 1, 1970, pp. 46-48.

[In Russian]

459. KREMNEV, O.A. and MOSIN, I.M. The Theoretical Foundations of the Calculation of Temperature Conditions in Mine Workings at Fire. *Dop. AN Ukr. RSR.* 1961, pp. 1487-1489.

[In Russian]

460. MAAS, W. and SADEE, C. Reversal of Airflow by a Fire. *Geologie en Mijnbouw.* Vol. 45, No. 3, 1966, pp. 59-69.

[In Dutch]

461. SCHMIDT, W. and GRUMBRECHT, K. Influence of Fires on Descensional Ventilation. *Unpublished Report.* 1971.

[In German]

462. VOSKOBOJNIKOV, V.I. Determination of a Favorable Ventilation when Fighting a Mine Fire by Using an Electric Analog Computer. *Ugol Ukrainy.* Vol. 44, No. 7, 1960, pp. 16-20.

[In Russian]

463. WOROPAJEW, A.F. Discussion of a Self-Produced Airflow Reversal when a Mine Fire Starts. *Ugol.* Vol. 32, No. 3, 1957, pp. 27-30.

[In Russian]

464. DONALDSON, F. Construction of the Summit Hill Fire Barrier. *Engineering Record.* Sept. 2, 1911.

Describes methods used for stopping the progress of a mine fire that has been burning since 1859.

465. ANON. Fire-Resistant Conveyor Belting. *International Mining Equipment.* Vol. 24, No. 3, July/Sept., 1973, p. 56.

Describes the replacement of nylon-ply rubber-covered belting with fire-resistant belting at the Sandwith (UK) anhydrite mine.

466. KEENAN, C.M. Historical Documentation of Major Coal-Mine Disasters in the United States Not Classified as Explosions of Gas or Dust: 1846-1962. *United States Bureau of Mines.* Bulletin No. 616, 1963.

Offers brief accounts of 47 coal mine fires (involving five or more deaths) in the U.S. since 1846. Fires of lesser severity have not been included. But 479 such minor occurrences were investigated by the Bureau of Mines from July, 1952-December, 1961, mostly initiated by electricity.

467. ANON. Atwater Slope Mine, Atwater, OH. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 5.

On July 3, 1872, a ventilation furnace at the bottom of the slope apparently ignited the slope timbers, filling the slope with smoke, and suffocating ten miners. (From "90 Years Ago Today," by James J. Corrigan, Anthracite Industry Historical Researchers, published in "The Sunday Independent," Wilkes-Barre, PA, Sept. 6, 1959).

468. ANON. West Pittston Breaker Fire, Pittston, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 5.

On May 27, 1871, a wooden breaker constructed on the surface near the only shaft caught fire and combustion gases were drawn into the shaft, asphyxiating 20 men underground. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1871, pp. 261-274).

469. ANON. Avondale Mine, Plymouth, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 5.

On Sept. 6, 1869, a ventilation furnace at the shaft bottom ignited and timbers of the shaft, the only means of ingress and egress. Fatalities totalled 110 due to asphyxiation. (From "90 Years Ago Today," by James J. Corrigan, Anthracite Industry Historical Researcher, published in "The Sunday Independent," Wilkes-Barre, PA, Sept. 6, 1959).

470. ANON. Buck Ridge Colliery, Shamokin, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 6.

Fire reported August 19, 1886 but origin unknown. Seven lives lost in various approaches to subdue the fire. (Excerpt from "Mining Herald and Colliery Engineer" dated Aug. 30, 1884, V. 4, page 447).

471. ANON. No. 3 Shaft, South Wilkes-Barre Colliery, Wilkes-Barre, PA. *United States Bureau of Mines.* Bulletin No. 6.6, 1963, p. 7.

On 3rd March, 1890, a miner stumbled and accidentally ignited a gas blower with his lamp. Efforts to subdue the fire with a fire extinguisher were fruitless, as were later efforts with a water hose. The mine was flooded twice to extinguish the fire. Eight men were asphyxiated. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1890, pp. 128-133).

472. ANON. Hill Farm Mine, Dunbar, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 9.

On June 16, 1890, gas from a deep borehole accidentally ignited by an open lamp. The fire spread and 31 lives were lost. (From a letter to Mr. George S. Rice, Bureau of Mines, from Fred C. Keighley, former State Mine Inspector, Feb. 12, 1913).

473. ANON. Neilson Shaft, Shamokin, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 9.

On 1st April, 1893, a can of kerosene exploded while filling a torch used to illuminate the shaft face. The resulting fire quickly spread, asphyxiating ten men. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1893, pp. 223-224).

474. ANON. Franklin Mine, Franklin, WA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 10.

A fire of unknown cause originated in a face on the sixth level, either through incendiarism or spontaneous combustion. Total fatalities through suffocation were 37 men, but these could have escaped safely had they not remained to extinguish the fire. The fan had been stopped and their retreat jeopardized. (From State of Washington, Department of Labor and Industries report).

475. ANON. Luke Fidler Colliery, Shamokin, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 10.

On October 8, 1894, a shaft brattice was ignited by an open lamp. Fortunately alternative openings allowed 55 men to escape but 5 men were nevertheless trapped and suffocated. The fire was extinguished by sealing the openings and flooding. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1894, p. 262).

476. ANON. Belle Ellen mines, Belle Ellen, AL. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 11.

On September 20, 1897, a fire in the No. 2 slope of the mine was reported, apparently caused by heat from steam pipes or from open lamps. Five men were trapped. (From "The Age-Herald," Birmingham, AL, Sept. 21, 1897, Sept. 28, 1897).

477. ANON. Jermyn No. 1 Colliery, Rendham, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 11.

A spontaneous ignition a week earlier was being subdued by organized crews of firefighters. On Sept. 28, 1897 a fire boss noticed an ignited gas blower and arranged to change the direction of the air current for an easier approach to the fire, but five miners were suffocated. (From Reports of the Coal Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1897, p. 53, and from "The Republican," Scranton, PA, edition of Sept. 28, 1897, courtesy of the Lackawanna County Historical Society, Scranton, PA).

478. ANON. Von Storch Colliery, Scranton, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 11.

On Oct. 29, 1897, a fire was discovered in the slope where it crosses the Diamond vein. Six men were trapped and asphyxiated. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1897, p. 53).

479. ANON. Maffett Slope, Wilkes-Barre, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 12.

Four or five men suffocated by smoke from a gangway timber fire of unknown origin on Oct. 1, 1898. (From microfilm record of "Sunday Morning Leader," Oct. 2, 1898, courtesy of the Wyoming Historical & Geological Society, Wilkes-Barre, PA and from the annual publication, "Pennsylvania Department of Internal Affairs, Part V, Report of Bureau of Mines, 1898," page 76).

480. ANON. Issaqua No. 4 mine, Issaqua, WA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 12.

On August 21, 1900, five miners were suffocated underground by a brush fire which spread to the downcast shaft. About 75 men escaped. (From microfilm records of "Seattle Post-Intelligencer," Aug. 22, 1900).

481. ANON. Diamondville No. 1 mine, Diamondville, WY. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 12.

On Feb. 25, 1901, 26 miners suffocated as the result of a fire apparently caused by ignition of a brattice by an open lamp. (From "Mines and Minerals," April, 1901, page 388).

482. ANON. Pocahontas Mines, Pocahontas, VA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 13.

On November 14, 1901 a fire was discovered in the Baby Mine exhaust fan, emanating from four points underground. In the process of extinguishing these fires, 17 lives were lost through asphyxiation. (From "Mines and Minerals," January, 1902, V. 21-22).

483. ANON. No. 2 Mine, Dow, OK. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 14.

On 13 January 1902, ten men were fatally suffocated when a blown out shot set fire to the coal. (From a report of William Cameron, U.S. Inspector for the Indian Territory).

484. ANON. Locust Gap Colliery, Locust Gap, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 15.

On May 5, 1904, a fire originated in a pumpway being timbered by men using open lamps against orders. Five men were suffocated. (From reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1904, p. 466).

485. ANON. No. 1 Mine, Decatur, IL. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 16.

On January 16, 1905, a fire was discovered in the mule stable apparently caused by a cigarette. All of the 60 men escaped except six, due to prompt action of the management. (From the State Coal Report, 1954, Illinois Department of Mines and Minerals.)

486. ANON. Red Lodge Mine, Red Lodge, MT. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 16.

On June 7, 1906, eight lives were lost in attempting to extinguish a fire and subsequent rescue efforts. Two fires due to spontaneous combustion had been burning for some time. Men should not have been allowed to enter the mine. (From the report of the State coal-mine inspector.)

487. ANON. Clyde Mine, Fredericktown, PA. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 16.

On October 13, 1905, a fire was discovered in the pump house. All employees except six had escaped safely. Due to evidence of gas reaching the surface, rescue efforts were restricted. (From a State report.)

488. ANON. Horton Mine, Horton, WV. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 16.

A ventilating furnace with a wooden stack caught alight and ignited the coal. Seven men were suffocated. (From Archives and History, State Capitol, Charleston, WV.)

489. ANON. Hailey-Okla. No. 1 Mine, Haileyville, OK. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 17.

On August 26, 1908, a fire started in tubs of lubricating oil underground from the flame of an open light. Fire spread to timbers. Smoke and gas asphyxiated 29 men trapped behind the fire and unable to reach the shaft. (From abstract of report of Wm. Cameron, by W.J. Fene, Bureau of Mines.)

490. ANON. Engleville Mine, Engleville, CO. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 17.

Fire first started in May, 1906. Stoppings were built and fire fought almost continuously. The fire was rekindled and caused reversal of current, asphyxiating 5 men. (From State Records.)

491. ANON. Pratt No. 3 mine, Ensley, AL. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 18.

A fire, apparently started by convicts in a manway on Nov. 16, 1908, caused the deaths of eight of their number, in an escape attempt. (From "The Age-Herald," Birmingham, AL, Nov. 18, 1908.)

492. ANON. Red Lodge Mine, Red Lodge, MT. *United States Bureau of Mines*. Bulletin No. 616, 1963, p. 18.

On November 20, 1908, nine men were killed when fire broke out in a crib on the No. 2 slope. (From "Mining Science," Dec. 3, 1908, and from the State Inspector of Coal Mines Report, "Accidents in Coal Mines from October 31, 1908, to October 31, 1909.")

493. ANON. Auchincloss Colliery, Nanticoke, PA. *United States Bureau of Mines*. Bulletin No. 616, 1963, pp. 18-19.

On November 9, 1909, a gas explosion occurred in No. 2 shaft fatally burning one man and setting fire to timber and coal at a face, thereby producing smoke and gas that suffocated eight other workmen. (From Reports of the Inspectors of Coal Mines of the Anthracite Coal Regions of Pennsylvania, 1909, p. 336.)

494. ANON. Pancoast Colliery, Throop, PA. *United States Bureau of Mines*. Bulletin No. 616, 1963, p. 22.

The North Slope Engine room (for rope haulage) was about 800 feet east of the bottom of the main hoisting shaft. This was the seat of the fire on April 7, 1911. Prompt attempts were made to subdue the fire but a number of coal cars had also caught alight. The smoke and gases spread through the mine and 73 men were suffocated. (From an abstract by W.J. Fene of a Bureau of Mines report by Chas. Enzian.)

495. ANON. Western No. 5 Mine, Lehigh, OK. *United States Bureau of Mines*. Bulletin No. 616, 1963, p. 23.

On Feb. 22, 1912, a fire was caused by a miner's open light accidentally igniting a quantity of car oil being warmed at the foot of the downcast shaft. Of the 200 men in the mine, 190 reached the surface through two escapeways, 9 were suffocated and one was rescued. (From a Bureau of Mines report by W.T. Burgess and R.Y. Williams.)

496. ANON. No. 1 Mine, Cinderella, WV. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 24.

A fire occurred in a wooden fan house (on surface) on June 30, 1914, and quickly spread to the pit mouth and the timbers and coal in the airway. The resulting gases suffocated the only five men in the mine (on the night shift). (From a Bureau of Mines report by J.W. Paul, H. D. Mason, and W.J. German.)

497. ANON. Villa Mine, Villa, WV. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 25.

On May 20, 1918, a fire originated in the main airway where a (gasoline) engine driven fan was located. The fire spread and trapped 13 men who were suffocated. (From Bureau of Mines report by D.J. Parker.)

498. ANON. No. 2 Mine, Amsterdam, OH. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 26.

On October 29, 1919, a fire started in an electric-driven fan house 200 feet from the shaft. Twenty men were asphyxiated. (From the "Pittsburgh Post," Oct. 30, 1919.)

499. ANON. Arnold Mine, Earlington, KY. *United States Bureau of Mines.* Bulletin No. 616, 1963, pp. 26-27.

A fire was reported on Nov. 16, 1920 in an entry of a drift mine. Despite efforts to rescue the entombed miners, six were asphyxiated. (From a Bureau of Mines report by C.A. Herbert.)

500. ANON. Kathleen Mine, Dowell, IL. *United States Bureau of Mines.* Bulletin No. 616, 1963, pp. 27-28.

A fire of unknown origin was discovered on Feb. 23, 1921 approximately 2000 feet from the air shaft and 2600 feet from the bottom of the main shaft. About 300 men were underground at the time. All but 7 escaped. Because explosive mixtures of gas were present, the mine was sealed to extinguish the fire. (From Bureau of Mines report by C.A. Herbert.)

501. ANON. Satanic Mine, Morrison, CO. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 28.

A small fire started in this almost vertical coal seam by spontaneous combustion in a worked-out area, on Dec. 13, 1921.

Seals were being erected without difficulty until a wind and temperature change on surface reversed the ventilation, and the crew was suffocated. The rescue team also experienced an airflow reversal due to another sudden change and they too suffocated. In all, six men lost their lives. (From "Coal Age," V. 21, No. 13; Mar. 30, 1922, page 532.)

502. ANON. Webb Mine, Bellaire, OH. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 28.

A fire was reported on Dec. 22, 1925, the exact cause unknown, but probably due to a smouldering brattice cloth. The night foreman gathered some men and conducted them to the shaft bottom with instructions to remain there while he collected some more. But nine attempted to climb the ladders and were asphyxiated. All the others were saved, as were three horses and a mule entombed for 13 days without food or water. (From a Bureau of Mines report by J.N. Geyer.)

503. ANON. No. 10 Mine, Wheatcroft, KY. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 29.

On March 12, 1934, a fire was casually reported at one of the coal faces. A trainload of men on the next shift were suddenly plunged into dense smoke but the driver reversed the loco and withdrew all the men save one who was found dead. Later four men were found dead in another entry. Seals were then erected. It is suggested that the fire may have been caused by shooting with pellet powder. (From a Bureau of Mines report by Joseph F. Davies.)

504. ANON. No. 41 Mine, Barrackville, WV. *United States Bureau of Mines.* Bulletin No. 616, 1963, pp. 29-30.

On May 11, 1935, a fire occurred in the main hoisting shaft, severely burning 11 men, six of whom fatally. Two others escaped without injury. Only 13 men were in the mine.

The cause of the fire is unknown. The men were burned by a blast of hot gases from the bottom of the shaft while they were attempting to prevent the spread of the fire to the coal bed, using a water hose. (From Bureau of Mines report by J.J. Forbes and M.J. Ankeny.)

505. ANON. Kathleen Mine, Dowell, IL. *United States Bureau of Mines.* Bulletin No. 616, 1963, p. 31.

On August 1, 1936, a fire occurred, apparently due to a fall of roof causing a short circuit of the trolley circuit. In the subsequent sealing procedure, in which 15 or more men were engaged, nine men succumbed to carbon monoxide poisoning. (From Bureau of Mines report by C.A. Herbert.)

506. ANON. No. 15 Mine, Pursglove, WV. *United States Bureau of Mines.* Bulletin No. 616, 1963, pp. 31-33.

On January 8, 1943, a fire occurred in a trolley locomotive hauling a train of 23 loaded cars on the night shift. Of 78 men underground, 65 escaped and 13 died.

Unsuccessful attempts were made to fight the fire directly with rock dust and water so it was decided to seal it. Meanwhile the fire had spread some 1500-3000 feet. After sealing for 7 days unsuccessfully, it was decided to flood the mine. The mine was officially reopened on April 12, 1943, but there were long delays in re-establishing operations. (From Bureau of Mines report by C.A. Herbert.)

507. ANON. Emerald Mine, Clarksville, PA. *United States Bureau of Mines*. Bulletin No. 616, 1963, pp. 34-35.

A mine fire occurred on June 7, 1944. There were 157 men underground. Six men lost their lives, presumably by suffocation and 151 escaped through an air shaft 3½ miles beyond the seat of the fire. The fire was caused by a roof fall onto a trolley wire igniting a car of hay. Following delays in using fire extinguishers, fire hoses were used followed by sealing. The mine was unsealed finally on Dec. 26, 1944. (From Bureau of Mines report by G.W. Grove and E.E. Quenon.)

508. ANON. Powhatan Mine, Powhatan Point, OH. *United States Bureau of Mines*. Bulletin No. 616, 1963, pp. 36-38.

A mine fire occurred on July 5, 1944. At this time 190 men were in the mine. Of these 124 escaped unassisted but 66 were killed. Of these, 60 had barricaded themselves.

The fire occurred when a timberman scaling the roof caused the trolley wire to part from the frog and to short circuit, with much arcing, on the rails, igniting the coal.

Attempts to extinguish the fire by rock dust and water and by loading out the burning caved material were unsuccessful and the fire spread.

The mine was subsequently sealed until June 9, 1945. During recovery operations, it was observed that the fire was still burning near the original site. The fire area was sealed on June 12 and the fan stopped. This area remained sealed until March 31, 1946. (From Bureau of Mines report by G.W. Grove, M.C. McCall, and O.C. Simpson.)

509. ANON. Milt No. 1 Mine, Kitzmiller, MD. *United States Bureau of Mines*. Bulletin No. 616, 1963, pp. 38-39.

Fire started in a gasoline engine driving a downcast fan on surface. Smoke and fumes quickly spread from the wooden fan house through the wooden connecting duct into the mine drift. Of seven men working underground, five lost their lives through suffocation. (From a Bureau of Mines report by W.D. Walker, Jr., T.J. McDonald, and W.D. Baldwin.)

510. ANON. Cherry Mine, Cherry, IL. *United States Bureau of Mines*. Bulletin No. 616, pp. 19-21.

Fire originated on Nov. 13, 1909, by a truck of hay contacting a kerosene torch at the Second Vein level next to the shaft.

About 259 lives lost, although 19 were rescued after sheltering behind a barricade for seven days. (From a report by George S. Rice, mining engineer, U.S. Geological Survey.

511. ANON. Leyden Mine, Leyden, CO. *United States Bureau of Mines*. Bulletin No. 616, 1963, p. 21.

On December 14, 1910, a fire occurred due to which 10 men were suffocated by smoke. The fire occurred in the electric winch room at the south side of No. 2 Shaft, and was discovered by smoke issuing from the exhaust fan on surface. Rescue crews went down and recovered five men from the north side and tried to extinguish the fire on the south side with a hose. But someone on surface reversed the fan and drove out the firefighters. The fire spread up the shaft to the surface. Ten men lost their lives. (From a Bureau of Mines report by J.C. Roberts, mining engineer.)

512. ANON. No. 22 Mine, Pine Creek, WV. *United States Bureau of Mines*. Bulletin No. 616, 1963, pp. 39-42.

On March 8, 1960, a fire was discovered. Of 50 men underground 30 were outby the fire area and escaped while 18 of the 20 working inby died from asphyxiation. The fire was probably caused through a trolley arc from a travelling loco. After recovery of the bodies, on March 17, the fire area was sealed off after driving a new set of entries to install seals inby the fire. (From a Bureau of Mines report by W.R. Park, J.T. Whalen, and W.M. Cordray.)

513. KINGERY, D.S. Bituminous Research. *Coal Age.* Vol. 68, No. 5, May, 1963, pp. 104, 106.

The use of rigid polyurethane foam with high expansion characteristics and with relatively high temperature resistance is proposed as a useful tool for sealing airways in the control of mine fires.

514. ROBERTS, A.F. and CLOUGH, G. Model Studies of Heat Transfer in Mine Fires. *Safety in Mines Research Establishment.* Research Report No. 247, 1967.

The propagation of fires along the timber lining of ventilated mine airways was studied by model experiments in a ventilated refractory-lined steel duct, lined on the side walls and roof with timber. Burning rates, temperature distributions and heat transfer rates were measured. From these data, heat transfer coefficients were derived.

515. ROBERTS, A.F. Fires in the Timber Lining of Mine Roadways. *Safety in Mines Research Establishment.* Research Report No. 263, 1970.

Scaling laws were developed from simplified mathematical models of fires in timber linings of mine roadways for application to full-size conditions and checked by large-scale experiments. Experiments showed that for adequate ignition of a continuous timber lining, a state could be reached where all the oxygen in the ventilating air could be consumed. Large scale experiments confirmed this finding.

516. ANON. Fire Protection Handbook. *National Fire Protection Association.* Boston, MA, 1969.

Embraces sections dealing with: Loss of life and property by fire; fire investigation and reporting; analysis of fire losses; fire protection; characteristics and behavior of fire; fire hazard properties of materials; hydraulic calculations; water services; detection and alarm systems; extinguishing agents.

517. BERRIEN, C.L. Fire-Fighting Methods at the Mountain View Mine, Butte, MT. *American Institute of Mining Engineers.* Transactions, Sept., 1915, pp. 1215-1225.

Describes the many problems encountered in fighting this metal mine fire which first became evident in inaccessible workings in June, 1913. It was extinguished by December, 1913.

518. DOUGHERTY, J.J. *Control of Mine Fires.* West Virginia University, 1969.

Textbook dealing with subject title and embracing the following areas: Types and firing characteristics of coal; direct methods of fire fighting; sealing mine fires; factors influencing time to open seals; importance of gas analyses; a synopsis of six fire sealing and recovery operations; fire prevention; effects of high-expansion foam.

519. NEUMANN, W., PLASCHE, F. and SONNEMANN, G. Mine Ventilation and Fighting of Mine Fires. *VEB Deutscher Verlag fuer die Grundstoffindustrie.* Leipzig, 1963.

[In German]

520. OSIPOV, S.N. and ZADAN, V.M. Progress of a Fire in a Horizontal Mine Roadway. *Ugol Ukrainy.* Vol. 11, No. 9, 1967, pp. 35-38.

[In Russian]

521. OSIPOV, S.N. and ZADAN, V.M. Simplified Method to Determine the Stability of Air Currents in Case of Mine Fires. *Ugol.* Vol. 44, No. 7, 1969, pp. 57-61.

[In Russian]

522. KENNEDY, M. and ROBERTS, A.F. Modelling Fires in Mine Roadways. *Second International Fire Protection Seminar.* Karlsruhe, 1964, pp. 103-114, 315-318.

523. ROOD, V.S. and NORDEN, J.A. Engineering Problems During Mine Fire at Utah-Apex Mine, Bingham Canyon, Utah. *American Institute of Mining Engineers.* Transactions, June, 1918.

This fire was caused by spontaneous combustion in a square-set stope off the 1,300 level. The ore consists of galena, pyrite, and sphalerite. Isolation of the fire zone by bulkheads meant a loss of 100,000 tons of reserve ore, with the probability of the fire breaking out into new work. Between 600 and 700 g.p.m. of water was available, and it was estimated that 15,000,000 gallons would be required to fill the mine to about the fire level. Four to five days' flooding sufficed for the water to reach the fire, after which flooding was continued several days. Bailing tanks were used in unwatering the mine, and good progress was made until the landing chairs were encountered at the 1,300-foot level. Much difficulty was encountered in getting these chairs out of the way because of carbon dioxide and nitrogen gas hanging above the water. After the mine was unwatered, about 1 foot of mud was found on the 1,500 foot level. In the region of the ore bodies the drifts and raises were virtually blocked with fine ore. The slices in the stopes adjoining the square-set stope which had been on fire had virtually filled with ore, but timbering *was in good condition. In mining after the fire the practice of sealing all openings to stopes as soon as they were finished was adopted. Approximately $40,000 was expended during the 3 month period of the fire and unwatering.*

524. NIGHMAN, C.E. and FOSTER, R.S. The Pennsylvania Mine Fire, Butte, MT. *American Institute of Mining Engineers.* Transactions, Feb., 1917.

On Feb. 14, 1916, a fire occurred at or near a ventilating fan on the 1200 downcast air shaft station. When the fan was stopped the hot gases and smoke were upcast to the 300 level and recirculated through the workings. Drifts and crosscuts were driven from the nearest accessible workings and water hoses used. Air currents were controlled with bulkheads, doors and brattices. 21 men lost their lives through suffocation.

Methods of protection against future fires is discussed.

525. RAHILLY, H.J. Mine Fires and Hydraulic Filling. *American Institute of Mining Engineers.* Transactions, Vol. 68, 1923, pp. 61-72.

Describes the 1906 fire in the Minnie-Healy mine which later spread in 1917 to the Leonard and West Colusa Mines. Caused by spontaneous combustion. Prior to 1917 mine fires in inaccessible areas in Butte had been controlled by sealing and introducing water through diamond drill holes. However, ground too badly fractured in this case. Hydraulic filling of mill tailings was used. Many advantages claimed for this method.

526. TALLY, R.E. Mine-Fire Methods Employed by the United Verde Copper Co. *American Institute of Mining Engineers.* Transactions, Vol. 55, 1916 and Dec., 1918 (discussion), pp. 186-202.

Underground fires in this mine have been common because of the highly pyritic nature of the ores. The first fire occurred in 1894.

For satisfactory fire control, the Plenum system has been adopted. Necessary to seal the fire zone to prevent its spread and to maintain close control of the ventilation system, distributing quenching water through diamond drill holes. Fire fighters should be carefully trained to control and extinguish fires.

527. BRUCE, J.L. Fire Prevention in the Butte and Superior. *Mining and Scientific Press.* Vol. 118, 1919, p. 752.

Describes rescue measures adopted to improve fire protection in various underground installations.

528. ANON. Proper Fire Protection for Coal Mines. *Coal Mining.* Vol. 25, No. 11, Nov., 1948, pp. 10-13.

Classifies fire sources into three categories for which no one extinguishing agent is a "cure-all." Describes various agents and equipment and the need for regular maintenance and instant readiness. Characteristics of hand fire extinguishers. Mobile cars carrying fire fighting units. Foams, Karbaloy, Cardox.

529. ASH, S.H. Extinguishing a Fire at the Argonaut Gold Mine. *Mining Congress Journal.* Vol. 25, May, 1938, pp. 20-25, 53.

On Feb. 15, 1938, a fire was discovered in this mine (at Jackson, CA). All the 98 men were working below the 5400 level, and all were removed promptly to safety. A major disaster and serious economic loss were averted by superior organization and co-operative effort. The fire, originating on the 4350 foot level, was localized by sealing with the fireproof doors and bulkheads installed following the 1922 fire. These precautionary measures proved to be of paramount importance.

530. JAMISON, W.B. Stability - The Key to Effective High Expansion Foam, Part I. *Fire Technology.* Vol. 6, No. 1, 1970, pp. 39-51.

Stability or water content is an essential element in high expansion foam. After reviewing the fundamentals, evaluation tests are deduced.

See also Part II, for effects of sprinklers on high expansion foam.

531. JAMISON, W.B. Fighting Mine Fires with High Expansion Foam. *West Virginia Coal Mining Institute.* April, 1963, Morgantown, WV.

532. FORBES, J.J. When and How to Unseal Coal Mine Fires. *Mining Congress Journal.* July, 1927, pp. 512-519.

Describes hazards, fatalities, property damage, demoralization, disorganization associated with mine fires. No fixed rule for control and extinguishment for each occurrence is an individual problem. Principal causes are listed. Primary aim is fire prevention from every possible hazard. Methods of control are listed - direct attack with water, chemicals or other materials; flooding; sealing; flushing with silt; snuffing with inert gases.

Effective sealing will exclude air and gradually subdue the fire through lack of oxygen. Where this proves successful, the next problem is to decide when and where to unseal in order to recommence operations. The associated problems are discussed at length. The question is of great importance. Aspects discussed include: Approximate time; effect of boreholes, area sealed, fire intensity, roof material, caving effects; tightness and material of seals; breathing of seals; sampling and analysis of gases; carbon dioxide content as a determinant; importance of low oxygen content, effect of ventilation. There follows a list of conclusions to guide decisions in unsealing procedures.

533. RAHILLY, H.J. Mine Fires and Mine Fire Prevention in the Butte Mines. *Lake Superior Mines Safety Council.* Proceedings, Twenty-Sixth Annual Conference, 1950, pp. 55-69.

Since 1889 there have been 59 major mine fires up till 1950, resulting in 203 fatalities. In one single fire 163 lives were lost by asphyxiation. Nearly all the remainder were lost in actual fire fighting operations.

The chief causes were - carelessness with lighted materials; incendiarism; electrical; spontaneous combustion. Fires can be detected by smell and the presence of smoke and then sulphur dioxide.

Fire fighting methods depend upon their accessibility. Methods are outlined in each case. If adequately sealed a fire progressively becomes dormant, showing gas analyses as below - oxygen, 20 to 3%; carbon dioxide, 8 to 12%; carbon monoxide, 0.1 to 0.5%; with larger percentages of nitrogen. Such seals should be left as long as possible to avoid rekindling of the fire; but this generally delays ore production operations. Current methods (1950) at Butte are given. Also a design of a fire seal door and air lock; and a hydraulic fill mixing plant. A section on fire prevention is given.

534. FELEGY, E.W. and FELLMAN, C.M. Fires and Fire-Prevention Practices in Lake Superior District Iron Mines. *Lake Superior Mines Safety Council.* Proceedings, Twenty-Eighth Annual Conference, 1952.

Over 50% of fires are of electrical origin and 20% due to welding operations. Gives an excellent analysis of practical problems affecting mine fire fighting organizations followed by detailed reports of fires of 11 different companies, with recommendations. A section on mine rescue apparatus and training follows.

535. GENTHE, M. Research on Explosion-Proof Bulkheads for Mine Fire Control. *Glueckauf.* 1968.

[In German]

536. MUELLER, R. Methods to Prevent Fires Due to Spontaneous Combustion and Active Coal Fires Worked by Caving in Collieries of Saarbergwerke AG. *Glueckauf.* October 26, 1967, pp. 1125-1131.

[In German]

537. ANON. Guidelines for Blocking and Sealing of Workings in Coal Mines (revised). *Steinkohlenbergbauverein.* Essen-Kray, Jan. 15, 1970.

[In German]

538. ABRAMOV, F.A. Movement of Air-Mechanical Foam in a Mine Working. *Ugol Ukr.* Vol. 13, No. 4, 1967. pp. 46-47.

[In Russian]

539. ROBERTS, A.F. Fires in Ducts Under Forced Ventilation Conditions. *Fire Technology.* No. 1, 1970, pp. 13-21.

Experiments with fires in ducts under forced ventilation conditions indicate that either of two types of fire can occur - oxygen-rich or fuel-rich. The latter is faster moving and generally represents a greater toxicity hazard than the former. It is also possible for such fires to make the transition from oxygen-rich to fuel-rich conditions.

540. ROBERTS, A.F. and CLOUGH, G. The Propagation of Fires in Passages Lined with Flammable Material. *Combustion and Flame.* No. 5, 1967, pp. 365-376.

An experimental study has been made of the propagation of fires along a 30 cm square duct, which was lined with wood and ventilated at a controlled rate. Fires in this duct achieved a condition in which all the oxygen in the ventilation current reacted, and an excess of fuel was generated by heat transfer to the wood from the hot combustion products. A simplified mathematical model of this type of fire was developed which related the propagation rate and temperature distributions of the fire to the heat transfer coefficients, fuel emission rates and other features of the system. For Reynolds numbers $>10^4$ *there was reasonable agreement between the experimental* *data and the predictions of this model. At lower Reynolds numbers, discrepancies occurred which were consistent with the appearance of the mixing rate of fuel and air as a rate-controlling process.*

541. WRIGHT, L.T. Controlling and Extinguishing Fires in Pyritous Mines. *Engineering & Mining Journal.* Jan. 27, 1906, pp. 171-172.

Describes the Iron Mountain Mine in Shasta County, CA and the fire problem, due to pyrite oxidation, that became evident. Problem solved by a fan to slightly pressurize the stope, thereby providing clean air for the miners and pushing oxygen-deficient heated air back into the fire zone.

542. HESLOP, W.T. Extinguishing a Mine Fire. *Mines and Minerals.* Nov., 1906, pp. 152-153.

Personal experience with a coal mine fire in St. George's Colliery, Natal.

543. NORRIS, R.V. Coal Mine Fires. *Engineering & Mining Journal.* Feb. 9, 1907, pp. 286-288.

Some general descriptive notes on coal mine fires followed by experiences with some specific instances.

544. YATES, B.C. The Homestake Mine Fire. *Engineering News.* Vol. 59, No. 1, Jan. 2, 1908, pp. 1-6.

A fire started on March 25, 1907, presumably by a blast in a timbered slope. Two hose lines were laid but the operators were hindered by smoke and by bursting of hoses. Efforts to seal the fire zone were only partially successful. After 7 days, steam was turned into the fire zone for a further 7½ days. After the main pumps were abandoned, it was decided to flood the mine.

On April 18, the mine water was allowed to fill the workings. The men were ordered out of the mine on April 22 and all mining operations were stopped. Water flumes from Whitewood Creek were built to hasten the inflow, plus water seeping through the open cut.

By May 29 the water level was 78 ft. above the 300 foot level and was shut off. By this time the CO_2 gas level had been reduced to less than 1% from 4% a few days before.

On May 30 unwatering operations commenced mainly by bailing tanks and airlift pumps. The total quantity of water handled by Sept. 6 was:

by bailing tanks	*541*	*million gal.*
by airlift pumps	*83*	*million gal.*
by Cornish pump	*19*	*million gal.*
Total	*643*	*million gal.*

Unwatering was completed to the 1550 level on October 7 without mishap. The mine workings were in good condition. A number of observations and lessons learned are quoted.

545. NOTEBAERT, F.E. The Theory and Practice of Fighting Mine Fires from Practical Experience Gained in Pictou County. *Canadian Mining Journal.* Vol. 41, No. 19, May 14, 1920, pp. 393-397.

Pictou County (Nova Scotia) contains four thick coal seams each ranging from 14 to 40 ft. below which there are 13 seams ranging from 3½ to 28½ ft. Seams dip northerly at about 22°, to a certain distance and then become very irregular. Bord and Pillar method is used. Much coal is therefore left in the gob producing excellent conditions for the generation of gob fires. Three different precautions are taken: (1) to reduce quantity of coal left to crush in the gob, (2) to reduce oxygen content in gob areas, and (3) to seal gob areas wherever practicable as an emergency measure.

Various detailed methods of achieving these measures are detailed. As an example, the Albion Mine fire of Jan., 1918 is described. It was shown that a gob fire could be suspended by excluding oxygen and that temperatures in and clear of the gob could be equalized by restricted natural ventilation.

546. ASHWORTH, J.A. An Underground Fire Disaster. *Engineering & Mining Journal.* Nov. 28, 1908, pp. 1060-1062.

A fire at Hamstead Colliery (England) caused the death of 25 men and many horses. Fire was apparently caused by negligent burning of candles near bottom of downcast shaft. Much confusion and lack of a positive fire fighting and rescue plan. Water hoses could have been used to advantage.

547. VERNER, J. Lessons to be Learned from Mine Fires. *Mines & Minerals.* Aug., 1911, pp. 19-20.

Three examples of mine fire disasters are given in which the severity of the fire was not due to its ultimate origin but to a strong ventilating current that quickly spread the fire. The means of controlling strong air currents in critical situations should be a necessary feature of fire protection plans. Managements should provide frequent training to ensure that all men are alert to the danger and prevention of incipient mine fire.

548. LYMAN, G.E. Fire Protection Above and Below the Ground. *Coal Age.* Vol. 3, No. 20, May 17, 1913, pp. 759-762.

A summary of methods used in fireproofing mines, based on (a) the adoption of every possible means of fire protection, (b) the planning and installation of the best firefighting equipment, (c) the organization of a competent fire corps with discipline and efficiency. The need for accurate mine maps is underscored.

549. TEFFT, T.A. Causes of Fires in Metal Mines. *Mines & Minerals.* Nov., 1912, pp. 218-219.

The main sources of fire in metal mines is the timber used, associated with naked lights and steam pipes. On occasions, gas blowers and spontaneous combustion of sulphide ores lead to fires. In deep mines, ventilation may be adversely affected by a fire. The use of water, *carbon dioxide, and steam have been successfully used to subdue a fire. The introduction of electric lamps has removed one of the fire hazards.*

550. FORRESTER, J.B. The Black Hawk Mine Fire. *The Colliery Engineer.* Aug., 1915, pp. 12-18.

A fire occurred in this coal mine on February 1, 1915. Cause unknown. Fire had gained considerable headway before aid was available. There was no one underground at the time. Early attempts to subdue the fire were foiled by explosions. Following these, the entry and exit to the mine was sealed on Feb. 3. Firefighting crews later operated within the seals by oxygen-breathing apparatus. The fire was deemed extinguished by March 31 and normal working was resumed. Meanwhile 2400 tons of fallen coal had been loaded out.

551. NORRIS, R.V. Coal Mine Fires. *Coal Age.* Vol. 10, No. 17, Oct. 21, 1916, pp. 666.

Mine fires are among the greatest hazards of coal production. Direct attack, smothering the affected section or the entire mine, surrounding, flushing, flooding and quenching with steam or inert gas are all means of coping with mine fires. Fighting fire underground, regardless of the means employed, is always an expensive and dangerous process. By far the cheapest and most satisfactory method of conquering mine fires is to prevent their starting.

552. SHERMAN, G. Measures for Controlling Fires at the Copper Queen Mine. *American Institute of Mining Engineers.* Transactions, Jan., 1918, pp. 169-173.

Provides notes on preparations being made to check a new fire and facilitate the escape of workmen prior to adoption of a specific fire fighting plan. Gives design of firedoors and shaft spray system. (Copper Queen Mine, Bisbee, AZ)

553. FIELDNER, A.C. and KATZ, S.H. Gases Produced in the Use of Carbon Tetrachloride and Foamite Fire Extinguishers in Mines. *United States Bureau of Mines.* Report of Investigations No. 2261, June, 1921.

Results of experiments by Bureau of Mines have shown that carbon tetrachloride extinguisher liquids when applied to fires produce small quantities of irritating and poisonous gases which may be dangerous under certain conditions.

554. LEE, E.C. Re-opening the Grayson Mine in Illinois. *Coal Age.* Vol. 7, No. 8, Feb. 20, 1918, pp. 322-324.

A dangerous mine fire was extinguished by sealing up the shafts. Rescue corps succeeded in opening up the workings without any serious mishaps. Methods of gas analysis. Permissible explosives adopted.

555. WALSH, J.J. Can Mine Fires Be Successfully Fought by the Aid of Cooled Boiler Gases? *Coal Age.* Vol. 21, No. 8, Feb. 23, 1922, pp. 328-329.

Deals with three methods commonly practiced in fighting mine fires: direct method, in which water or chemicals are used; flooding; and sealing, and especially the dangers attending the sealing of a mine fire, particularly if located in a gaseous mine.

Some mine fires can be subdued by the inert gas method, using nitrogen and carbon dioxide. The presence of 8-10% oxygen might be tolerated. Such gases may be produced in an ordinary boiler furnace except that excess air should be controlled and gases should be cooled before application. Sketches of a suitable installation are given.

556. GALLOWAY, J. Some Experiences with Underground Fires. *Canadian Institute of Mining & Metallurgy.* Bulletin, No. 137, Sept., 1923, pp. 547-551.

Cites experiences, causes and remedies associated with fires in a mine in the Souris Valley coal field, Canada.

557. MITKE, C.A. Discussion of Measures for Preventing and Fighting Fires in Metal Mine Workings. *Engineering & Mining Journal.* Vol. 115, No. 7, Feb. 17, 1923, pp. 309-313.

Based upon personal experience at thirty mine fires. The primary object is to plan an efficient method of attack in the event of fire. Discusses best protection for shafts; rescue of men is first consideration; selection of fan depends upon local conditions; reversal of air currents is a delicate procedure; refuge chambers; velocity of ventilating currents; automatic fire doors; fire fighting methods.

558. ANON. Mine Fires and Explosions. *National Fire Protection Association.* Quarterly, Vol. 16, No. 3, Jan., 1923, pp. 236-243.

Describes several major mine fires (and explosions). Mine Fire Prevention. Bibliography.

559. MARQUARD, J.D. Fires in Mines. *Chemical Metallurgical and Mining Society of South Africa.* Journal, Vol. 31, Nos. 3, 7, 9, Sept., 1930, pp. 64-68, Jan., 1931, pp. 202-204, and March, 1931, pp. 258-259.

Origins of fires in metal mines; preventive action; precautions following an outbreak; rescue work; general remarks.

560. ANON. Engineers Encounter Many Problems on Mine Fire Project. *Coal Mining.* Vol. 14, No. 3, March, 1937, pp. 7-8.

Describes major engineering problems involved in the WPA Project to check the spread of the fire in the New

Straitsville OH area that has been burning for 53 years and has destroyed $50 million worth of coal. See also Items #561 and 562.

561. POWELL, W.S. Bottling Up an Underground Fire. *Compressed Air Magazine.* Vol. 42, No. 4, April, 1937, pp. 5297-5301.

Efforts to extinguish a coal mine fire burning since 1883 by placing barrier trenches and tunnels to be filled with earth and mud wherever the coal seam extends beyond the fire zone. Undertaking financed by Federal Govt. with a WPA Grant. See also Items #560 and #562.

562. ROBINSON, C.A. $50,000,000 Fire. *Excavating Engineer.* Vol. 31, No. 3, March, 1937, pp. 150-153.

Notes on WPA Mine Fire Project at New Straitsville, OH in effort to check fire which has burned since 1883. Tunnels being dug on three fronts to be filled with non-combustible material to limit spread of fire. Involves no effort to extinguish fire but to confine it to present limits.

See also Items #560 and #561. See also Fire Engineering, Vol. 93, No. 3, March, 1940, which shows project completed. Engineers predict fire will burn for another 50 years but not beyond barrier system provided.

563. JOHNSON, J.W. Fighting Fires Underground. *Colliery Guardian.* Vol. 160, No. 4123, Jan. 5, 1940, p. 17.

Discusses causes of coal mine fires; methods used; and notes on water supply for fire-fighting. From paper before North Staffordshire Colliery Under-Managers' Association.

564. GIBSON, C.S. Fire Prevention at Ontario Mines. *Canadian Mining Journal.* Vol. 70, No. 8, Aug., 1949, pp. 75-80.

Paper deals with underground (non-coal) mines; 50 regular producers employ approximately 25,000 persons, of whom about 14,000 work below surface; majority are gold mines; causes and locations of fires; use of chemicals to retard fire in wood; sprinklers, hose, etc.; ventilation; ruptured party walls between mines, both as hazard and as providing emergency escape; rescue stations; fire fighting apparatus; personnel for fire fighting and rescue work.

565. NETHERY, T.V. and SHORT, E.S. Lessons Learned from East Malartic Fire. *Canadian Mining & Metallurgical Bulletin.* Vol. 43, No. 458, June, 1950, pp. 316-320.

Fire occurred in metal mine on April 24, 1947. Cause has never been determined. It occurred on least likely place which was quite wet.

Account of fire with loss of 12 lives caused by CO; fire may start at least likely place under apparently ideal safety conditions; education and training for men in fire prevention cannot be over-emphasized; illustrations.

See also discussion on p. 606 of Canadian Mining & Metallurgical Bulletin, Nov., 1950.

566. ENNIS, W.L., CANT, A.W. and LITTLE, R.W. Prevention of Mine Fires at Noranda. *Canadian Mining & Metallurgical Bulletin.* Vol. 43, No. 456, April, 1950, pp. 197-202.

Paper outlines the causes of underground fires at Noranda Mines and the precautionary measures taken to guard against such metal mine fires in some detail. Also describes fire fighting methods and equipment and general procedure drill in case of fire. A spirit of fire consciousness has been developed. As a result no fire of serious consequence has developed. Chief risk is electricity; also granulated slag backfill when cemented by pyrrhotite oxidation.

567. HARDY, V.O., HATTERSLEY, R. and TAIGEL, P.G. Diesel Locomotives in Mines: the Fire Hazard from Hot Surfaces on the Exhaust System. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 126, 1956.

The occurrence of a number of fires on underground diesel locomotives has been due to overheating of the exhaust system, which ignited oily dust deposits fanned by the radiator cooling fan.

Tests were made under a variety of load conditions. Modifications were advanced to reduce the effects to a safe working range.

568. BRYAN, A.M. Creswell Colliery Disaster Report. *Iron & Coal Trades Review.* Vol. 164, No. 4395, July 4, 1952, pp. 23-26.

Disastrous fire started at transfer point of the trunk belt conveyor system in southwestern main intake haulage road in the High Hazel seam on Sept. 26, 1950. Because of the intensity and extent of the fire, it was necessary to seal the fire zone to deprive it of air. Behind the fire there were 131 men, 51 of whom escaped by the return airway and 80 were trapped and asphyxiated.

Examination of fire area; timber supports contributed to the conflagration; frictional heating theory developed; recommendations for prevention of conveyor fires, fighting fires, warning personnel, and means of escape.

569. REED, J.J. Mine Safety. *Mining Congress Journal.* Vol. 41, No. 8, Aug., 1955, pp. 58-62.

Every mine fire (or explosion) can be prevented or controlled. Deals with ventilation control; types of fire; evacuation plan; warning signals; fire drills; multiple doors; refuge design; stores of apparatus; training; savings due to safety control.

570. RYAN, J.T. Relationship between Sealing and Unsealing Mine Fires. *Mining Congress Journal.* Vol. 13, No. 7, July, 1927, pp. 520-521.

Detailed description of a recent coal mine fire. What happened. How it was handled. Rescue work. Sealing the fire. Exceptions to rules sometimes made necessary by conditions encountered.

571. HEERS, R.G. and DENNISON, W.K. Fire Fighting Experiences. *Mining Congress Journal*. Vol. 46, No. 7, July, 1960, pp. 61-64.

On June 8, 1958 a fire appeared in the Koehler coal mine near Raton, NM. Smoke was pouring out of the two intake airways. The fan had stopped because heat had affected the drive-belts. The mine was sealed leaving 28 million cu. ft. in the fire zone. Dry ice and liquid CO_2 were introduced - 1300 tons over a period of 7 months, enough to liberate 23.5 million cu. ft. of CO_2 gas, to cool the fire zone and subdue the fire. But its effect was reduced by surface leaks.

Seals were then advanced by crews equipped with breathing apparatus. Foam plugs were tried but not successfully.

The fire zone was then bypassed by constructing new entries and finally restricted to 400 × 600 ft. and then flooded. By the time operations could be resumed, $750,000 dollars and 3480 manhours of helmet work during 14 months of fire fighting had been expended.

572. ANON. About Maintenance and Mine Fires. *Coal Age*. Vol. 67, No. 8, Aug., 1962, pp. 80-81, 83.

Study of causes of 84 mine fires leads to conclusion that 60 were directly or indirectly result of improper maintenance, incorrect operating procedure, disregarding maintenance, poor safety practices and hazards associated with electricity and flammable hydraulic fluids; equipment components involved in mine fires in 1960 included trailing cables, trolley and feeder lines, control wiring, controls and electric motors, belt conveyors and bearings, oxygen and acetylene tanks, and compressors.

In 1961, 46 of the 59 mine fires reported were also directly or indirectly due to poor maintenance and disregard of safety practices in relation to maintenance and associated hazards.

573. BOGERT, J.R. How the Recent Magma Mine Fire was Brought under Control. *Mining World*. Vol. 24, No. 6, May, 1962, pp. 20-24.

Fire was discovered at 2900 ft. level of Magma copper mine, Arizona, Dec. 2, 1961; fire was successfully contained and mine purged of smoke and fumes on Feb. 7, 1962; this was accomplished by sealing off critical section with air tight concrete bulkheads, temporary brattice bulkheads, filling raises with muck and sealing with clay, grouting muck in raises, and grouting all suspect fractures that would serve to feed oxygen to flamed; ventilation proved to be decisive and most important factor in controlling fire.

Exact cause of fire is unknown but it is a hot dry mine with rock temperatures approaching 132° F. in lower levels. All underground workings are supported by timber. Fire was successfully brought under control without loss of life. Six main lessons are underlined. A day-by-day official fire program log is given. Ventilation was the key to fire control. Also refer to Item #574.

574. SHORT, B. Magma Mine Fire. *Mining Congress Journal.* Vol. 48, No. 9, Sept., 1962, pp. 42-45.

Fire started in caved section of Magma copper mine, Arizona, on Dec. 2, 1961; section had been mined out and in 1957 was sealed with brattices; fire started by spontaneous combustion when drill holes from new drift admitted air into sealed section; fire was controlled by sealing off critical section with airtight concrete bulkheads, temporary brattices, filling and sealing raises with clay and grouting all suspect fractures. See also Item #573.

575. CANT, A.W. Underground Fire at Noranda. *Canadian Mining Journal.* Vol. 84, No. 9, Sept., 1963, pp. 82-88.

A major underground (metal mine) fire occurred at the Horne Mine on about Oct. 6, 1962.

Fire apparently due to heat from oxidation of backfill. Experience with use of foaming agents and water to fight fire. Organization of fire fighting teams. Recommendations and preventive measures.

576. McCRODAN, P.B. Underground Fire at McIntyre Porcupine Mines Limited. *Canadian Mining Journal.* Vol. 86, No. 9, Sept., 1965, pp. 66-75.

On Feb. 8, 1965 major fire broke out 6500 ft. below surface and 5200 ft. from main shaft at Schumacher, Ontario, mine; path of fire extended vertically through 1190 ft. and horizontally through 7155 ft. of workings; fire was brought under control on Feb. 15; inside fire zone, which was sealed off, hi-expansion foam, water, and hydraulic backfill were employed to extinguish all traces of fire and suppress generation of carbon monoxide; by March 6 carbon monoxide had been reduced to nil reading, and fire area was opened and big cleanup commenced.

Also gives extent of fire damage; lessons learned; and comments on refuge stations, high expansion foam generators, carbon monoxide detectors and recovery program.

577. MURPHY, E.M., MITCHELL, D.W. and KAWENSKI, E.M. Quenching Face Ignitions. *Coal Age.* Vol. 72, No. 1, Jan., 1967, pp. 80-82.

The extended use of continuous miners has multiplied face hazards, particularly where frictional sparks are produced by cutter bits striking pyrite inclusions or hard rock. The need to minimize the ignition hazard has inspired the Bureau of Mines to develop and test a quenching device to be mounted on the machine. It is based on a flame-detection system that causes flame-quenching chemical dust to be rapidly discharged within the critical area.

Tests indicate four minimum design criteria needed for the device. Results of tests and future aims are explained.

578. ANON. Mandatory Safety Standards, Underground Coal Mines Miscellaneous Amendments. *United States Bureau of Mines Federal Register.* Vol. 38, No. 209, Oct. 31, 1973.

New and revised regulations are promulgated to reduce sources of electrical fires in underground coal mines and to strengthen fire fighting procedures. Specifically, they will:

1) establish a requirement that electric current permitted to exist between frames of electric face equipment be limited to not more than one ampere;

2) provide for frequent testing and calibration of devices for overcurrent protection;

3) specify requirements for movement of off-track mining equipment in areas where energized trolley wires or trolley feeder wires are present;

4) provide for instructions in the location and use of fire-fighting equipment, escapeways, exits, routes of travel and for fire drills;

5) improve two-way communication between working sections and the surface; and

6) require improved escapeways and periodic drills in their use.

579. BURRELL, G.A. The Use of Mice and Birds for Detecting Carbon Monoxide After Mine Fires and Explosions. *United States Bureau of Mines.* Technical Paper #11, 1912.

The presence of carbon monoxide in the air during and after a mine fire has caused the majority of fatalities, even among rescue teams. A miner's safety lamp gives warning of almost every other gas except CO. The use of mice and birds as an indicator of its presence was tested. Mice were not found to be significantly sensitive to CO poisoning. Small birds were much better indicators of poisonous atmosphere.

580. BURRELL, G.A. and SEIBERT, F.M. Gas Analysis as an Aid in Fighting Mine Fires. *United States Bureau of Mines.* Technical Paper #13, 1912.

When a mine fire zone is sealed, its progress is difficult to determine. The sampling of the atmosphere behind the seals and a study of the gas analyses so obtained can yield valuable information during a period of great anxiety. The evidence so obtained can help decide the time to unseal on the one hand and the need to flood on the other.

581. CLARK, H.H. The Factor of Safety in Mine Electrical Installations. *United States Bureau of Mines.* Technical Paper #19, 1912.

Gives five terse suggestions for reducing the number of accidents, including fires, due to electricity in mines.

582. RICE, G.S. Mine Fires. *United States Bureau of Mines.* Technical Paper #24, 1912.

Mine fires start in a small way except in the case of those caused by gas or coal dust explosions. Nothing causes so much dread among miners. Not only danger to life but also of great financial loss. Fires do not attract public attention unless large loss of life.

Deals in detail with underground fires, and methods of fighting, including warning systems, refuge chambers, equipment used, ventilation adjustments, sealing, gas analysis, flooding, snuffing with inert gases, and unsealing. Also gives a summary of precautions to be taken.

583. PAUL, J.W. Mine Fires and How to Fight Them. *United States Bureau of Mines.* Miners' Circular #10, 1912.

Basic need is to prevent a mine fire or to get it quickly under control if started. This is a matter for the individual miner. A fire out of control is a matter for the mine management and is not dealt with in this publication.

Deals with causes, general precautions, use of breathing apparatus, sounding an alarm, use of extinguishers or water nozzles, fire drill, smoke and gases, and first aid.

584. BURRELL, G.A. and SEIBERT, F.M. The Sampling and Examination of Mine Gases and Natural Gas. *United States Bureau of Mines.* Bulletin #42, 1913.

Deals with methods of collecting samples and of examinations of mine gases, and also of natural gas. Describes precise apparatus assembled for laboratory testing as well as portable apparatus for field work.

585. RICE, G.S., HOOD, O.P. et al. Oil and Gas Wells Through Workable Coal Beds. *United States Bureau of Mines.* Bulletin #65, 1913.

Describes a serious mine fire that occurred at Vandergrift, PA, on July 30, 1912 when gas from an abandoned gas well became ignited after coal mining operations had intersected the well.

586. RICE, G.S. International Conference of Mine Experiment Stations. *United States Bureau of Mines.* Bulletin #82, 1914.

Proceedings of conference include description of water supply and fire protection at the (Bruceton) Experimental Mine, also a paper by H.C. Porter on Spontaneous Combustion; by G.A. Burrell on Sampling and Analysis of Mine Gases; and on Mine Rescue Breathing Apparatus by J.W. Paul.

587. HIGGINS, E. Fires in Lake Superior Iron Mines. *United States Bureau of Mines.* Technical Paper #59, 1913.

Gives notes on mine fires in the previous 23 years; their causes; methods of fire prevention called for; fire fighting methods and equipment; gases encountered; ventilation effects; sealing arrangements.

Also deals with five particular fires; analyses of combustible black slates; causes and methods of preventing spontaneous fires.

588. INGALLS, W.R., DOUGLAS, J., FINLAY, J.R., CHANNING, J.P. and HAMMOND, J.H. Rules and Regulations for Metal Mines. *United States Bureau of Mines.* Bulletin #75, 1915.

Covers Federal draft regulations in force in 1915 including sections on inflammable material, fire fighting helmets, fire protection, fire buckets for electrical installation, two openings to surface. Also includes a digest of State metal mine inspection laws, and some historic mine fires such as London Mine (1909), Giroux Shaft (1911), Belmont Mine (1911), North Lyell Mine (1912), High Ore-Modoc Mine (1911), and Hartford Mine (1911).

589. BURRELL, G.A. and OBERFELL, G.G. Explosibility of Gases from Mine Fires. *United States Bureau of Mines.* Technical Paper #134, 1915.

Gives the results of observations of gases produced during mine fires and their respective liability to explode. Observations from a particular coal mine fire are also given.

590. FLEMING, J.R. and KOSTER, J.W. The Use of Permissible Explosives in the Coal Mines of Illinois. *United States Bureau of Mines.* Bulletin #137, 1917.

Points out the advantages of permissible explosives in avoiding mine fires in coal mines.

591. KATZ, S.H., ALLISON, V.C. and EGY, W.L. Use of Stenches as a Warning in Mines. *United States Bureau of Mines.* Technical Paper #244, 1920.

Opinion is stated that placing of stenches in compressed-air lines of mine to warn miners of danger offers certain advantages over use of electric bells or other means of warning. Of 24 chemicals examined, butyl mercaptan, ethyl mercaptan, amyl acetate, butyric acid and valeric acid were found most promising for mine warnings.

592. FIELDNER, A.C., KATZ, S.H., and KINNEY, S.P. Gas Masks for Gases Met in Fighting Fires. *United States Bureau of Mines.* Technical Paper #248, 1921.

Discusses physiological effects of various gases on firemen, whether from the mine atmosphere, from fires, or from various fire extinguishers. Types of breathing apparatus and respiration. Gases and atmospheres for which a gas mask does not protect. Effects of gases from incomplete combustion. A list of publications on mine fires and oxygen breathing apparatus.

593. STEIDLE, D. Causes and Prevention of Fires and Explosions in Bituminous Coal Mines. *United States Bureau of Mines.* Miners' Circular #27, 1920.

A pictorial guide, culled from reports of State Mines Departments and of Bureau of Mines, showing common causes of fires and explosions in coal mines. Also extends this approach by depicting both safe and dangerous practices with a descriptive notation. The aim is to demonstrate the dangers more clearly and forcibly.

594. HARRINGTON, D. Lessons from the Granite Mountain Shaft Fire, Butte. *United States Bureau of Mines.* Bulletin #188, 1922.

On June 8, 1917, the flame of a carbide lamp accidentally set fire to the damaged carcase of an oiled fabric armored power cable being lowered down the shaft. The fire spread to the timbers of the downcast shaft and the mine soon filled with smoke and gas. Of 410 men underground, 247 escaped and 163 perished. Only two of these were burned. The work of rescue and fire fighting continued for eight days. Gives details of the rescue work, the efforts of the trapped men, with conclusions and suggestions based on lessons learned as follows:

1. *The upper end of an electric cable being lowered in a shaft should be firmly clamped, even if such clamping does ruin 8 or 10 feet of cable.*

2. *Electric cables in hoisting or ventilation shafts are a fire hazard, and boreholes should be used to bring*

such cables into a mine if practicable; if not, they preferably should be placed in upcast shafts or in shafts or shaft compartments that are as nearly fireproof as possible.

3. *When a mine has two shafts and the one downcast is afire and filling the workings with smoke, efforts should be made by fans and other means to convert this shaft into an upcast.*

4. *The main hoisting shaft of every deep mine should be fireproofed.*

5. *Connections between mines should be closed with airtight doors held closed by a positive latch that can be readily opened from either side in an emergency.*

6. *To provide adequate ventilation and allow safe removal of men during a disaster, every mine should have at least two fully equipped shafts from the surface to the lower stoping level. All levels should be connected with both shafts.*

7. *Tight-fitting fire doors, preferably of fireproof construction, should be provided in every drift, crosscut, or other opening leading from any shaft. These doors should be of the self-closing type with a latch or other means to prevent opening (if kept normally closed) by reversal of the air current.*

8. *Direction signs in as many languages as needed to be understood by the mine personnel should be posted at suitable points, indicating plainly the direction of escape.*

9. *Timbered shafts should have ample facility for quick-action fire protection; and waterlines for fire protection should be extended through mine workings, especially if much timber or other combustible matter is present.*

10. *Means should be provided for warning men promptly in an emergency.*

11. *Rescue apparatus is likely to be of great value in saving life and property if a serious mine fire occurs, such as that in the Granite Mountain shaft or the Argonaut shaft. Men should be carefully trained to use such apparatus and to know its advantages and limitations.*

See also Item #445.

595. HARRINGTON, D., PICKARD, B.O., and WOLFLIN, H.M. Metal-Mine Fires. *United States Bureau of Mines.* Technical Paper #314, 1923.

Describes causes, methods of prevention, and methods of fighting fires in underground metal mines. Although not frequent, fires in metal mines can cause great loss of life and property and delays in operation. Mine superintendents should be well prepared for them. In 57 metal mine fires in the U.S. between 1866 and 1922, 520 lives were lost. Most lives lost through suffocation rather than direct fire injury. The cost of a mine fire is directly proportionate to lack of preparedness.

596. ANON. Mine Rescue Standards. *United States Bureau of Mines.* Technical Paper #334, 1923.

An international mine-rescue standardization conference appointed a committee to examine subject title. Gives reports of four subcommittees on investigations into

(a) rescue apparatus requirements and tests for permissibility,

(b) physiological effects in use of mine rescue apparatus and methods for detecting dangerous gas,

(c) one use of mine rescue apparatus in coal mines,

(d) on regulations for use of mine rescue apparatus in metal mines.

597. KATZ, S.H., GLEIM, E.J. and BLOOMFIELD, J.J. Carbon Tetrachloride Extinguisher on Electric Wires. *United States Bureau of Mines.* Report of Investigations No. 2499, July, 1923.

Gives the results of tests made to determine the nature and toxic properties of gases and smoke evolved when carbon tetrachloride extinguishers are applied to electric arcs, burning insulation or other types of electrical fire.

598. TRACY, L.D. and HENDRICKS, R.W. Small Hose Streams for Fighting Mine Fires. *United States Bureau of Mines.* Technical Paper No. 330, 1925.

Following on tests published in Technical Paper No. 24 (see Item #582) further tests were made to ascertain the equipment and pressures with which a man of average strength and weight could fight a mine fire most effectively. Results of tests and conclusions are given.

599. PICKARD, B.O. Lessons from the Fire in the Argonaut Mine. *United States Bureau of Mines.* Technical Paper No. 363, 1926.

Gives a description of the mine before the fire, an extensive account of the disaster, the causes of the fire, criticisms of the procedures used, the driving of the Kennedy Levels, recovery and rescue work, and gas sampling and analysis. Also discusses the failure to control the fire, the costs and effects.

See also Item #445.

600. PICKARD, B.O. Emergency Fans for Fighting Metal-Mine Fires. *United States Bureau of Mines.* Report of Investigations No. 2240, April, 1921.

In many cases the efforts of fire fighters are restricted because their vision is impaired by dense smoke. Describes an emergency mobile ventilation fan solely for fighting fire to provide enough forced ventilation for a fresh air base in their immediate vicinity without danger of seriously spreading the fire. Technical details are given.

601. BURRELL, G.A. and SEIBERT, F.M. (revised by G.W. Jones). Sampling and Examination of Mine Gases and Natural Gas. *United States Bureau of Mines.* Bulletin No. 197.

This Bulletin revises Bulletin No. 42 by updating the apparatus and procedures.

See also Item #584.

602. RICE, G.S., PAUL, J.W. and VON BERNEWITZ, M.W. Fifty-Nine Coal-Mine Fires. *United States Bureau of Mines.* Bulletin No. 229, 1927.

Essential details of reports on fires in different coal mines in United States, circumstances of origin and method of controlling or extinguishing fires, lessons taught; in all, fires caused great damage to property and killed nearly 400 men.

603. HOWARD, H.C. and GREENWALD, H.P. Tests with Rock Dust for Extinguishing Fire. *United States Bureau of Mines.* Report of Investigations No. 2801, April, 1927.

Test results show that rock dust may be effective to control fire when a blanket of 2" of dust is used to smother the flame. Localizes the flame. Does not evaporate like water. Ventilation should be restricted for best results.

604. GREGORY, F.C. Fires and Fire Prevention in Lake Superior Mines. *United States Bureau of Mines.* Information Circular No. 6073, June, 1928.

Reviews the mine fire record of the Lake Superior district noting the frequency of fires, their causes and the fire prevention methods employed. Those fires occurring in 1917-1928 are likely to involve more sophisticated methods than 40 fires prior to 1917. A survey of fire hazards and a detailed plan of firefighting in each mine is recommended.

The circumstances attending fires which have recently occurred compel the conclusion that the mines of the district contain serious fire hazards. However, much *good fire-prevention work has been done, the results of which are seen in the decrease in fires in shafts and stations through fireproofing. The tendency in new construction is toward fireproof structures. Some mines have done practically all that is possible in the way of providing firefighting equipment, trained men, building fire doors, installing stench warnings, keeping the mine clean, and formulating fire-fighting plans. The protected class of mines is becoming larger each year, but there are still a few which are unprotected and have grave fire hazards.*

Probably the most essential factor in the handling of a mine fire is mechanical control of ventilation; hence every mine, metal as well as coal, should have a mechanically operated fan and a well systematized coursing and control of air currents.

605. MARSHALL, K.L. How Fires Start in Mines. *United States Bureau of Mines.* Information Circular No. 6076, July, 1928.

Causes discussed under two heads: (a) foreign heat ignitions, such as external flames, heat or electricity and (b) spontaneous combustion. Each type is dealt with in some detail.

606. ILSLEY, L.C. Electrical Accident Prevention. *United States Bureau of Mines.* Information Circular No. 6100, Feb., 1929.

There are many ways in which poorly installed or maintained electric circuits or apparatus may cause a mine fire. These possibilities are discussed.

607. RICE, G.S. Safety in Coal Mining. *United States Bureau of Mines.* Bulletin No. 277, 1928.

A handbook outlining the most important aspects of safe practice in coal mining operations, including an analysis of accidents and the many critical aspects of ventilation.

608. DAVIS, J.D. and REYNOLDS, D.A. Spontaneous Heating of Coal. *United States Bureau of Mines.* Technical Paper No. 409, 1928.

Deals with the review of 29 previous investigations and summarizes these. Discusses theories of spontaneous heating of coal and relative tendencies of various coals to oxidize. Gives methods of determining this tendency by large scale and laboratory methods.

609. COWARD, H.F. and JONES, G.W. Limits of Inflammability of Gases and Vapors. *United States Bureau of Mines.* Bulletin No. 279, Revised, 1931.

Presents a comprehensive listing of inflammability limits of various gases and vapors in air and other atmospheres.

610. HOWARTH, H.C. and McCAA, G. Control of a Small Mine Fire with Rockdust. *United States Bureau of Mines.* Report of Investigations No. 2914, Feb., 1929.

Describes recovery operations following a coal mine explosion in which 12 small fires were encountered. All except one of these was quickly subdued by the recovery parties. The other had spread and was burning briskly. Describes how the fire was brought under control and extinguished by the use of rockdust following initial action with fire extinguishers. Method was in line with Test 7, Report of Investigations No. 2801. See Item #603.

611. MILLER, A.U. Fire Fighting Equipment and Organization of the Madison Coal Corporation, Glen Carbon, Madison County, IL. *United States Bureau of Mines.* Information Circular No. 6323, July, 1930.

Surface and underground fire protection; equipment, organization, fire prevention, and fire-fighting practices; company operates several mines and its policy is to maintain high standards in training of personnel in fire prevention and fire fighting, safety promotion, mine rescue, and first aid.

Seven general rules for handling mine fires are given.

612. HARRINGTON, D. and OWINGS, C.W. Mine Explosions, Mine Fires, and Miscellaneous Accidents in the United States during Fiscal Year Ended June 20, 1930. *United States Bureau of Mines.* Information Circular No. 6419, Jan., 1931.

At least 24 mine fires were reported, 19 of which were in coal mines, 4 in metal mines, and 1 in railroad tunnel; coal-mine fires resulted in four deaths and metal-mine fires in one fatality; no lives lost in tunnel fire; tabular data and analysis of causes and circumstances.

613. HARRINGTON, D. and VON BERNEWITZ, M.W. Hazards to Underground Workers from Inflammable Surface Structures Near Mine Openings. *United States Bureau of Mines.* Information Circular No. 6557, March, 1932.

Extracts from fire-control article of proposed mine safety law in preparation; examples of surface fires which transmitted fire or smoke to mine openings; data compiled from reports submitted by engineers to U.S. Bureau of Mines.

Nine pertinent conclusions are given based on actual examples of surface fires which transmitted fire or smoke to mine opening.

614. HARRINGTON, D. Mine Explosions and Fires in United States During Fiscal Year Ending June 30, 1931. *United States Bureau of Mines.* Information Circular No. 6540, Dec., 1931.

24 fires with 23 fatalities in 14 States, as compared with 24 fires in 14 States and only 5 fatalities in previous fiscal year; electricity caused 7 fires; 3 fires caused by open lights or smoking; 5 by explosives, 9 due to miscellaneous or unknown causes.

615. HARRINGTON, D. Underground Ventilation at Butte. *United States Bureau of Mines.* Bulletin No. 204, 1923, pp. 37, 69, 107, 113.

Describes the ventilation problem in an old mining district where most mines are interconnected yet some have mine fires burning continuously since 1889. Fumes from a fire in one mine reach adjoining mines very quickly. Typical analyses of fire gases are given. Rock temperatures in working places are significantly increased by those in neighboring fire zones.

616. HARRINGTON, D. Mine Explosions and Fires in United States During Fiscal Year Which Ended June 30, 1932. *United States Bureau of Mines.* Information Circular No. 6680, Jan., 1933.

21 fires with 1 death only in 10 states; 8 fires were of electrical origin and one of these caused 1 death of year from fire, in state of Washington.

617. HARRINGTON, D. Metal-Mine Fires and Ventilation. *United States Bureau of Mines.* Information Circular No. 6678, Jan., 1933.

Analytical study of metal mine fires, their causes and consequences, and methods of prevention, control, and extinguishing, with special reference to inter-relation of ventilation and fires.

Gives a list of causes of several metal mine fires up to 1933 and a bibliography of articles dealing with mine fires.

618. HARRINGTON, D. and VON BERNEWITZ, M.W. Saving Life by Barricading in Mines and Tunnels at Times of Disaster. *United States Bureau of Mines.* Information Circular No. 6701, April, 1933.

Describes many instances where trapped miners survived by barricading themselves in temporary refuge chambers out of reach of the main air current, polluted by a mine fire.

Explains the principles of barricading and sets out the requirements.

Some mining companies now erect permanent refuge chambers, or maintain stacks of barricading materials at strategic points in the mine, and many instruct employees in the methods and use of barricades along with their safety drills.

619. ANON. Recommendations of the United States Bureau of Mines on Certain Questions of Safety as of February 3, 1933. *United States Bureau of Mines.* Information Circular No. 6732, July, 1933.

Findings of a Mine Safety Board established by the Bureau of Mines to define and explain safety practices, devices and methods for underground mining operations. A list of 25 definitions or clarifications is given, some of which are applicable to conditions that may cause or be affected by mine fires.

620. HARRINGTON, D. and FENE, W.J. Mine Explosions and Fires in United States During Fiscal Year Ended June 30, 1933. *United States Bureau of Mines.* Information Circular No. 6761, Jan., 1934.

Studies of 22 explosions in 10 states, and of 27 mine fires, 5 in metal mines; nearly one third of fires, causes of which are known, were due to electricity; 2 were caused by explosives and 8 were of spontaneous origin.

621. RICE, G.S. and HARTMANN, I. Liquid Carbon Dioxide Used to Extinguish a Gob Fire in German Coal Mines. *United States Bureau of Mines.* Information Circular No. 6970, Nov., 1937.

Describes a novel method of extinguishing a coal mine fire in a gob-filled area by using liquid CO_2 under high pressure. Used successfully at the President Coal Mine, Bochum, Germany. Fire Zone must be well sealed. See also Item #134.

622. GLEIM, E.J. Coal-Mine Fires of Electrical Origin; Their Cause and Prevention. *United States Bureau of Mines.* Information Circular No. 6981, Dec., 1937.

Modern methods of coal extraction call for the use of electrically-operated machinery. The consequent increased use of electricity introduces additional hazards and causes of fire and explosion.

Some fire hazards and their elimination; descriptive notes on some fires of actual or suspected electrical origin; summary of lessons learned from fires discussed; U.S. Bureau of Mines tests to determine possibility of igniting coal and other materials by electrical means, fire prevention; fire fighting equipment and materials.

623. BERGER, L.B. and SCHRENK, H.H. Bureau of Mines Haldane Gas Analysis Apparatus. *United States Bureau of Mines.* Information Circular No. 7017, May, 1938.

Describes the Haldane Gas-Analysis Apparatus as used by the Bureau of Mines to permit accurate determination of gases encountered in mine fires. Accuracy and limitations of the apparatus, and methods of calculating results are included.

624. SCOTT, G.S. and JONES, G.W. Composition and Inflammability of Gaseous Distillation Products from Heated Anthracite. *United States Bureau of Mines.* Report of Investigations No. 3378, Feb., 1938.

Investigation forms part of program dealing with causes, behavior, and control of anthracite mine fires; study included means for detecting incipient heating underground, and of determining trend of heating once a fire is known to be present; amount and composition of gaseous distillation products liberated by three anthracites at temperatures varying from room temperature to 1000 C.

625. SCOTT, G.S., JONES, G.W. and COOPER, H.M. Effect of Oxidation on Volatile Matter of Anthracite and Its Significance in Mine-Fire Investigations. *United States Bureau of Mines.* Report of Investigations No. 3398, May, 1938.

Report on tests supplementing paper in Industrial & Engineering Chemistry, July 1937; work was done to determine not only relationship of oxidation products at temperatures up to 350 C. but also composition of distillation products up to 1000 C; effect of oxidation of composition of coal. See Item #624.

626. McELROY, G.E. Some Observations on the Causes, Behavior, and Control of Fires in Steep-Pitch Anthracite Mines. *United States Bureau of Mines.* Information Circular No. 7025, June, 1938.

All available records of fires that had occurred in large group of mines in Western Middle and Southern fields of Pennsylvania anthracite district were examined and analyzed; present report is primarily discussion of factors, based on close study of these particular records.

A list of tentative recommendations is given, with a view to reducing fire occurrences in anthracite mines.

627. SCOTT, G.S. Heat Liberated in Low-Temperature Oxidation of Anthracite. *United States Bureau of Mines.* Information Circular No. 7053, March, 1939.

Supplementing study from Report of Investigations No. 3398, present work was undertaken as further step in elucidating causes of heating in certain anthracites subjected to oxidation; calculated values of heat liberated given; only known direct determination of heat liberated by low temperature oxidation was made by F.E. LAMPLOUGH and A.M. HILL, in 1913.

628. GUITERAS, J.R. Fireproofing Mine Shafts. *United States Bureau of Mines.* Information Circular No. 7075, May, 1939.

Of 40 mine fires in the Lake Superior region before 1917, 22 originated in shafts or shaft stations, and 16 out of 50 fires in 1917 to 1928. Mine shafts are exceedingly *vulnerable in mine fire situations, especially where timbered. Explains the need to fireproof shaft structures by concreting or by guniting the timber; or using steel sets and guides. Concrete can be applied as a continuous lining, as precast set members, or as discontinuous concrete rings. The use of gunite sprayed over timber as a fireproofing measure is explained in detail. Recommendations made for a comprehensive range of fireproofing measures in shafts.*

629. JONES, G.W. and SCOTT, G.S. Oxidation of Carbon Monoxide and Hydrogen by Bacteria. *United States Bureau of Mines.* Report of Investigations No. 3466, Sept., 1939.

Observations in controlling anthracite mine fires show that carbon monoxide disappeared from a sealed fire area much more rapidly than a leakage of gases can explain. An investigation was made on the effects of action of microorganisms such as may be attributed to mule droppings or to decay of mine timber; results show that hydrogen and carbon monoxide are oxidized by certain soil bacteria and that such bacteria seem to be identical with Beijerinck and Van Delder's Bacillus oligocarbophilum.

630. SCOTT, G.S. and JONES, G.W. Phenomena Observed During Prolonged Oxidation of Anthracite. *United States Bureau of Mines.* Report of Investigations No. 3504, April, 1940.

Report supplements data from Information Circular No. 7053 (see Item #627). Sample of 28 to 48-mesh anthracite was oxidized at 300 C., in oxygen for 848 hours; sample lost 78.2% of its original dry weight; investigation gave change in composition of gaseous oxidation products during prolonged oxidation and change in composition of coal with extent of oxidation.

631. FIELDNER, A.C. and BREWER, R.E. Annual Report of Research and Technologic Work on Coal, Fiscal Year 1939. *United States Bureau of Mines.* Information Circular No. 7105, March, 1940.

Includes a section on fires in anthracite mines.

632. SCOTT, G.S. and JONES, G.W. Effect of Particle Size on the Rate of Oxidation of Anthracite. *United States Bureau of Mines*. Report of Investigations No. 3546, Jan., 1941.

For particle sizes less than 20-mesh the initial rate of oxidation increases more slowly per unit of increase of surface area than particles larger than 20 mesh; it also appears to reach a maximum beyond which further subdivision of the particles has no effect, within the temperature range studied (150-350° C).

633. SCOTT, G.S. Anthracite Mine Fires: Their Behavior and Control. *United States Bureau of Mines*. Bulletin No. 455, 1944.

Important factors are oxidation rate; rate of heating and cooling; effect of oxidation on composition; composition of mine atmospheres and their significance in connection with fires. Includes 82 figures.

634. GRIFFITH, F.E., GLEIM, E.J., ARTZ, R.T. and HARRINGTON, D. Prevention of Fires Caused by Electric Arcs and Sparks from Trolley Wires. *United States Bureau of Mines*. Information Circular No. 7302, Nov., 1944.

Coal production in war time invites opportunity for sabotage and mine fires offer the best method. During 2 years, 40 serious coal mine fires have occurred in the U.S. and many more fires of lesser degree; and 104 lives have been lost, nearly all in electrically caused fires. About 50,000 miles of electric trolley wire is installed, and it represents a potential fire hazard.

These fire hazards must be minimized. Improvements are suggested and discussed.

635. ELDER, J.L., SCHMIDT, L.D. and STEINER, W.A. Relative Spontaneous Heating Tendencies of Coals. *United States Bureau of Mines*. Technical Paper No. 681, 1945.

Includes a description of a test method and apparatus *developed. A total of 46 samples of coal of various ranks were examined and their relative tendencies to heat were determined.*

636. CASH, F.E. and JOHNSON, E.W. Stench Warning Tests, Lake Superior District Mines. *United States Bureau of Mines.* Report of Investigations No. 3850, Nov., 1945.

Most underground mines of Lake Superior district are prepared to inject stench liquid into compressed-air system quickly to give warning to underground mine workers at occurrence of mine fire or other threatened disaster; 9 tests were made with ethyl mercaptan and 3 with amyl acetate; ethyl mercaptan is considered more effective; neither is toxic.

637. GROVE, G.W., GRIFFITH, F.E. and BURDELSKY, H.R. Procedure Used in Fighting and Sealing a Fire in an Ohio Coal Mine and Recovery of the Mine by Air-Locking Methods. *United States Bureau of Mines.* Information Circular No. 7418, Oct., 1947.

Fire described was discovered Dec. 11, 1941; panel room and pillar mining, without pillar extraction; ventilation system; details of fire and rescue; sealing; sampling and analysis of mine atmosphere; air locking; recovery operations; removing gas from newly recovered areas.

Concluded that a sealed mine fire can be controlled and recovered safetly by air locking methods by strictly observing nine important points.

638. HARRINGTON, D. and FENE, W.J. Barricading as a Life-Saving Measure Following Mine Fires and Explosions. *United States Bureau of Mines.* Miners' Circular No. 42, revised Dec., 1946.

Updates MC 25 of 1923 and MC 42 of 1941 with later examples and new material.

The value of barricading methods is underscored and knowledge of such methods should be widely disseminated among *miners, and at conferences of mine executives, with the object of reducing the number of lives otherwise lost by mine fires and explosions.*

639. ASH, S.H. and FELEGY, E.W. Analyses of Complex Mixtures of Gases. *United States Bureau of Mines.* Bulletin No. 471, 1948.

Such analyses are applied to the control and estinguishment of fires and the prevention of explosions in mines, tunnels and hazardous industrial processes.

640. GROVE, G.W. and QUENON, E.E. Outcrop and Underground Mine Fires in Allegheny County, PA. *United States Bureau of Mines,* Information Circular No. 7434, Feb., 1948.

Typical examples of fires investigated by Bureau of Mines representatives during 5 yr; damages to property and to health of persons living in vicinity of fire will increase proportionately unless prompt measures are taken to extinguish them or retard their progress; work will have to be handled as project and at expense of general public.

641. LOOK, A.D. Underground Metal-Mine Fires from Cutting and Welding. *United States Bureau of Mines.* Information Circular No. 7453, April, 1948.

Review of 19 examples of fires caused by cutting and welding; precautions to be taken to prevent other fires from this cause; suggested general rules.

Promiscuous use of welding and cutting equipment underground at any time or in any place is not safe practice. Preliminary precautions and adequate follow-up in connection with underground cutting and welding operations require a little time and effort; but as long as there is the slightest chance of a mine fire from that source, all feasible precautions should be taken.

642. HERBERT, C.A., GALLAGHER, W.A. and SMITH, F.J. Investigation of Fire in the Kings Mine, Princeton Mining Co., Princeton, IN. *United States Bureau of Mines.* Information Circular No. 7491, Feb., 1949.

A fire started on Nov. 10, 1947, about 1800 feet inby the main shaft bottom. No lives were lost, as 27 men escaped after a series of explosions which necessitated sealing the mine.

Adverse conditions were overcome, when reopening, by expert planning and close cooperation and comparatively little difficulty and risk was experienced. Conclusions are given.

643. GROVE, G.W. and SIMPSON, O.V. Fire Fighting Facilities at Four Pennsylvania Bituminous Coal Mines. *United States Bureau of Mines.* Information Circular No. 7498, April, 1949.

Hazards of mine fires; serious results of mine fires; fire fighting facilities at Indianola mine, Republic Steel Corp; Springdale mine, Allegheny Pittsburgh Coal Co., Renton No. 3, and Montour No. 10 Mines, Pittsburgh Coal Co; requirements of mining laws and Federal safety code for fire fighting facilities.

644. FORBES, J.J. and FENE, W.J. Report of the Health and Safety Division, Fiscal Year 1949. *United States Bureau of Mines.* Information Circular No. 7562, 1950.

Refers to the need to gain control of fires in inactive coal deposits that have caused the loss of thousands of acres of valuable coal reserves, damaged surface property, and menaced the lives and health of the inhabitants.

645. WESTFIELD, J., BRUMBAUGH, H.C. and WHITTAKER, R.W. Extinguishing Fire with Carbon Dioxide in the Valier Mine, Valier Coal Co., Valier, Franklin County, IL. *United States Bureau of Mines.* Information Circular No. 7563, 1950.

Describes the sealing of a coal mine fire and the subsequent use of CO_2 gas to extinguish it. On March 29, 1949, a fire *of electrical origin was discovered. All men were ordered from the mine. Four temporary seals were placed. Two were blown out by an explosion produced by the fire. They were rebuilt and again blown out. Attempts to dam and apply water were unsuccessful. Four seals were completed and 5 tons of CO_2 gas was introduced which extinguished the fire. About one hour after CO_2 was introduced one seal was cooled to normal. However it was a small localized fire.*

646. O'CONNOR, J.A., MALESKY, J.S. and HIGGINS, T.C. Fighting a Fire in No. 59 Mine, Peabody Coal Co., Springfield, IL. *United States Bureau of Mines.* Information Circular No. 7564, 1950.

On August 15, 1949 a fire of electrical origin occurred. All 257 men escaped, but 75 had to use gas masks or self-rescuers. The fire was fought directly with rock dust and by loading out the burning material for 3 days, after which it was decided to seal the mine. Carbon dioxide was introduced. There was much leakage but enough cooling was achieved to promptly reopen the seals without rekindling the fire. A number of important conclusions are enumerated.

647. NAGY, J., HARTMANN, I and HOWARTH, H.C. Tests on the Control of Coal Mine Fires in the Experimental Coal Mine. *United States Bureau of Mines.* Report of Investigations No. 4685, April, 1950.

Fires in ordinary solid materials; fires in oil, gasoline, paints, solvents or other liquids; class "C" fires involve electric equipment; test zone located in concreted section of main aircourse in experimental mine; floor, rib and roof fires; test equipment and procedure; control of fires; relative effectiveness of extinguishers. Bibliography.

648. ASH, S.H. Carbon Dioxide Content of Mine-Fire Atmospheres as Aid When Fighting Metal-Mine Fires. *United States Bureau of Mines.* Information Circular No. 7590, Dec., 1950.

Controlling mine fires and preventing explosions and other accidents require collection and analyses of samples of atmospheres surrounding fire; air analyses furnish only means of judging what is going on in fire area; problem of gas poisoning is great in non-coal mines because of more frequent occurrence of poisonous and noxious gases; lack of controlled ventilation, and greater difficulties in sealing mine fire areas. Bibliography.

649. GALLAGHER, F.J. Minimizing Fire Hazards in Coal Mines by Proper Circuit-Breaker Protection of 250/275-Volt Direct-Current Systems. *United States Bureau of Mines.* Information Circular No. 7624, 1951.

Existence of fire hazards in mines despite use of circuit breakers; means to overcome hazards; method for determining whether additional circuit breaker protection is required for 250/275-v d-c distribution system; test conditions and results.

650. COWARD, H.F. and JONES, G.W. Limits of Flammability of Gases and Vapors. *United States Bureau of Mines.* Bulletin No. 503, 1952.

Definitions and conditions for flame propagation. Covers inflammability limits of most individual gases and vapors in various atmospheres.

651. WALKER, W.D., Jr., EATHORNE, W., POLACK, S.P. and KEENAN, C.M. Fire-Fighting Equipment in Coal Mines. *United States Bureau of Mines.* Information Circular No. 7662, 1953.

Fire classification; grouping of mines, and selection of fire fighting facilities according to group size; selection, placement and care of fire fighting facilities; inspections, training, maps, and efficiency ratings of hand type equipment.

652. SHAW, J.F. Graphic Method of Determining Explosibility Characteristics of Mine-Fire Atmospheres. *United States Bureau of Mines.* Bulletin No. 551, 1955.

Analysis of complex mixtures of gases encountered in mine fires and application of these data in fire fighting procedures; how analysis of mine fire gases can be utilized to determine progress of mine fires and to establish safe tactics for controlling and extinguishing fires; charts for determining whether given gas is explosive or capable of forming explosive mixture with air.

653. BROWN, C.L. Preventing Coal-Mine Fires Caused by Electrical Equipment. *United States Bureau of Mines.* Information Circular No. 7716, 1955.

Coal mine power distribution systems and equipment; electric power source and application; methods of power distribution; short circuit protection of power circuits, and direct current power facilities in four coal mines; short circuit protection of secondary branches.

Fire hazards from underground power distribution systems are at a minimum only where designed with accepted good emergency practices and protected from direct short circuits that do not isolate the power. Seven common methods of avoiding this problem are given.

654. HUMPHREY, H.B. and STRATTON, H.J. Bibliography of Bureau of Mines Health and Safety Publications, January 1947-June 1955. *United States Bureau of Mines.* Bulletin No. 558, 1956.

Includes a section dealing with mine fires.

655. VAN NATTER, P.V. Fire-Protection System, Allen Coal Mine, Colorado Fuel and Iron Corporation, Stonewall, CO. *United States Bureau of Mines.* Information Circular No. 7852, 1958.

Guide in selection, placement, and care of fire protection systems in similar coal mines; ventilation, haulage, *and electrical system; water supply, surface fire fighting facilities, underground fire fighting equipment rock dusting machines, and fire extinguishers; care of fire fighting equipment; fire fighting organization.*

656. STAHL, R.W. Firefighting Facilities at Coal Mines Compared with Those at Other Industrial Plants. *United States Bureau of Mines.* Information Circular No. 7931, 1959.

Comparison of facilities, equipment, training and suggestions as to where in mines improvements can be made.

657. KEENAN, C.M. Coal-Mine Fires and Gas and/or Dust Ignitions Since Enactment of 1952 Federal Coal Mine Safety Act. *United States Bureau of Mines.* Information Circular No. 7967, 1960.

Disaster potential from mine fires and gas and/or dust ignitions in coal mines after 7½ yr. under Federal Coal Mine Safety Act; tabulated data on mine fires, ignitions, injuries, and deaths.

658. McDONALD, T.J. Use of High-Expansion Foam on Pennsylvania Coal-Mine Fire. *United States Bureau of Mines.* Information Circular No. 8019, 1961.

Mine and fire control facilities and application of high-expansion foam; air entering fire area must be coursed through net where foam is generated; foam generator may be moved to control leading edges of fire that may be endangering particular area; high-expansion foam generating unit is not substitute for any standard fire-fighting equipment, but is supplemental thereto. Other important conclusions are given.

659. GRIFFITH, F.E., MAGNUSON, M.O. and TOOTHMAN, G.J.R. Control of Fires in Inactive Coal Formations in United States. *United States Bureau of Mines.* Bulletin No. 590, 1960.

Procedure for initiating cooperative fire-control projects on non-Federal lands; source of ignition, hazards, and destruction; method of controlling fires; research to develop fire-control methods and fire-control projects.

660. MITCHELL, D.W., MURPHY, E.M., NAGY, J. and CHRISTOFEL, F.P. Practical Aspects of Controlling an Underground Fire on a Mining Machine. *United States Bureau of Mines.* Report of Investigations No. 5846, 1961.

Most fires in coal mines are started by electrical arcs that ignite hot oil, grease and dust on mining machines. Fires spread to electric cables, coal accumulations, and to hoses and tires. Miners generally try to disconnect power, apply extinguishing agents and rock dust. If fires are not controlled, the areas are sealed.

Studies made in experimental coal mine to evaluate effectiveness of extinguishing agents and techniques; investigation showed that water containing alkali metal salt or surface active agent was more effective than water alone; ability to control fire increased as distance of attack decreased; dry powders controlled fire when applied by shovel but not when applied airborne by rock dust distributor or by hand fire extinguishers.

Dry alkali metal salt powders quenched the fire more readily than limestone dust. In each instance, the finer the powder, the greater its effectiveness.

661. HARTMANN, I., NAGY, J., BARNES, R.W. and MURPHY, E.M. Studies with High-Expansion Foams for Controlling Experimental-Coal-Mine Fires. *United States Bureau of Mines.* Report of Investigations No. 5419, 1958.

Foam is formed by spraying dilute solution of foaming agent in water on lace knitted cotton net stretched across entire mine entry; air-filled bubbles fill cross section of entry and create foam plug that is moved toward fire by ventilating current; blanketing effect and decrease in oxygen concentration, cooling action on fire stops combustion.

About 35 foaming agents were tested in the laboratory, with widely differing results. The scale of laboratory experiments was too small. In the experimental mine, it was shown that the vital factors in achieving control of a fire were the moisture content of the foam, the tightness of the plug in the mine entry and the rate of vaporization of the moisture in the hot fire zone.

662. NAGY, J., MITCHELL, D.W. and MURPHY, E.M. Sealing a Coal-Mine Passageway Through a Borehole: A Progress Report. *United States Bureau of Mines.* Report of Investigations No. 6453, 1964.

Summarizes initial research by Bureau of Mines on subject topic.

Information is presented on remote sealing of mine passageway through borehole by five methods - penumatic injection of mineral wool and sand, urea-formaldehyde foam, balloons, urethane foam, and caving by blasting; adaptation of method using pneumatically conveyed mineral wool was tried in operating mine; further research is needed to simplify and to improve techniques involved, as well as to explore possibilities of other methods and combinations.

663. BROWN, C.L. Coal-Mine Hazards Caused by Electrolysis. *United States Bureau of Mines.* Information Circular No. 8088, 1962.

Fires in coal mines may sometimes be caused by stray electric currents from d-c traction systems; conventional d-c power-distribution system in coal mines is conductive to electrolysis damage to mine tracks, metallic pipe lines, grounded power conductors, and structures in position to become conductors of stray currents; some of electrolysis hazards in coal mining industry and corrective measures to alleviate them.

664. STAHL, R.W. Equipment, Accessories, and Procedure for Fighting Mine Fires with High-Expansion Foam. *United States Bureau of Mines.* Information Circular No. 8085, 1962.

Auxiliary equipment required with large and small foam generators, portability, storage, erection of generator and equipment, operation and maintenance of large and small generators; procedure adopted by some companies in event of fire; fire drills; suggestions and precautions; suggested procedures for mock fire drills.

665. HUFF, W.J. Annual Report of the Explosives Division, Fiscal Year 1938. *United States Bureau of Mines.* Report of Investigations No. 3454, June, 1939.

Refers to the effect of oxidation on the volatile matter of anthracite and its significance in mine fire investigations; the significance of low-temperature oxidation products in anthracite mine fire studies; associated with the investigation of causes, behavior and control of anthracite mine fires. Reports relating to mine fires published during the year.

666. HUFF, W.J. Annual Report of the Explosives Division, Fiscal Year 1939. *United States Bureau of Mines.* Report of Investigations No. 3490, Feb., 1940.

Includes a section dealing with the investigation of causes, behavior and control of anthracite mine fires.

667. HUFF, W.J. Annual Report of the Explosives Division, Fiscal Year 1940. *United States Bureau of Mines.* Report of Investigations No. 3537, Nov., 1940.

Includes a section on the investigation of causes, behavior and control of mine fires.

668. HUFF, W.J. Annual Report of the Explosives Division, Fiscal Year 1941. *United States Bureau of Mines.* Report of Investigations No. 3602, Jan., 1942 and No. 3669, Dec., 1942.

Includes a section on the investigation of causes, behavior and control of mine fires.

669. ROBERTS, A.F. Some Aspects of Fire Behavior in Tunnels. *Tunnels and Tunnelling.* Vol. 5, No. 1, Jan., 1973, pp. 73-76.

Special considerations need to be given to fires in vehicular tunnels. The seat of a fire may be inaccessible due to distance and smoke. Also, toxic fumes circulated by the ventilation system may endanger lives downwind. Many flammable materials not ordinarily dangerous may make downwind atmosphere irrespirable if involved in a tunnel fire.

The effect of a tunnel fire may produce toxic gases, thermal effects (on walls and vehicle loads), smoke and carbon monoxide, and aerodynamic disturbances to tunnel ventilation.

Factors defining the severity and size of a tunnel fire are given.

670. ANON. Symposium on Underground Fires Held at Welkom on Feb. 11, 1970. *Journal of the Mine Ventilation Society of South Africa.* Vol. 23, No. 10, Oct., 1970, pp. 158-179.

Six papers were presented. See Items #436-441.

671. ANON. Symposium on Fires in Gold Mines. *Journal of the Mine Ventilation Society of South Africa.* Vol. 26, Nos. 2, 6, 9-12, Feb., June, Sept. to Dec., 1973.

Opening address by A.B. Daneel. Eight papers were presented. See Items #428-435. Closing address by E. A. Quilliam.

672. ENZIAN, C. The Warrior Run Mine Disaster. *Mines and Minerals.* Vol. 27, May, 1907, pp. 439-444.

This coal mine fire occurred on Aug. 1, 1906, in the Warrior Run Colliery of the Lehigh Valley Coal Co. Presence of wood smoke and after-damp in the upcast was the first evidence of the fire.

Describes the unusual situation in that this fire presented three complex and treacherous elements: a fire, the prevalence of gas susceptible to explosions, and squeeze of the strata.

Fire was successfully extinguished after 2 months without flooding.

673. MITKE, C.A. The Prevention and Fire Fighting Methods at Mines. *Arizona Mining Journal.* Vol. 6, No. 22, April 15, 1923, pp. 7-9.

Provides a general discussion of the pros and cons of many procedures for fighting fires in metal mines.

674. YOUNG, G.J. Fires in Metalliferous Mines. *American Institute of Mining Engineers.* Bulletin, Oct., 1912.

Cites seven metal mine fires in Nevada up to 1911. Discusses the need for fireproof construction, the comparative cost of such construction, methods of preventing the spread of fires, the fighting of mine fires, and suggested metal mine fire regulations.

675. MURPHY, E.M. Flame Spread Evaluation of Ventilation Cloth. *United States Bureau of Mines.* Report of Investigations No. 7625, 1972.

The Coal Mine Health and Safety Act of 1969 states that brattice cloth used underground shall be of flame-resistant material which means that brattice cloth (jute or any substitute) and ventilation tubing use underground shall be flame-resistant to the extent that the flame spread index, as determined by ASTM test methods E-84 or E-162, shall be 25 or less. Tests conducted at the

Experimental mine confirm ASTM test results and that materials having a flame spread index of 25 or less do not present a serious fire hazard in a coal mine.

676. POLACK, S.P., SMITH, A.F. and BARTHE, H.P. Recent Developments in Fire-Resistant Hydraulic Fluids for Underground Use. *United States Bureau of Mines.* Information Circular No. 8043, 1961.

Too often the hazard from mine fires has been considered an inevitable part of the coal-mining industry. The subject of fire has been discussed on many occasions, but progress has been slow in combating and minimizing it.

The gradual increase in the size and capacity of hydraulically operated mine equipment has greatly increased the fire hazard. Tremendous amounts of flammable petroleum hydraulic oil are taken into the face regions of the mines. Mining equipment, although constructed to comply with Bureau of Mines rigid rules of permissibility, often is filled with 50 gallons or more of flammable petroleum hydraulic oil and is operated in face areas where fire is always a possibility. Early in 1956, therefore, the Bureau of Mines began a program to encourage development of a reasonably priced fire-resistant hydraulic fluid meeting operating requirements.

Tests were established to evaluate fire resistance and the necessary characteristics to assure adequate service when fire-resistant fluids are used to replace petroleum hydraulic oils. The research was conducted in the laboratory and field trials under actual operating conditions in underground mines.

Over 100 coal mines are now using water-in-oil emulsion-type fire-resistant hydraulic fluids in varying degrees from a trial in one machine to all the hydraulic equipment in an entire mine.

Seven synthetic-type fire-resistant hydraulic fluids submitted by two producers are also approved.

677. MITCHELL, D.W., MURPHY, E.M. and NAGY, J. Fire Hazard of Urethane Foam in Mines. *United States Bureau of Mines.* Report of Investigations No. 6837, 1966.

After two years of research on sealants and coatings, the Bureau of Mines published RI 6366 (1964) on urethane foam. As a result, more than 200 mines have used rigid urethane foam. However, in 3 reported instances, misuse of equipment caused foam to ignite spontaneously, and in another to become ignited by an electric arc.

This report summarizes the research that has now led to a certifiable foam system for use in mines. Certifiable tests are described as well as techniques for applying foam. See also Item #836.

678. MITCHELL, D.W. and NAGY, J. Problems of Fire Control in Coal Mines. *Mining Environmental Conference, University of Missouri.* Proceedings, Rolla, MO., 1971.

Most fires in coal mines are controlled quickly and easily. But unless extinguished at the incipient stage, the fire can spread rapidly and will not be amenable to direct attack.

Fire control problems are accentuated by smoke roll back and by spread of fire into pillars and gob.

For early extinguishment, fire detectors are useful. Extinguishing agents, rock dust and water (in some cases) are useful. Seven pointers to successful fire fighting are given.

679. PARK, W.R. Mine Fires. *United States Bureau of Mines.* Paper prepared for Mine Inspectors' Conference, 1973.

Describes personal experiences with fighting coal mine fires. Direct methods are generally only applicable to incipient fires. At a later stage, most fires need to be sealed. This is not difficult unless methane is being liberated freely, in which case unusual hazards occur. Gases from the sealed area are sampled and analyzed at intervals to indicate the progress of the fire. Many important considerations are enumerated. Federal Inspectors' obligations and duties are listed.

680. DEACON, T. and THOMAS, A.J. Rapid Detection and Accurate Location of Underground Fires and the Use of Fire Doors to Provide an Immediately Effective Seal. *Journal of the Mine Ventilation Society of South Africa.* Vol. 26, No. 2, Feb., 1973, pp. 13-19.

At the Free State Geduld Gold Mine, block faulting has divided the mine into areas which facilitate early detection and more rapid location of mine fires. A Fire Door system has recently been introduced and this has an added advantage. This door system was tested by mine fires on Dec. 29, 1971 and Jan. 22, 1972. Three actions necessary before a mine fire can be extinguished - detection, location, and control. These measures are discussed in detail.

681. GREENE, P. Designing Safety into Underground Mining Equipment - Fire Suppression on Face Machinery. *Mining Congress Journal.* Vol. 59, No. 9, Sept., 1973.

In recent years, the growth of mechanized coal mining methods has involved a corresponding growth of electrically powered equipment in the coal face. This has increased the potential for mine fires of electrical origin. As machines become more sophisticated, additional combustible material is incorporated in their design. There are three possible solutions to this problem:

(1) Make machines wholly of non-combustible components.
(2) Separate ignition sources from combustible parts.
(3) Provide inbuilt fire suppression systems.

These aspects are discussed in detail.

682. ANON. Sealing Off Fires Underground. *The Mining Engineer.* Committee Report, Vol. 121, No. 23, Aug., 1962, pp. 709-760.

Memorandum first published in Vol. 103 and rewritten by a committee to reflect more advanced techniques. Draws conclusions based on principles enumerated - requirements for stoppings; preparatory planning; distance of explosion-proof stoppings from the fire; design and construction of stoppings; monolithic stoppings; precautions within the *sealed area; balancing of pressures; barometric effects; sampling in an air current; sampling within a sealed area; frequency of sampling; indication of explosion within sealed area; interpretation of mine air analyses; and possible future methods. Bibliography.*

683. ANON. Tonopah-Belmont Mine Fire. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 7-8.

Photos of this metal mine fire in Nevada in 1911 are shown as the flames envelop the headframe. See also Item #588.

684. ANON. Granite Mountain Shaft Fire, Butte, MT. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 7-10.

A fire in one of the two main shafts of the North Butte mine, an underground copper property operated by the North Butte Mining Co., on the night of June 8, 1917, caused the death of 163 men - the greatest number killed in any American metal-mine disaster. When the fire occurred 410 men were underground. One main shaft, the Granite Mountain, was 3740 feet deep and had 2 main hoisting compartments, as well as a third compartment, separated from the others by a solid timber partition, with a man cage, air lines, water lines, and electric power lines; it had a downcast air current. The other main shaft, the Speculator, about 800 feet from the Granite Mountain, was about 3,000 feet deep, was equipped with cages, and was connected by drifts or crosscuts to the Granite Mountain at the various levels. There were two subsidiary ventilation shafts, the Gem and the Rainbow, and various connections to other mines.

The North Butte mine was one of the best ventilated mines in the Butte district. Two surface fans at the Gem and Rainbow shafts exhausted about 50,000 cubic feet of air per minute from the mine, and about 10,000 cubic feet of air per minute left the mine through the Speculator shaft a natural upcast. A reversible fan at the collar of the Speculator shaft was not in operation when the fire started. These surface fans were augmented by a large number of auxiliary, electrically driven, underground fans with canvas pipe for carrying air to the faces. A large number of underground doors controlled the air currents.

Electricity was widely used underground for power, light, and the 15 trolley locomotives; it was available on virtually every level. Current at 2,300 volts potential was transmitted from the Granite Mountain shaft to a transformer station on the 2,600-foot level.

Just before the fire the North Butte Co. had started to pipe the shaft and place sprinklers in it to provide better fire protection. Small tanks were placed at intervals of a few hundred feet down the shaft to reduce and equalize the pressure. Plans had been made to move the main transformer station from the shaft at the 2,600-foot level back several hundred feet, partly as a fire-prevention measure. Preparatory to moving the transformer station at the 2,600-foot level, 6 men started to lower 1,200 feet of lead-armored cable into the shaft to be used in extending the main transmission line to the new station. The cable weighed 5 pounds per foot or 3 tons in all; it was lashed to a hoist rope by 4-foot lengths of hemp rope, placed every 10 feet for the first 500 feet and at 5-foot intervals thereafter. No clamps were used because of the possibility of crushing the cable. As the cable was about to be landed on the 2,600-foot level, it slipped from its lashings and fell, lodging in the shaft between the 2,400- and 2,800-foot levels and breaking water pipes; in its fall much of the lead armor was torn off, exposing and fraying the oil-impregnated cambric and jute insulation. Fully half of the cross section of the cable was oil-impregnated, highly flammable material. The cable was ruined, and at 11:30 p.m. on June 8 the assistant foreman, a shift boss, and 2 shaft men went just below the 2,400-foot level to try to attach the cable to the cage and pull it up. As the badly wrecked cable was being examined, the flame of a hand carbide lamp came in contact with the frayed, oil-soaked insulation, and a blaze started which forced these men to retire to the 2,400-foot station. With other men on the level, they tried to extinguish the fire, but in a few minutes the shaft timbers had become sufficiently ignited to change the normal downcast in one compartment of the Granite Mountain shaft to an upcast, and smoke started to spread through both the upper and lower levels of the mine. Within 30 minutes smoke started to issue from the nearby Speculator shaft; within 1½ hours it had spread into 2 connecting mines. Various foremen and shift bosses rushed through the mine warning the men. A number of the men escaped through 3 connecting mines; 3 groups of men bulkheaded themselves from the fire (most of the men in 2 of these groups were saved - 25 out of 29 in one place and 6 out of 8 in another), and 32 men were taken up from the Speculator shaft to safety. Of the 410 men in the mine, 163 perished, only 2 by direct contact with fire and the others *because of gases from the fire. Soon after the fire started the Gem shaft fan was stopped to minimize the spread of gases through the mine. Shortly afterward fans at the Gem, Rainbow, and Speculator shafts were started as blowers, thus blowing approximately 100,000 cubic feet of fresh air per minute into the mine to clear the workings of fumes and force them up to the Granite Mountain shaft. Eventually the fire in the Granite Mountain was curbed with water, care being taken to keep this shaft an upcast. Fans were installed underground to aid the rescue parties, and about 48 hours after the fire started suction fans were placed in operation over the Granite Mountain shaft.*

Rescue work was begun almost immediately. Employees of the North Butte Mining Co. and the Anaconda Copper Mining Co. with oxygen breathing apparatus began immediately to assist men to safety. A Bureau of Mines rescue car and crew arrived from Red Lodge, MT, the day after the fire began. Twelve hours after the fire started 50 oxygen breathing apparatus were available, and for several days at least 30 apparatus wearers were employed on each shift. On the second morning after the fire the recovery workers were augmented by a second Bureau of Mines rescue car from Colorado, making additional rescue apparatus available; in all, 92 sets of rescue apparatus were used. Forty-eight hours after the fire started the Speculator shaft had been freed of gases from the fire, and the 2,400-foot level had been sufficiently cleared of smoke to permit rescue of the 25 live men out of the 29 behind the 2,471 bulkhead and recovery of 80 dead bodies. The recovery of 75 more bodies was difficult but was completed 8 days after the fire started. Several additional bodies were found afterward in cleaning up rock falls.

The following conclusions are derived from a study of this fire:

1. *The upper end of an electric cable being lowered in a shaft should be firmly clamped, even if such clamping does ruin 8 or 10 feet of cable.*

2. *Electric cables in hoisting or ventilation shafts are a fire hazard, and boreholes should be used to bring such cables into a mine if practicable; if not, they should be placed preferably in upcast shafts or in shafts or shaft compartments that are as nearly fireproof as possible.*

3. *When a mine has two shafts and the one downcast is afire and filling the workings with smoke, efforts should be made by fans and other means to convert this shaft into an upcast.*

4. *The main hoisting shaft of every deep mine should be fireproofed.*

5. *Connections between mines should be closed with air-tight doors held closed by a positive latch that can be readily opened from either side in an emergency.*

6. *To provide adequate ventilation and allow safe removal of men during a disaster, every mine should have at least two fully equipped shafts from the surface to the lower stoping level. All levels should be connected with both shafts.*

7. *Tight-fitting fire doors, preferably of fireproof construction, should be provided in every drift, crosscut, or other opening leading from any shaft. These doors should be of the self-closing type with a latch or other means to prevent opening (if kept normally closed) by reversal of the air current.*

8. *Direction signs in as many languages as needed to be understood by the mine personnel should be posted at suitable points, indicating plainly the direction of escapeways.*

9. *Timbered shafts should have ample facility for quick-action fire protection; and waterlines for fire protection should be extended through mine workings, especially if much timber or other combustible matter is present.*

10. *Means should be provided for warning men promptly in an emergency.*

11. *Rescue apparatus is likely to be of great value in saving life and property if a serious mine fire occurs, such as that in the Granite Mountain shaft or the Argonaut shaft. Men should be carefully trained to use such apparatus and know its advantages and limitations. See also Item #594.*

685. ANON. The Argonaut Mine Fire, Jackson, CA. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 10-11, 38.

A fire in the main shaft of the Argonaut mine in August, 1922 killed 47 miners. This mine is a gold quartz property and at the time of the disaster employed about 165 men underground. It was worked through an inclined (57°) shaft that followed the dip of the vein 4,900 feet. The *shaft had 3 compartments, each 4 by 5 feet, and was heavily timbered. Two compartments were used for skip hoisting; the manway contained a ladderway, a compressed-air line, a pump column, a high-tension cable, electric-light wires, and signal and telephone lines. Levels were driven at approximately 150-foot intervals. Ventilation was supplied through a second shaft 800 feet deep and offset raises connecting to the lower levels of the mine. This ventilation-raise system was equipped with ladderways from the bottom level to the surface. At the collar of the ventilation shaft was a nonreversible fan exhausting about 40,000 cubic feet of air per minute from the mine. Wooden doors directed the air in the downcast Argonaut main shaft to the lower levels.*

About 11 p.m. the shift boss and 2 skip tenders smelled smoke at the 4,200-foot level of the main downcast shaft and realized that there was a fire in the shaft above them. They had themselves hoisted to the 3,000-foot station and found 2 timber sets burning on the hanging-wall side just below the station. One of these men remained at the 3,000 station to observe conditions; the other two went in the skip through the fire to the 2,000-foot level, where they telephoned to the hoisting engineer, and then went to the surface to obtain means of fighting the fire. Soon after their arrival the mine telephone, signal system, and lights went out of order. The 47 men below were cut off. Smoke began issuing from the ventilation shaft and soon was backing up the main shaft. Men equipped with oxygen breathing apparatus entered the skip and futilely attempted to combat the fire. Changes in the fan housing to allow reversal of the air current would have taken several hours and probably would have been useless, as doors in levels above the fire zone normally closed would have been pushed open by a reversal of the air current and short-circuited the air; the air current was not reversed during the fire fighting. Exploration or rescue work through the ventilation raises was impracticable because 4 to 5 hours would be required for the men to climb back out of these raises, all in highly toxic air from the fire. Men wearing oxygen breathing apparatus controlled extension of the fire up the shaft by means of a high-pressure waterline and hose and then put in an airtight bulkhead about 2,300 feet down the main shaft. Access to the lower levels of the Argonaut mine could be gained by reopening caved connections with the adjoining Kennedy mine and driving some 80 feet in solid rock; 21 days of the arduous labor opened a way to the 4,200-foot level of the Argonaut mine. Another connection from the 3,900-foot level of the Kennedy mine through 140 feet of solid rock was being driven at the same time as that on the 3,600-foot level but was not completed.

Forty-six bodies were found on the 4,350-foot level behind a double bulkhead built of waste, boards, and clothing. Evidently gases had penetrated the bulkhead, and the men had died within a few hours after the fire. The 47th body was found later on one of the levels below the 4,350.

Three possible causes for this fire have been advanced: (1) electricity; (2) incendiarism; and (3) lighted cigarette or match inadvertently thrown to the hanging-wall sets. Most of the investigators believed that a short circuit in the 2,300-volt powerline in the shaft caused the fire. The skip tender testified that during his observation the fire was spreading from about the location of the shaft wiring. The point of origin was near a cast-iron junction box, where the armor and outer insulation had been removed from the cable to allow it to enter the ends of the box. On the day before the fire some decayed timber just below the 3,000-station chute had been replaced. The old timber, stored temporarily in the manway, may have been thrown against the power cable, jarring or displacing the wiring at the junction box. A short circuit in the junction box or in the cable itself could have ignited trash in the chute or the stored punky timber. After the fire there was evidence of arcing about the cable at the junction box. The power cable comprised 3 smaller cables of 18 copper wires, each insulated with rubber and cotton fabric. The cable was encased in lead tubing, which in turn was armored, and the whole was protected from moisture by a covering of tarred hemp cord. A circuit breaker in the hoisting house was said to operate readily.

Advocates of incendiary origin of the fire pointed out that a previous fire in the mine had been proved of incendiary origin, that the fire spread very rapidly in heavy timbering, and that footprints had been discovered in a drainage tunnel below the shaft collar. Against this was the difficulty of anyone climbing 3,000 feet up the manway without discovery; moreover, other places in the shaft nearer the surface could have been fired more easily and probably with greater damage to the mine.

The following points stand out in this fire as a guide in preventing future loss of life in such circumstances:

1. *Men in the mine should be warned immediately.*

2. *An attempt should be made to hoist them.*

3. *All underground doors that can be reached should be opened to short-circuit the air; or all of them, including those along every level, should be closed to confine the fire within the shaft and smother it.*

4. *The fan should be readily reversible.*

5. *Doors should be so hung and arranged to remain closed when air is reversed.*

6. *Stoppage of the fan is of debatable value; unquestionably, the natural draft of the fire in such an instance would reverse the normal downcast tendency of the Argonaut shaft.*

7. *Timbered shafts should be fireproofed or fire-protected or at least the timbered stations fireproofed. Particularly, the space around electrical devices and switches should be protected against fire.*

8. *Every mine should have an organization for preventing and controlling fires, as well as fire-fighting equipment and a good water supply immediately available.*

A refuge chamber was constructed in the crosscut that connected the 5,700 level (incline depth) of the Argonaut and Kennedy gold mines at Jackson, California. This chamber was made by enclosing 75 feet of crosscut between 2 concrete bulkheads with close-fitting iron doors. Air, water, and telephone lines entered the chamber from both mines, the two systems being separate and independent of each other. Fire extinguishers and hose were also provided.

686. ANON. The Magma Mine Fire, Superior AZ. *United States Bureau of Mines*. Miners' Circular No. 55, 1957, pp. 11-12.

A fire in the No. 2 shaft of the Magma mine, Magma Copper Co., about 3 a.m. November 24, 1927, caused the death of 7 of the 49 men in the mine at the time of the fire. The mine was developed by 5 shafts; No. 2 was 2,700 feet deep and Nos. 3 and 5 shafts 2,550 feet. Shafts 2, 3, and 5 were connected on the 2,550-foot and other levels. The No. 2 had 3 compartments, 2 for hoisting and 1 used as a manway; it also contained electric power and light lines.

Ventilation of the Magma mine at the time of the fire was directed by 3 surface and 3 underground fans, as well as various small blowers. An exhaust fan with a capacity of about 95,000 cubic feet per minute (c.f.m.) exhausted from No. 4 shaft but had been shut down a few minutes before the fire. Another exhaust fan at No. 1 shaft ventilated the upper levels of the mine. Shafts 2, 3, and 5 were intakes.

About 3:30 a.m. the fire in No. 2 shaft was discovered by the shift boss, who was investigating the continued steady ringing of the electric bells in both hoisting compartments of the shaft. He found smoke at the 1,200-foot level and by signaling with the pull bell was returned to the 500 level, where he carried the cage tender, who had been overcome by gas, through the ventilation doors and reported the fire. Shortly afterward a cage with one man on it was lowered; he died, presumably from burns or suffocation, and the cable was burned off. The men in the mine smelled smoke, and most of them proceeded to No. 3 shaft, where they were quickly hoisted. Some men came to the 2,200 station and saw the fire roaring up the shaft, but no smoke was coming out into the station. They were unable to attach a hose to the fire connection because it was at the shaft and in the fire.

The fire in the No. 2 shaft was controlled and eventually extinguished by streams of water turned down the shaft from two levels.

The No. 2 shaft had been gunited and concreted in part; but from the 1,600 level to the bottom it was timbered without fire protection, except at the stations, which were gunited to the 2,000 level. Guniting had been discontinued because of its stated tendency to promote and conceal timber decay. Gunited station timbering was fired during the shaft conflagration and continued to burn for days within the concrete shell after the main fire had been extinguished.

The fire evidently originated at or near the shaft at the 2,250 station, which was timbered and dry; the shaft timber was also dry. Oily waste at the car-repair station near the shaft ignited by a carbide lamp or possibly a cigarette butt was the origin of the fire; a transformer, a motor-driven fan, and light and power wiring, all at the 2,250 station, are also suspected.

The Bureau of Mines has drawn some 19 conclusions from this fire; the more important of which follow:

1. *All main working shafts and stations, particularly downcast shafts or shafts in which men are handled, should be concreted or otherwise rendered fireproof or fire-resistant.*

2. *All electrical equipment should be placed in a fireproof location; if feasible, it should not be in or near shafts or shaft stations.*

3. *Stations and all workings should be kept clean of all flammable material, and refuse should not be allowed to accumulate in a mine.*

4. *Placing of waterlines on shaft stations, as was done at Magma, undoubtedly prevented much damage to the Magma mine. Connections for hose attachments, however, should be at least 50 feet from the shaft in order that they may be reached during a fire in the shaft.*

5. *Underground electrical wiring and equipment should be placed even more carefully than surface installations and should be inspected at least monthly by a competent electrician. Any defects should be remedied without delay.*

6. *If smoking is allowed underground it should be limited to prescribed areas in the mine where a minimum fire hazard exists; preferably smoking should not be permitted in dry timbered areas.*

7. *During the Magma fire the gunite definitely acted as a fire retardant. Even when the fire burned the gunite-timbered region, the progress of the burning appeared to be retarded to such an extent that there was a minimum of caving as compared with the large amount in ungunited timbered regions. If the No. 2 shaft had been entirely gunited or concreted and the station at the 2,200-foot level had been gunited, the fire might not have started.*

8. *It is dangerous to send men down on a cage when there is fire in a timbered shaft, even though the shaft is downcast. Fire may quickly climb up a downcast timbered shaft and convert such shaft into an upcast, even when the shaft is damp or fairly wet.*

9. *The escape of most of the 43 underground workers who came out alive is credited to the excellent ventilating system in the Magma mine; the foresight of the company in having 3 downcast shafts with hoisting equipment in them deserves high commendation.*

As evidence that the improbable sometimes happens, 3 days after the fire in the No. 2 shaft started and when it was virtually under control, No. 1 shaft caught fire, although there was no possibility of fire being transmitted from the No. 2 shaft to the No. 1 shaft. This second fire apparently started from embers dropping down the shaft from a surface fire built near the shaft by a watchman on a cool night. This shaft contained no wiring or electrical *equipment. Water could be turned into the shaft both from a water tank on the hillside just above the collar of the shaft and from the fifth level. The fire was controlled in a few hours. During the time it burned however, there was considerable danger that the fire might reach the magazine, which contained 65,000 No. 8 detonators, in the 200 station near the No. 1 shaft. To avoid this, an oxygen breathing apparatus crew removed the detonators to the outside.*

687. ANON. The Glenn Mine Fire, Placer County, CA. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 12-13.

A fire originated in some unknown manner in the wooden surface structures near the portal of the Glenn mine of the Capital Glenn Mining Co. on July 14, 1930, about 10:15 a.m. This mine was an underground placer property operated through adits driven into the hillside to recover the auriferous gravel from an old stream bed. The uppermost adit, the part of the mine then working, had been driven 1,121 feet from the portal; about 758 feet from the portal it connected with the middle or Moss adit by means of an incline dipping about 15°. The Moss adit was part of some old workings of a similar nature but was not kept repaired.

The ventilation was natural; fresh air entered the top adit at a velocity of nearly 200 f.p.m., followed down the incline, and left through the Moss adit and its connections.

The surface compressor house and shop building was about 25 feet from the portal of the upper adit, to which it was connected by a snowshed. The snowshed extended to the edge of the dump, connecting with the powerhouse about 75 feet from the end of this shed.

When the fire started no one was near the portal of the adit on the surface, and five men were working at the faces; these men tried to escape by going down the incline and out the Moss adit but were overcome and died in the attempt.

The fire burned all of the structures on the surface near the portal and about 70 feet of timbered adit inside the portal, jumped an untimbered gap of 63 feet, and ignited other timber sets; on account of the wetness of these sets, the fire died out when the timber at the portal was consumed.

No fire-fighting equipment was available at or near the mine, and equipment of the United States Forest Service was brought to extinguish what was left of the fire.

Like many small properties, little or no consideration had been given to the possibilities of fire and its results; consequently no protection had been provided or plans made for combatting fire or preventing smoke from entering the mine.

688. ANON. The Sunshine Mine Fire, Kellogg, ID. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 13-14.

The Sunshine mine fire occurred in December 1945 and resulted in a loss of 1 million dollars principally from loss of production and payment of direct costs in fighting the fire. The fire was confined to mined-out workings and was extinguished by sealing and flooding the lower levels. No injuries or loss of life occurred. The fire originated off the inclined shaft station on the 2,900-foot level when a short circuit in the battery-charging station set fire to the surrounding timbers. The fire started over the weekend when the mine was idle and was not discovered until Monday morning. The ventilating air current carried sparks for a distance of 300 feet along an untimbered drift; these ignited the connecting raise to the 3,100-foot level, which was heavily timbered. When discovered on the 3,100-foot level, the fire had reached major proportions.

689. ANON. The Braden Mine Fire, Chile. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, p. 14.

A metal-mine fire at the Braden Copper Co. mine in Chile caused the loss of 355 lives due to carbon monoxide poisoning. Apparently caused when a drum of oil exploded in an underground blacksmith shop near the main downcast portal. A high concentration of carbon monoxide was carried to all parts of the mine within a few minutes.

690. BIRD, G.H. and McGUIRE, L.H. Report of Mine Fire and Rescue and Recovery Operations, Dolores Mine, American Smelting and Refining Co., Angangueo, Mexico. *United States Bureau of*

Mines. Unpublished Report, July 29, 1953.

Fire started in a timbered raise and believed to be caused by sabotage, open lights, or smoking. See also Item #445.

691. ANON. Fire at North Mount Lyell Copper Mine, Queenstown, Tasmania. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, p. 37.

In October, 1912, 50 lives were saved by a man who blew compressed air from a hose against the face of a drift instead of against the smoke and made the men keep as close to the walls as possible. On striking the face, the compressed air spread out and prevented the smoke from reaching that point or so largely diluted it that the air was breathable.

692. ANON. Fire at Cardinal Mine, Nederland, CO. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 39-40.

One instance where men were saved by a barricade is afforded by a fire at the Cardinal mine near Nederland, CO. in December 1925. The mine had been worked for many years and produced lead ore carrying gold, silver, and copper. A tunnel 3,300 feet long was heavily timbered at the portal. Fire, which destroyed the surface buildings, spread to these timbers, imprisoning 20 men and 2 horses. The men retreated to a drift branching off the face of the tunnel and put up a bulkhead of timber, boards, mud, and clothes. Several men were more or less overcome with smoke while erecting the barricade. One horse was taken back of the barricade with the men; the other was lost in the smoke. The barricaded section had open stopes and drifts above it, but there were no connections to the tunnel through which smoke or gases could enter. Rescuers reached the barricade about 12 hours later, entering the mine through an air shaft. One man wore a 1-hour oxygen breathing apparatus, but three others are said to have entered without respiratory protection. The four reached the barricade and tapped on the air pipe to notify the men behind the barricade of their presence. The rescuers then pulled off two or three of the boards of the barricade and smoke poured in through the opening. The three rescuers without apparatus collapsed and two were pulled inside the barricade by those behind; one was unconscious for

2 hours yet recovered, but the other died. Later, two men from the imprisoned group dashed outside with the third unprotected rescuer and the one with apparatus; the last probably saved the lives of two of his companions, but the other was found dead. Finally the fire was sealed off, the smoke cleared from the tunnel, and the barricaded miners walked out or were hauled out in mine cars by the horse they had taken in with them. In this instance, little time was lost in deciding upon the erection of a barricade, and it was built quickly. There was enough air in the bulkheaded workings to last the men 2 or 3 days.

When barricading is done, dependence is placed upon early success of efforts to control the fire; if the fire has to be sealed and men are barricaded within these sealed regions, there is little hope for their survival unless boreholes or compressed-air lines are run into the place barricaded. If the confinement is prolonged, food and water may be required.

Some suggestions regarding barricades follow:

1. *Miners behind a barricade should not group closely if the oxygen content of the air is being lowered.*

2. *Workings back of a bulkhead should not be in broken or filled ground through which gases may penetrate.*

3. *If carbide lights are used, only one or two should be kept lighted. Spent carbide should be thrown outside the barricade, if possible.*

4. *A double barricade is advisable.*

693. ANON. Fire at Utah Apex Mine, Bingham Canyon, UT. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, p. 45.

This fire occurred in March, 1917 and was successfully extinguished by flooding. See Item #523.

694. ANON. Fire at Homestake Mine, Lead, SD. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, p. 45.

In 1907 the fire at the Homestake gold mine caused by fuse or explosives was successfully flooded. In about

40 days the mine was filled to a point above the fire level. Over 643 million gallons was pumped out of the mine in a 4-month period. There was little damage to the mine from flooding.

See also Item #544.

695. ANON. Fire in a Lake Superior Iron Ore Mine. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 46-48.

Smoke from a fire in the downcast shaft of an unnamed mine was detected underground on April 19, 1951. Ultimately the fire was extinguished by sealing and applying carbon dioxide. The procedure adopted is described in considerable detail.

See also Item #534.

696. ANON. Fire at Anaconda Copper Co., Butte, MT. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, pp. 49-50.

In 1906 the Anaconda Copper Co. experienced a large fire, probably starting from spontaneous combustion, which finally spread downward through cracked pillars until it became necessary in 1917 to bulkhead off portions of three mines. The sections walled off had been mined by the square-set method. Mill tailings were obtained from a mill and from a mill pond and pumped, as a sludge, into the fire area. Access to the fire area was obtained by opening old drifts and driving new ones to reach the top of old stopes. When close approach to the fire area was impossible, diamond-drill holes were bored. In driving toward the fire the drifts often were pressurized by means of double doors and a Sirocco fan with 12- or 16-inch tubing to hold back the gases. Much of the work was done by men wearing oxygen breathing apparatus. More than 800,000 tons of solids were introduced. On reopening several crosscuts and drifts, the tailings were found to have filled the openings completely; they were well drained and compact enough to pick to a vertical face. This slime filling permitted the recovery of several million tons of ore; where applied, it extinguished the fire in almost every instance, reduced and in places eliminated fire gases, cooled some of the abnormal rock temperatures, improved ventilation, and tended to stop further movement of the ground.

Slime filling is still being used in the Butte mines for controlling and extinguishing mine fires in broken ground.

See also Item #533.

697. ANON. Fire at Hollinger Mine, Ontario. *United States Bureau of Mines.* Miners' Circular No. 55, 1957, p. 56.

Fires have been started in mines for lack of even ordinary precautions in disposing of waste material. In 1928, 39 men were asphyxiated in the Hollinger mine, Ontario, Canada, by the smoke and fumes from a refuse fire in an old stope. Dry explosive-magazine refuse was dumped into an empty stope without concurrent backfilling or covering with broken rock.

698. STEFFENHAGEN, A. and GRUMBRECHT, K. Large-Scale Fire Tests in a Deep Intake Shaft. *Great Britain. Safety in Mines Research Establishment.* Report 241, Paper A1, 1966.

Following a mine fire at Marcinelle, Belgium, directives were issued for the control of fires in shafts and for full scale tests.

A test was carried out on an intake shaft at a depth of 830-940 metres. A fire was kindled and developed great violence. An explosion of unburnt gases occurred. But by pouring measured quantities of water from the surface the fire was extinguished in about ten minutes. Seventy instruments were used to monitor the various parameters of the ventilation air. The tests supported the directives issued.

699. GRUMBRECHT, K. and VON DIEPENBROICK-GRUETER, H. Testing the Fire Hazard of Mining Equipment. *Great Britain. Safety in Mines Research Establishment.* Report 241, Paper 5, 1966.

Testing methods for fire resistance of conveyor belts, hoses and ducting already exist throughout ECSC. Paper *now describes suitable test conditions for hydraulic fluids and plastic components of operating machinery.*

700. MITCHELL, D.W., NAGY, J. and KAWENSKI, E.M. Flame Propagation on Conveyor Belts. *Great Britain. Safety in Mines Research Establishment.* Report 241, Paper 11, 1966.

Reports on factors affecting ignition and flame propagation on conveyor belts being investigated by the Bureau of Mines. The study included aspects of ignition source, air velocity, type of belt cover, and belt carcase. At air velocities exceeding 100 f.p.m., flame propagated along neoprene and PVC belts but more rapidly for rubber belts. Rate of flame propagation was affected by area of the gallery, to some extent by the nature of the belt carcase, but not by belt width.

701. BYSTRON, H., MARKEFKA, P. and STRUMINSKI, A. Influence of Pressure Conditions around Fire Areas on Safety in Mines. *Great Britain. Safety in Mines Research Establishment.* Report 241, Paper 15, 1966.

Fire areas in goafs sometimes create a serious hazard to the safety of mining operations. The causes of this hazard are discussed and illustrated by examples of situations that have arisen in practice. A method of eliminating this hazard, by a suitable choice of pressure conditions around fire areas and goafs, is described.

702. SOBOLEV, G.G. and SUKHAREVSKII, V.M. Analysis of the Causes of Exogenous Fires and Methods for Their Prevention and Elimination in Coal Mines of the U.S.S.R. *Great Britain. Safety in Mines Research Establishment.* Report 241, Paper 35, 1966.

Measures have been developed for preventing the occurrence of dangerous heatings, for restricting combustible materials in mine workings, and for the protection of coal mines from unherground fires. Methods have also been developed for extinguishing fires. The efficiency of atomized water and foam has been investigated and equipment developed. The requirements for preventing the *formation of explosive gas mixtures during the sealing of fire zones have been determined.*

703. ROBERTS, A.F., CLOUGH, G. and BLACKWELL, J.R. A Model Duct for Mine Fire Research. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 243, Dec., 1966.

Describes the construction of a duct being used in a model study of certain types of mine fire. Details of the instrumentation are given and some typical data are presented.

704. ANON. Fire Suppression of Mining Equipment. *United States Bureau of Mines.* USBM Final Report (Contract No. H0111386) Prepared by MSA Research Corporation. August 10, 1973.

The study includes a review of history of fires associated with coal mining face machinery; an appraisal of hazards on representative machine types; and an assessment of required fire suppression systems.

Recommendations are made to reduce the fire hazard of electrically operated face machinery. These include the advantages of fire detection devices; the use of less flammable materials in machine manufacture, especially cable and hose; the fire training of operators; an onboard fire suppression system using water deluge, or dry chemicals, or froth, but not necessarily foam; the use of better fire-retardant and more durable coverings for trailing cable. A new cable system needs to be developed. Hydraulic fluid itself is not an important source of fire, especially when a fire-retardant hose is used; but leaks from hose fittings associated with accumulation of coal dust and grease represent a significant hazard.

705. FORBES, J.J. and GROVE, G.W. Horning Mine Fire. *United States Bureau of Mines.* Miners' Circular No. 36, 1948, pp. 53-55, 60-65.

On Feb. 5, 1926 a section of the Horning Mine of the Pittsburgh Terminal Coal Corp. was sealed following a *fire and two subsequent explosions. Twenty men were killed in the disaster. Subsequent gas samples showed a progressive reduction in oxygen probably due to a gas feeder which caused an increase in pressure and an outward leakage of the sealed atmosphere. Recovery was begun by a system of air locks outby the seals. These enabled helmet men to enter the sealed area without admitting air to recover the bodies. Meanwhile the fire had died out through want of oxygen. Details of construction of seals, stoppings, and air locks are given.*

706. FORBES, J.J. and GROVE, G.W. Oakmont Mine Fire. *United States Bureau of Mines.* Miners' Circular No. 36, 1948, pp. 50-51, 55-56.

On Jan. 14, 1925, a section of the Oakmont Coal Mine of the Hillman Coal & Coke Co., in Pennsylvania was sealed following the discovery of fire. A series of well built brick airtight stoppings did not prevent inward leakage of air. A doubling of the stoppings had little effect. An adjustment of the ventilation circuit was made so that an equal pressure was maintained on all seals and finally the fire was snuffed by October 8th.

707. ANON. St. Paul No. 2 Mine Fire. *United States Bureau of Mines.* Miners' Circular No. 50, 1954, p. 86.

A fire disaster occurred in the St. Paul No. 2 Mine of the St. Paul Coal Co., Cherry, IL on November 13, 1909. This is also known as the Cherry Mine. An outstanding example of a disaster caused by open lights. A total of 259 men lost their lives, but 20 who had barricated themselves escaped after a 7-day imprisonment. Six bales of hay being taken into the mine were ignited by an open light. After futile attempts were made to extinguish the fire the car on which the hay was transported was dumped down the air shaft into a sump, where the fire was extinguished by water. However, before the car was dumped the flame from the burning hay, farmed by the intake air, fired the timbers and cut off escape through the shaft.

See also Item #510.

708. FORBES, J.J. and GROVE, G.W. Rockwood Mine Fire. *United States Bureau of Mines*. Miners' Circular No. 36, 1948, p. 65.

Referred to as an instance where a coal mine fire was subdued by sealing and airlocking. Roane Coal & Iron Co., Rockwood, TN, 1925.

709. FORBES, J.J. and GROVE, G.W. Sunnyside Mine Fire. *United States Bureau of Mines*. Miners' Circular No. 36, 1948, p. 65.

Referred to as an instance where a coal mine fire was subdued by sealing and airlocks. Utah Fuel Co., 1920.

710. FORBES, J.J. and GROVE, G.W. Connellsville No. 1 Mine Fire. *United States Bureau of Mines*. Miners' Circular No. 36, 1948, p. 65.

Referred to as an instance where a coal mine fire was subdued by sealing and airlocking. Connellsville By-Product Coal Co., Purseglove, WV, 1927.

711. FORBES, J.J. and GROVE, G.W. Woodward Mine Fire. *United States Bureau of Mines*. Miners' Circular No. 36, 1948, p. 65.

Referred to as an instance where a coal mine fire was subdued by sealing and airlocking. Glen Alden Coal Co., Edwardsville, PA, 1927.

712. FORBES, J.J. and GROVE, G.W. Federal No. 3 Mine Fire. *United States Bureau of Mines*. Miners' Circular No. 36, 1948, pp. 73-74.

Cited as an instance where it was necessary to use air-locks following a coal mine fire in May, 1927. New England Fuel & Transportation Co., Everettville, WV.

713. VARIOUS. "Recovery" Somerset Mine. *63rd Annual Convention of Mine Inspectors' Institute of America.* Presented on June 10-13, 1973, Checotah, OK.

Somerset coal mine is located in Gunnison County, Colorado. On April 10, 1972, a fire, believed to be of spontaneous origin, was evidenced by smoke entering the main haulageway. Direct fire fighting with water hoses on one side and foam and water on another was employed until intense smoke nullified these efforts.

Initial sealing seemed successful but gas analyses levelled off before reaching required levels of oxygen and carbon monoxide. On May 7, fire broke through one of the seals and could not be abated. This necessitated sealing the mine at all portals - permanently sealed by May 11. However, it was expected that seals would leak oxygen to the fire, thereby delaying extinguishment and re-entry indefinitely. Therefore, a plan was evolved to re-enter 'B' seam, with airlock control, for a distance of 4500 ft. to build 4 dams to impound water throughout the known fire zone.

A comprehensive organisational plan was developed in three parts: (a) to erect the dams, (b) to recover the major portion of the mine, and (c) to drain the dams and recover the remainder and the main haulageway. Recovery teams were selected and trained. Recovery operations are explained in detail. 2950 samples were analyzed.

By Sept. 29th most of the mine had been recovered.

Nine conclusions are drawn:

1. *Liquid oxygen type apparatus was a must when working mine rescue people in high temperatures and high humidity conditions.*

2. *Voice communications, audible to all team members and people at fresh air base is effective.*

3. *Impounded water is the most effective seal.*

4. *Fly ash cement dams proved more effective and were quicker to construct than those of reinforced concrete.*

5. *Reinforced nylon curtain and RIGI-PAK foam in conjunction with adjustable uprights and boards provide quick and effective materials for erecting airlocks. A total of 174 were built, 110 of them by rescue teams under apparatus.*

6. *Planning, coordination, communications and daily briefings are essential elements.*

7. *At all times adequate sources of water should come from behind firefighters.*

8. *Attention to analysis of mine gases is an essential part of control.*

9. *An infrared scanning device for early detection of spontaneous combustion should be further developed.*

Paper was illustrated by 84 slides.

714. JARRETT, S.M., BRAKE, E.L., RILEY, R.E. and WILSON, R.V. Final Report of Major Mine Fire Disaster, Sunshine Mine, Kellogg, Idaho, on May 2, 1972. *United States Bureau of Mines Health and Safety Report.*

Report relates all available conditions prior to discovery of fire, events immediately thereafter, subsequent rescue and recovery efforts, investigation of the cause of the fire, and an overall analysis. Also includes conclusions drawn and recommendations to prevent a similar occurrence. The information presented applies generally to many other underground mines.

Smoke was detected in the main haulageway near the electric shop on the 3700 level of the Sunshine Mine, Kellogg, Idaho, about 11:40 a.m., May 2, 1972. The volume of smoke, accompanied by carbon monoxide, increased rapidly and was also detected in the 3100 level main haulageway. Both the 3100 level and 3700 level haulage drifts served as main fresh air intakes to the stope area below 3700 level near No. 10 shaft, where most of the 173 men in the mine on that shift were assigned. Mine supervisors, after attempting to locate the fire, ordered evacuation of workmen from the mine about 12:03 p.m. Before the evacuation was halted by the death of the No. 10 shaft hoistman, 80 men escaped from the mine. An intensive rescue operation, organized by industry and Bureau of Mines personnel, resulted in the rescue of 2 men. The remaining 91 died of carbon monoxide poisoning. None of the survivors reported seeing fire or flames.

The Bureau of Mines believes the probable cause of the fire was spontaneous combustion of refuse near scrap timber used to backfill worked out stopes. The fire *occurred in an abandoned stoping area near the intersection between the 3400 level exhaust airway and the 09 vein. Extensive ground falls and caving occurred in the immediate area when timber supports were consumed, making investigation of the entire fire area impossible.*

It is not possible to single out any one fact as the chief cause for the large loss of life. However, the Bureau of Mines believes that the following major factors contributed to the severity of the disaster:

1. *The emergency escapeway system from the mine was not adequate for rapid evacuation.*

2. *Top mine officials were not at the mine on the day of the fire and no person had been designated as being in charge of the entire operation. Individual supervisors were reluctant to order immediate evacuation or to make a major decision such as stopping the 3400 level fans.*

3. *Company personnel delayed ordering evacuation of the mine for about 20 minutes while they searched for the fire.*

4. *The series ventilation system used in the mine caused all persons inby the fire, which contaminated the main intake airways, to be exposed to smoke and carbon monoxide.*

5. *Most of the underground employees had not been trained in the use of the provided self rescuers and had difficulty in using them. Some self rescuers provided by the company had not been maintained in usable condition.*

6. *Mine survival training, including evacuation procedures, barricading, and hazards of gases, such as carbon monoxide, had not been given mine employees.*

7. *The emergency fire plan developed by the company was not effective. The company had not conducted evacuation drills.*

8. *Abandoned areas of the mine had not been sealed to exclude contaminated air from entering the ventilation air-streams.*

9. *The controls built into the ventilation system did not allow the isolation of No. 10 Shaft and its hoist rooms and service raises or the compartmentalization of the mine. Smoke and gas from this fire was thus able to move unrestricted into almost all workings and travelways.*

These and many other factors involved in the disaster are discussed in detail in the report.

715. ANON. Sunshine Mine Disaster Due in Part to Poor Safety Practice. *Journal of the Mine Ventilation Society of South Africa*. Vol. 26, No. 7, July, 1973, p. 100.

The following was reproduced from the Canadian Mining Journal, January, 1973.

An Interior Department examiner concluded that general acceptance of poor safety practices by industry and government contributed to the Sunshine mine disaster in Kellogg, Idaho, in May, 1972. The finding would appear to provide ammunition for advocation of a tougher federal metallic mine safety law.

Ninety-one miners died of carbon monoxide and smoke poisoning when fire swept through the Sunshine Mining Co. operation, the U.S.A.'s largest silver mine.

In his special report, James M. Day, Director of the Interior Department's Office of Hearings and Appeals, suggested that the department's Bureau of Mines could have been more vigilant in seeing that the Sunshine miners had more and better emergency breathing devices and were better trained in their use.

Mr. Day also faulted inadequate posting of escape routes, poor emergency communications within the mine, and the failure to equip lift operators with the emergency breathing devices as factors contributing to the high death toll. Mr. Day's report, based on testimony taken during a week of hearings held in Kellogg in July, noted that several men who operated lifts died at their posts. These lifts offered the only escape route for many of the trapped men.

Mr. Day said cause of the fire may never be determined because of the confusion in the mine at the time, and the death of most of those who witnessed what took place. He concluded, however, that "a large number of deaths and the magnitude of the disaster are a direct result of inadequate safety standards, industry-wide poor safety practices, the lack of training of the miners in the event of a disaster, and the fact that no one expected that a disaster of such size or extent could occur."

Based on the testimony of witnesses at a hearing, Mr. Day placed much of the blame for the deaths on the previous lack of training in use of the self-rescuers. These are designed to provide breathable air, but in the case of the federally approved units stored in the mine at the time of the fire, the air-purification process apparently heated the temperature of the air entering the users' mouth to more than some 360°F.

The report noted that the rescuers are designed to operate at that temperature if the atmosphere contains 2% carbon monoxide - a fact that appears not to have been explained to many of the miners who tried to use them and found the air too hot to breathe. In addition as an indication that the rescuers were inadequate for the mine's needs, the report said that some carbon monoxide concentrations found there measured as high as 4.5%.

See also Item #714.

716. SEPULVEDA, F. Report of Fatal Accident, Lakeshore Mine, Casa Grande, AZ. *Office of Arizona State Mine Inspector.* Health & Safety Report, 1973.

On August 17, 1973, a run of muck (loose rock) from the walls of the No. 6 Ventilation Borehole blocked the 500 north drift of the Lakeshore Copper Mine which was under development. Two miners were trapped in the tail drift beyond the fall.

An ST-8 Scooptram was put to work to remove the fallen muck in order to rescue the miners. After working for about two hours, a further run of muck buried the scoop-tram which then caught fire. Fire warnings were given and 110 men were safely brought to the surface.

717. STAHL, R.W. Are Coal Mine Employees and Dollars Protected from Fire as Well as Other Industrial Employees and Dollars? *American Institute of Mining Engineers.* Transactions, Vol. 217, 1960.

Discusses the economic and humanitarian factors involved in a coal mine fire. Stresses the need for more adequate protective measures. Although Federal and State laws require only a bare minimum of fire protection, operating companies would do well to provide greater insurance against mine fires which can be costly in terms of human lives and property dollars.

718. ASHURST, M. and SIDDALL, F.N. An Account of a Fire in the Bickershow Seven Feet Mine at Leigh, Lancashire, and Its Action upon the Coal. *Institute of Mining Engineers.* Transactions, Vol. 65, 1923-24, pp. 149-157.

> *In July, 1889, a smouldering piece of fuse apparently set the coal on fire. After the weekend several pillars were found to be on fire and were blazing on all sides. Great efforts were made to extinguish the fire but it was necessary to seal it with a ring of stoppings. The fire area was watched constantly for leaks which called for new stoppings. Three men on three 8-hour shifts were in constant attendance for about 20 years. In about 1914 an attempt was made to extinguish the fire. Details are given.*

719. WESTFIELD, J. Discussion of Recent Mine Explosions and Fires, Their Causes and Prevention. *Mine Inspectors' Institute of America.* USBM Paper, Huntington, WV, June 10, 1957.

> *The rapid improvements in mechanized coal mining, accompanied by marked increases in productivity have created new hazards against which protective measures must be developed.*
>
> *During the 16 months ending in April, 1957, the Bureau of Mines received reports of 66 mine fires of which 45 were of electrical origin.*

720. POLACK, S.P. Progress in Developing Fire Resistant Hydraulic Fluids for Use in Underground Mining. *Mine Inspectors' Institute of America.* Huntington, WV, June 10, 1957.

> *Presents a progress report on research conducted by the Bureau of Mines on fire-resistant hydraulic fluids.*

721. BROWN, C.L. Trailing Cables: The Number One Fire Hazard Underground. *Coal Mining Institute of America.* USBM Paper, Pittsburgh, PA, Dec. 16, 1960.

With the growth of underground coal mine mechanization, the use of mobile electrically operated face equipment has introduced many hazards. Chief among these are fires of electrical origin. Between July 16, 1952 and Nov. 15, 1960, 415 coal mine fires were reported, 274 being of electrical origin and over 40% of these due to trailing cables following four enumerated sources of mechanical damage.

Concludes that a substantial reduction in trailing cable fires can be realized only with the co-operation of all concerned.

722. WEAVER, H.F. Resumé of Gas Ignitions and Fires in Coal Mines. *National Safety Congress.* USBM Paper, Chicago, IL, Oct. 23, 1957.

From July 1952 to June, 1957, following the introduction of the Federal Coal Mine Safety Act, 198 mine fires were reported to the Bureau of Mines with 8 fatal and 39 non-fatal injuries. Undoubtedly others occurred but were not notified. Although no disasters occurred, each fire has a disaster potential, especially in gassy mines.

Encourages operators to police their own operations conscientiously and with constant vigilance to avoid another disaster.

723. STATHAM, I.C.F. Underground Fires. *Colliery Engineering.* Vol. 12, No. 135, 136, 137 and 138, May, 1935, pp. 152-155, June, pp. 191-194, 209, July, pp. 224-226, 244, and Aug., pp. 272-275.

A series of four articles dealing with the causes, prevention and fighting of fires in coal mines other than those caused by spontaneous combustion.

724. DONEGAN, H. Coal Mine Fires. *Colliery Engineering.* Vol. 36, No. 419, 420, 421, 422, 423, 427, 428, Jan., 1959, pp. 15-20, Feb., pp. 53-63, Mar., pp. 111-118, Apr., pp. 142-150, May, pp. 205-212, Sept., pp. 391-396, Oct., pp. 447-452.

In a series of seven articles, author gives details of an investigation to examine the effects of sealing fire areas in some New South Wales collieries. The aim was to see if experience abroad could be successfully applied to New South Wales conditions.

Part 1 outlines mining methods in New South Wales and describes instruments used in the investigation.

Part 2 describes the Lithgow State Coal Mine Fire which was noticed on August 12, 1953, and gives details of the gas sampling work carried out. Sketches of the seal construction are given; also the progressive gas analyses.

Part 3 describes the gas sampling and analysis work and the behavior of the gases in the sealed fire zone.

Part 4 contains author's conclusions resulting from the gas sampling work involved at the Lithgow State Coal Mine.

Part 5 deals with a fire which occurred at the Aberdare Central Colliery in late July, 1943, over a weekend when no one was underground. It was impossible to save the horses as it was necessary to seal both the downcast and upcast shafts. Gas analyses are given; also the measures taken to re-open the mine after sealing, in July, 1944.

Part 6 gives the author's conclusions based on the gas sampling and analysis work at the Aberdare Central Colliery.

Part 7 gives an account of the fires at the Ivanhoe Colliery (due to a bush fire at the outcrop in August-Sept. 1952) and at the Bellbird Colliery (in which a fire and explosion occurred in 1923 with the loss of 21 lives). General conclusions are presented.

725. HALL, C.J., MORRIS, T. and PATRICIO, J. Ventilation Studies and Escape Plans for Underground Hardrock Mines. *United States Bureau of Mines.* Contract Report No. S0230037, October, 1973.

Visits of inspection were made to 16 individual mines mostly in the western United States. Discussions were made with ventilation and supervisory staff of each mine in regard to fire hazards, escape routes, ventilation circuits, fan locations, recirculation problems, location of working crews, power cable locations, compressed air and water line reticulation, etc. The potential hazards and conditions during emergencies were also considered.

Reports on each mine together with pertinent diagrams of ventilation circuits and recommended emergency procedures are included. Major factors affecting the evacuation of men from the 16 mines are summarized.

The report includes two additional papers entitled "General Considerations with Regard to Evacuation of Men in Case of Fire in Hardrock Mines" and "Airflow in Mines with Gobs of Large Vertical Extent."

Part of the investigation overlaps an earlier contract study No. SO220131 entitled: "Ventilation Studies and Escape Plans for Mines in the Coeur d'Alene District of Idaho" which terminated on Nov. 30, 1972.

726. HALL, C.J. Ventilation Studies and Escape Plans for Mines in the Coeur d'Alene District of Idaho. *United States Bureau of Mines*. Contract Report No. SO220131, November 30, 1973.

Following discussions with ventilation and supervisory staff, recommended escape plans were proposed for the major mines in this district. Schematic diagrams of ventilation circuits are included.

See also Item #725.

727. HALL, C.J. and MORRIS, T. General Considerations with Regard to Evacuation of Men in Case of Fire in Hardrock Mines. *United States Bureau of Mines*. Contract Report No. SO230037, October, 1973.

Deals in detail with fire warnings, notices to evacuate, escape plans, refuge chambers, maintenance of services, ventilation problems, testing procedures, and organisation and management plans. Conclusions are drawn.

See also Item #725.

728. HALL, C.J. and MORRIS, T. Airflow in Mines with Gobs of Large Vertical Extent. *United States Bureau of Mines*. Contract Report No. SO230037, October, 1973.

Deals with subject title, taking into account airway friction, fans and natural ventilation. A basic study based on motive column principles. Recommendations are made concerning field measurements and fan locations.

See also Item #725.

729. FORBES, J.J. and GROVE, G.W. Organization Chart for Metal Mine Fires. *United States Bureau of Mines.* Miners' Circular No. 36, 1948, p. 4.

Sets out a standard format of surface organizational procedures for underground metal mine fires (Figure 2).

730. FORBES, J.J. and GROVE, G.W. Organization Chart for Coal Mine Fires. *United States Bureau of Mines.* Miners' Circular No. 36, 1948, p. 4.

Sets out a standard format of surface organizational procedures for underground coal mine fires. (Figure 1)

731. WILLETT, H.L. Spontaneous Combustion in the Yorkshire Coalfield. *Institution of Mining Engineers.* Transactions, Vol. 117, Part 9, June, 1958, pp. 643-658.

There appear to have been no cases of spontaneous combustion underground in the Yorkshire Coalfield until the working of the Barnsley Seam commenced at Denaby Colliery.

The subsequent spread of the coalfield to the east revealed that spontaneous combustion was a serious problem in the Barnsley Seam over a large area, and, in fact, it was considered a possibility in about 1910 that the hazards and difficulties might prevent the further development of the Barnsley Seam.

This liability to spontaneous combustion remains, particularly within a radius of several miles of Doncaster; but as a result of the preventive measures adopted, the incidence of heatings has been reduced considerably. A few heatings have occurred in recent years in seams other than the Barnsley Seam.

The general causes of spontaneous combustion and the characteristics of the Barnsley Seam and associated strata are discussed in the paper. Comment is also made on the main preventive measures and on methods of detection and treatment.

The liability to spontaneous combustion underground may change with future mining methods, and it is necessary, therefore, that the assessment of new methods of working the Barnsley Seam should always include an assessment of the hazard of spontaneous combustion.

732. JOLLIFFE, G.B. and RAYBOULD, W.E. The Application of Pressure Balancing Chambers to Control Air Movement in Sealed Areas. *The Mining Engineer*. No. 11, August, 1961, pp. 861-877.

The use of pressure chambers as a means of controlling the flow of methane from old workings and the adjustment of the flow rate to correct for barometric changes are now well known. The present paper describes the use of similar chambers as a means of precisely balancing the ventilation pressure across a sealed area to prevent air-flow, when dealing with heatings and fires underground, which is less well documented. The importance of stopping all air-flow, in order to produce an inert atmosphere as quickly as possible in the affected zone, is stressed. The early use of balancing chambers to prevent air-flow while the final seals are being completed is discussed, especially in those cases where there is no natural make of gas to displace air from the fire zone. The factors influencing air currents within a sealed area are dealt with, together with the effect of fluctuating pressures due to the movement of cages and tubs on the breathing of stoppings.

733. HUGHES, A.J. and RAYBOULD, W.E. The Rapid Determination of the Explosibility of Mine Fire Gases. *The Mining Engineer*. Number 1, October, 1960, pp. 37-53.

A rapid method for determining the explosive limits of mine fire gases containing methane, hydrogen and carbon monoxide is described. The method utilizes limit diagrams in order to construct an explosive triangle for the given mixture; full information about the explosibility characteristics of the mixture is then readily deduced.

The method has been extensively tested on a number of mine fire gases and has been found to give close agreement with the results obtained by the classical method of COWARD and JONES. In addition to being quicker, it can provide information about the atmosphere which is not readily available by the latter method. To simplify the calculations, carbon dioxide is equated with nitrogen; since carbon dioxide has a greater extinctive effect on combustibles than nitrogen, the method always errs on the safe side, the magnitude of the safety margin depending on the proportion of carbon dioxide in the mine fire atmosphere.

The method determines whether the atmosphere is explosive or not, or whether it is capable of becoming explosive when diluted with air. The quantity of air required to reach the upper and lower explosive boundaries can also be calculated. The trend shown by successive mine air samples is revealed, and this should be of considerable assistance in deciding what practical action should be taken.

734. BOTH, W. and MEERBACK, H. Development and Testing of Explosion-Proof Calcium Sulphate Fire Stoppings. *International Conference Safety in Mines.* Paper No. 21, Warsaw, 1961.

735. ROBINSON, H. and SMITH, P.B. The SMRE Manometer, Mark 2, for Recording Explosions behind Stoppings. *Safety in Mines.* Research Report No. 15, 1951, 21 p.

736. MITCHELL, M. and NAGY, J. Practical Aspects in Fighting a Fire of a Mining Machine. *International Meeting of the Directors of Mine Safety Institutes.* Warsaw, 1961.

737. GREUER, R.E. Influence of Mine Fires on the Ventilation of Underground Mines. *United States Bureau of Mines.* Contract No. S0122095, July 6, 1973. OFR 74-73.

Predictions of the airflow distribution in a mine on fire are complicated by the forces and disturbances the fire *can cause to the ventilation system. This depends on local circumstances. In some mining areas, they can impose a serious threat. Some large mine disasters were due to unexpected airflow reversals that were not anticipated in fire fighting plans. A greater appreciation of these effects should be available to fire emergency planners.*

The report deals in detail with: (a) the properties of mine fires and their dependence upon ventilation, (b) the temperatures of air and gases behind the fire, modified by heat exchange with the airway walls, and (c) the ventilation forces developed by the combustion gases.

The ventilation disturbances so produced are discussed qualitatively. The different types of ventilation plans and their usefulness for prediction of ventilation disturbances are shown. Examples of observed disturbances are given.

The different approaches available for quantitative predictions are given; also the criteria for judging the stability of ventilation currents. The use of analog and digital computers for design of fire emergency plans is described and their potential analyzed.

738. HOOPER, R.P. Underground Mine Fire Prevention at the South Mine, Broken Hill. *Australasian Institute of Mining and Metallurgy.* Proceedings, No. 73, 1929.

Discusses the fire fighting organization developed for squad training and equipment procedures.

739. KNEVITT, L.T. Further Notes on Underground Mine Fire Prevention at the South Mine, Broken Hill. *Australasian Institute of Mining and Metallurgy.* Proceedings No. 142, 1946, pp. 127-150.

Following three fires in 1944, fire fighting methods and equipment were revised in line with experience gained.

Deals with organisation and training of fire squads; fire fighting and rescue equipment; hose practice; fire warning system; and standard procedure. Drawings of equipment included.

740. ANON. Fires in Witwatersrand Mines. *South African Mining and Engineering Journal.* Vol. 41, No. 2017, May 24, 1930, pp. 349-350.

Some causes and suggested remedies.

741. HARRINGTON, D. Fires in Metal Mines. *Canadian Mining Journal.* Dec. 21, 1928, pp. 1059-1063.

A very comprehensive paper detailing a wide variety of causes of fires in metal mines. Warns mine operators not to be complacent. Fires can and have occurred in wet metal mines. Need for better supervision and improved vigilance as well as better fire fighting organizations.

Since open lights have been discarded, now more fires of electrical origin.

Even gases produced in metal mine fires can be more insidious than in coal mines.

Mechanical ventilation and a well planned system of fire doors should be a necessary feature of all metal mines.

742. GLAESER, O.A. Ventilation at the United Verde Mine. *American Institute of Mining and Metallurgical Engineers.* Technical Publication No. 199, 1929.

Provides a full description of the ventilation conditions and equipment. Ventilation is provided not only to improve working conditions but also to limit the possible hazards of mine fires. An old fire in an area now sealed adds heat to adjacent working faces. A mine fire foreman is on the payroll. His duty is to oversee the prevention and fighting of mine fires.

Steel and concrete fire doors, horizontal fire breaks in the form of level pillars, and fireproof coverings over raises are part of the system. Door instructions in case of fire are provided on each door and trapdoor in large letters. Adequate fire signals are also provided. A fresh air base can be established on every level within a short distance of any fire. Firedrills are regularly held and fan reversals are practiced. 35 refuge chambers are also provided.

743. BROCKUNIER, O.H. Reflections on the Argonaut Fire. *Engineering & Mining Journal.* Vol. 114, Oct. 28, 1922, p. 755.

Suggests that the Argonaut mine disaster could have been averted if the main exhaust fan had been reversed. Cites experience at Cordova gold mine, Ontario, under similar conditions.

744. POTTER, O. Fire Protection at Calumet & Hecla. *Engineering & Mining Journal.* Vol. 114, No. 18, 1922, p. 754.

Describes how fire warnings are transmitted at subject mine by cutting off the compressed air supply. Men not using compressed air are notified by shift bosses. Fire drills held periodically. Results have proved effective at this deep mine.

745. ANON. Fire Escapes for Mines. *Engineering & Mining Journal.* Vol. 114, No. 14, Sept. 30, 1922, p. 573.

Draws attention to the need for adequate fire escape-ways in mines.

746. ANON. An Enemy of the Mining Industry. *Engineering & Mining Journal.* Vol. 114, No. 12, 1922, p. 486.

Describes the serious effect that mine fires have on mining activities. Gives several examples of fire prevention methods learned through bitter experience.

747. ARNOLD, T.H. Fan Equipment for Metal Mine Fires. *Engineering & Mining Journal.* Vol. 111, 1921, pp. 590-591.

Describes the use of portable fan units as an aid to fire fighting under certain classes of fires.

748. ANON. Air-Controlled Fire Door at Copper Queen Mine. *Engineering & Mining Journal.* Vol. 105, March 23, 1918, pp. 559-560.

Describes a device for closing fire doors simultaneously all over a mine by opening an air valve anywhere on the system from the surface to the stopes. From a paper presented to a meeting of the AIME in February 1918. Sketches are supplied.

749. ANON. The Automatic Sprinkler in Metal Mines. *Engineering & Mining Journal.* Vol. 114, No. 17, Oct. 21, 1922, p. 705.

Automatic sprinklers are suggested as fixed installations in timbered mine shafts and stations. Trials are recommended.

750. ANON. Argonaut Jury Recommends Connections between Neighboring Properties. *Engineering & Mining Journal.* Vol. 114, No. 16, Oct. 14, 1922, pp. 691-692.

Gives findings of coroner's jury investigating the Argonaut mine disaster of August, 1922, in which 47 miners lost their lives. Jury recommended that neighboring mines be connected with permanent openings; that better fire prevention measures be taken; and that better fire fighting facilities be maintained.

There was unnecessary delay in rescuing the trapped men after the fire was reported.

751. HIGGINS, E.H. How Shall We Get Mining Efficiency? *Engineering & Mining Journal.* Vol. 109, No. 26, 1920, pp. 1404-1405.

Includes a comprehensive review of fire prevention and fire protectin methods; and also a discussion on fire extinguishers of several types.

752. ANON. Fire in the West Colusa Mine. *Engineering & Mining Journal.* Vol. 95, March 1, 1913, p. 491.

This fire started in the heavily timbered portion of the mine on the 600 foot level. Men had to be evacuated through the adjoining Mountain View Mine before all connections could be bulkheaded to halt the flow of gas.

No fatalities have occurred although several firemen were overcome by smoke and gas.

753. ANON. Fire in the Stewart Mine. *Engineering & Mining Journal.* Vol. 95, Feb. 8, 1913, p. 345.

This fire broke out in the stopes between the 1500 and 1700 ft. levels early in December, 1912. It has now been completely extinguished and mining should be resumed in the fire zone within two weeks.

Miners are now replacing the burned timbers.

754. ANON. More Installation of Mine Rescue Apparatus Needed. *Engineering & Mining Journal.* Vol. 127, June 22, 1929, p. 987.

One of the most effective means of lessening the number of fatalities in the mining industry in recent years has been the utilization of self-contained oxygen breathing apparatus. Rescue parties are thereby enabled to penetrate irrespirable atmospheres and save lives otherwise lost.

Gives a brief history of this apparatus in the U.S., particularly the promotional work of the Bureau of Mines, and the value of trained crews when fires occur.

755. ANON. Fire Protection at Butte Mines. *Engineering & Mining Journal.* Vol. 120, 1925, p. 986.

A Bureau of Mines report reviews improvements in safety work in the Butte district, especially in regard to fire protection and the training of fire fighting crews.

The largest old mine fire area has been filled with slimes and the previously abandoned ore is now being mined.

756. JONES, W. Fires in Mines. *Engineering & Mining Journal.* Vol. 101, No. 4, July 28, 1917, pp. 176-177.

Discusses the chemistry and physics of mine fires.

757. ANON. Twenty-One Dead in Mine Fire at Butte. *Engineering & Mining Journal.* Vol. 101, No. 8, 1916, p. 362.

A fire broke out in the 1200 ft. level of the Pennsylvania Copper Mine on Feb. 14, 1916. The station at the air shaft was found ablaze.

A prompt alarm enabled all of the 200 men to escape except 21, some of whom were members of rescue crews.

The origin of the fire is unknown. Connections with other mines were sealed but some gas passed through and several men were overcome.

758. ANON. Fire Protection in Shafts. *Engineering & Mining Journal.* Vol. 103, Jan. 27, 1917, p. 191.

A fire broke out at the 1500 level station during an unwatering project on the Comstock Lode, Nevada. Although two 12-in. water pumping mains passed directly through the fire zone, there was no way of diverting the water to the fire.

Fire extinguishers were used but the CO_2 affected the fire fighters more than the fire.

Every pumping installation should have tees and valves for fire fighting purposes.

759. ANON. Fire in Pocahontas Mine, Joplin District. *Engineering & Mining Journal.* Vol. 97, No. 20, 1914, p. 1024.

The timber in a badly caved portion of the Pocahontas Mine was set afire through the decomposition of marcasite. The fire spread rapidly causing many falls of ground, cutting off the air between two shafts and resulting in the abandonment of the mine until the water level rose to snuff the fire. Adjoining properties were also put out of commission.

760. ANON. General Alarm for Mine Fires. *Engineering & Mining Journal.* Vol. 97, April 25, 1914, p. 873.

Mine fires are the least expected, the most insidious and the most destructive of the dangers threatening the miner.

One of the most serious difficulties is that of evacuating miners before the workings become filled with deadly smoke and gases. The need for a foolproof fire warning system is paramount.

Describes the standard warning system used at United Verde. All electric lights underground are flashed nine times, repeated three times, and the level signal on which the fire occurs is then flashed.

761. VAIL, R.H. New Smeltery at the United Verde Copper Co. *Engineering & Mining Journal.* Vol. 96, No. 8, 1913, p. 344.

The use of square setting is being restricted to areas of heavy ground. All stopes are now being filled with waste.

The old fire extends from the 700 level to the surface. It is now kept under control by the plenum system of maintaining a slight positive pressure on the seals to develop more SO_2 *in the fire zone to help smother the fire and to introduce sufficient air to enable neighboring areas to be worked comfortably.*

A comprehensive system of ventilation control is now exercised through the stopes. A careful fire inspection program is maintained.

762. ANON. How Mine Fires are Started. *Engineering & Mining Journal.* Vol. 96, 1913, p. 1233.

Fire in an iron mine starts by lighting paper and throwing it down a chute to see how much ore is there. Wrong tactics are used to subdue it. The chute became a roaring furnace. A long fight to subdue it.

The mine now employs fire inspection and is better equipped for fire fighting.

763. ANON. Mine Fires. *Engineering & Mining Journal.* Vol. 94, No. 19, Nov. 9, 1912, p. 869.

Reviews recent mine fires in metal mines and relates their causes to undetermined carelessness. The employment of a corps of fire inspectors by some mining companies is supported.

764. ANON. Candle Fires. *Engineering & Mining Journal.* Vol. 94, No. 26, 1912, p. 1204.

Refers to the danger of candles left to burn at the end of shift near dry timber or rubbish.

Cites this as the cause of the Stewart Mine fire at Butte and the Belmont shaft fire at Tonopah, NV.

The employment of inspectors ("fire bugs") to visit all working places at end of shift is considered a good approach.

765. RICE, C.T. Mining Methods at Goldfield. *Engineering & Mining Journal.* Vol. 92, Oct. 21, 1911, p. 801.

Discusses the practice of employing a safety inspector to regularly inspect the mine workings after each shift to check for lighted candles and oil lamps that may otherwise cause a fire.

766. VON BERNEWITZ, M.W. Reversing Ventilation Currents During Mine Fires or Explosions. *Engineering & Mining Journal.* Vol. 114, Nov. 18, 1922, p. 885.

Fan reversal in case of fire calls for a prompt decision, but also a thorough knowledge of normal conditions and the likely effects of reversal.

Cites a number of cases where prompt reversal saved lives; and others where reversal had or would have had an unfortunate result.

767. RICKARD, T.A. The Hazard of Fire Underground. *Engineering & Mining Journal.* Vol. 114, No. 21, 1922, p. 884.

Discusses and enumerates various lessons that should be learned from the Argonaut Mine fire. Advises that hasty legislation be avoided. A recognition of fundamental principles and the stimulation of a desire for mine operators to minimize risk would work much better.

768. ANON. Committee Recommends Fire Control Measures. *Engineering & Mining Journal.* Vol. 114, No. 21, Nov. 18, 1922, p. 914.

A committee representing operators, employees, industry and the California Industrial Accident Commission adopted the following resolution:

"In considering the following suggestions, the general committee desires to emphasize its belief that no blanket rule or regulations can apply alike in all mines. It feels that the suggestions made herein should be considered in the light of basic principles that may be modified, in the judgment of the mine inspector, to meet existing physical and other conditions at each mine; furthermore, that this thought and intention should be embodied in the rules as finally adopted by the California Industrial Accident Commission."

Suggestions applying to fire control measures were also made.

Committee was appointed following the Argonaut Mine disaster.

769. ROYCE, S. Fire Prevention in the Sunday Lake Mine. *Engineering & Mining Journal.* Vol. 114, No. 22, Nov. 25, 1922, pp. 934-935.

Describes an installation in the inclined shaft of the Sunday Lake iron mine on the Gogebic Range, which could with advantage be used in other mines.

A tee in the pump column within the shaft is fitted with a valve operated by pull ropes from top and bottom. If pumps are kept operating, a pull on the rope can spray and subdue a shaft fire.

770. HARRINGTON, D., PICKARD, B.O. and WOLFLIN, H.M. Metal Mine Fires. *Engineering & Mining Journal.* Vol. 114, No. 22, Nov. 25, 1922, pp. 937-941.

A résumé of precautions that should be taken to minimize fire risks in mines. Selection of equipment and training of employees to fight underground conflagration.

Based on a review of 114 metal mine fires costing 533 lives.

771. DUNCAN, R.J. Difficulties in Fighting Mine Fires. *Engineering & Mining Journal.* Vol. 114, No. 27, Dec. 30, 1922, pp. 1149-1150.

Describes in detail some of the problems encountered in fighting the Argonaut Mine fire.

772. MILLER, G.D. Extinguishing Mine Fires. *Engineering & Mining Journal.* Vol. 114, No. 27, Dec. 30, 1922, p. 1150.

Describes the use of water and foam for cooling and smothering a fire respectively.

Gives details of the portable CO_2 foam extinguisher.

773. ANON. Work Resumed After Fire in Morning Mine at Mullan, Idaho. *Engineering & Mining Journal.* Vol. 115, Feb. 17, 1923, p. 333.

On Jan. 23, 1923 a fire was discovered in the Morning Mine as the day shift was being lowered. They were quickly raised but one man was missing. Two others sought to rescue him. All three were asphyxiated.

The fire was hosed out and extinguished in 8 days. Fans were used to clear the smoke and gas. Mining operations were resumed on Feb. 5.

774. SCOTT, G. and MEWHIRTER, S.A. Mining Under Fire Conditions. *Engineering & Mining Journal.* Vol. 116, No. 3, July 21, 1923, pp. 101-106.

Discusses mining conditions at the Coronado Mine at Clifton, AZ in which a number of fires had occurred in the previous 5 years and 2 were still burning. These were impossible to extinguish because of their inaccessible location. Also because of its elevation above a long adit, the mine could not be readily flooded. However, a series of dams were built around the fire zone and it finally appeared to be subdued. However two months later another fire was reported. Fire was localized in an inaccessible timber mat area. Stoping was resumed under difficult conditions near the fire zone.

Detailed descriptions and mine plans are included.

775. ANON. Do Fire Drills Pay? *Engineering & Mining Journal.* Vol. 121, May 29, 1926, p. 895.

Cites an instance where mine safety crews subdued a fire within an hour of the alarm on the Utica iron mine.

776. ANON. Ontario Makes Fire Hazard Survey. *Engineering & Mining Journal.* Vol. 125, No. 13, 1928, p. 552.

The Chief Inspector of Mines in Ontario is carrying out a survey of fire hazards in all provincial mines. Every district will be thoroughly examined.

777. ANON. Pointers on Precautions Against Mine Fires. *Engineering & Mining Journal.* Vol. 125, May 5, 1928, p. 741.

Nine important pointers on safe practices calculated to minimize fire hazards in underground mines are offered by D. Harrington, U.S. Bureau of Mines.

1. *Every mine or working place in which more than five men work should have more than one opening for ingress and egress of both men and air. In mines reached by shafts more than 300 ft. deep there should be hoisting equipment in more than one shaft.*

2. *Every mine (coal or metal) employing five or more men should have mechanically controlled ventilation, preferably through a fan located on the surface in fireproof housing and so arranged as to allow of prompt reversal of direction of air currents in case of necessity. The approach to the fan from the shaft should be fireproofed also.*

3. *No timbered shaft should act as both intake and return.*

4. *Every opening leading from every shaft should have in it and reasonably close to the shaft a fireproof or fire-resistant door such that by closing these doors air flow to or from the shaft may be excluded at any or all levels in case of necessity. Unless this system of doors is maintained at all times along all timbered shafts leading into deep mines (even if not used at ordinary times) there is danger of suffocation to all or practically all men in the mine in case of fire in the mine and especially in case of fire in or near the downcast shaft.*

5. *Ventilation doors should be solid, tight, and fire-resistant; they should be equipped with a latch to keep them closed in case of reversing of direction of air and, where made automatic, the automatic feature should be positive as to closing the door rather than holding it open.*

6. *The shaft or shafts in which men are hoisted should be intake (or downcast).*

7. *Downcast shafts should preferably be lined with concrete or other absolutely fireproof material.*

8. *Underground electrical stations should be fireproof and all electrical equipment and wiring carefully safeguarded as to fire.*

9. *No open lights, smoking, torches, or other flame ought to be allowed in any mine where timber or other inflammable material is used or found.*

778. ANON. Fire-Gas at Hollinger Kills 39. *Engineering & Mining Journal.* Vol. 125, No. 7, Feb. 18, 1928, pp. 308-309.

A fire broke out on the 500 level of the Hollinger Mine at Timmins, Ont. on Feb. 10, in a stope where refuse had been accumulating but the direct cause of the fire is unknown. There were between 800 and 900 men underground. Rescue efforts were abandoned after 11 days and 39 bodies were later found. Meanwhile, breathing apparatus had been rushed by special trains from Toronto and Pittsburgh.

779. ANON. The Hollinger Fire. *Engineering & Mining Journal.* Vol. 125, No. 8, Feb. 25, 1928, p. 321.

Questions arising from the Hollinger Mine Fire disaster are raised. These include (a) why was inflammable refuse allowed to accumulate, (b) why was the nearest oxygen helmet as far away as Toronto, (c) why were these helmets unsuitable, (d) in fact why was it necessary to go to Pittsburgh for suitable helmets, a distance of nearly 900 miles, (e) why is systematic fire patrol work not undertaken, (f) why was an effective warning system not used, and (g) are the fire doors adequate for the purpose?

See also Item #778.

780. WOOTON, P. Mine Rescue Car Makes Record Trip from Pittsburgh to Timmins. *Engineering & Mining Journal.* Vol. 125, 1928, p. 343.

Describes the spectacular rush trip of Bureau of Mines Rescue Car No. 3 from Pittsburgh to Timmins, Ont. in 21 hours in a vain attempt to rescue trapped miners in the Hollinger Mine. Drawn by a special locomotive it was given preference over all traffic on U.S. and Canadian lines. See also Item #778.

781. ANON. Hollinger Inquiry Marked by Conflicting Evidence. *Engineering & Mining Journal.* Vol. 125, March 10, 1928, p. 427.

Much conflicting evidence was presented to the Commission of Inquiry following the Hollinger Mine disaster.

Shift bosses were aware of the practice of dumping powder magazine refuse into old stopes.

The safety inspector was not aware of this but did not consider it his responsibility to question the disposition of refuse.

In such a large organization, the biggest gold mine in North America, it was difficult to pin-point the responsibility. Chief Inspector of Mines has now ordered all underground powder magazines to be removed to the surface.

See also Item #778.

782. ANON. Ventilation and Mine Fires. *Engineering & Mining Journal.* Vol. 125, 1928, p. 459.

Stresses the importance of fire prevention in all ventilation planning, based on results of the Hollinger and Magma mine fires. The downcast airways should be fireproofed. Combustible materials should not be allowed to accumulate. Carelessness of workers should be countered by exacting inspections. Superintendents should be more fire conscious.

See also Item #778.

783. ANON. Coroner's Jury Emphasizes Negligence of Hollinger Executives. *Engineering & Mining Journal.* Vol. 125, No. 13, 1928, p. 548.

The Coroner's jury called to inquire into the deaths of 39 miners in the Hollinger Mine disaster has determined the cause of death as carbon monoxide poisoning; the fire was due to gross negligence on the part of the Hollinger management and the operating executives in allowing inflammable material to be dumped in old stopes.

This finding is somewhat contrary to that of the Commission of Inquiry which was unable to fix the responsibility for the negligence. See also Item #778.

784. ANON. Canadian Royal Commission and Mine Operators Approach Agreement on Safety Regulations. *Engineering & Mining Journal.* Vol. 125, No. 16, April 21, 1928, pp. 665-666.

Co-operation with Government Inspectors and reforms in industry practice should result from an inquiry into the Hollinger disaster. A committee of managers is now studying the problem.

A list of seven important suggestions has been drawn up for consideration.

Other possible recommendations should also be studied.

Comments on some of these suggestions are given.

See also Item #778.

785. ANON. Danger at Hollinger not Realized. *Engineering & Mining Journal.* Vol. 125, June 9, 1928, p. 951.

Justice Godson, Royal Commissioner appointed to inquire into the Hollinger Mine disaster, reports that lack of co-ordination in the organization resulted in a disjointed system of control, thereby permitting the improper dumping of magazine refuse into empty stopes. Conditions at the mine had led to belief in physical security by management and miners. The practice of dumping inflammable refuse had not been recognized as a fire hazard.

See also Item #778.

786. ANON. Gunite as a Fire Preventive. *Engineering & Mining Journal.* Vol. 115, No. 4, 1923, p. 192.

Tests conducted by the Bureau of Mines show that cement gunite sprayed on timbers will prevent the starting of a mine fire.

Suggests that headframes, shaft timbers, shaft stations and all timbered permanent installations should be fireproofed with gunite.

787. ANON. Mine Fires. *Engineering & Mining Journal.* Vol. 117, Jan. 19, 1924, p. 103.

Following the Argonaut Mine fire, the Industrial Accident Commission of California has drafted mine fire control safety orders.

These have been discussed by various experts in a number of publications cited.

788. ANON. A New Portable 40-Gallon Foamite Fire Extinguisher. *Engineering & Mining Journal.* Vol. 118, No. 21, 1924, p. 836.

Describes a new improved type of metered foam chemical generator with twice the capacity of a former model and with other improvements. Marketed by Foamite-Childs Corporation of Utica, NY. Approved for both Class A and Class B fires by the Underwriters' Laboratories.

789. ANON. Two Lose Lives in Unusual Mine Fire at Butte. *Engineering & Mining Journal.* Vol. 118, No. 12, 1924, p. 470.

At the Seymor lease, near the Nettie Mine, a hoist engineer over-filled the tank of a gasoline engine. The hoist-house immediately caught fire, then the headframe, and then the timbers of the only shaft. Two miners were burned to death trying to escape. One survived.

790. ANON. Helmet Men Isolate New Fire in Copper Queen Mine. *Engineering & Mining Journal.* Vol. 118, No. 8, 1924, p. 308.

Fire was discovered in the Lowell Mine at Bisbee, AZ on July 31, 1924.

Helmet crews who were continuously constructing bulkheads to seal and control an earlier fire found that the new fire was confined to an old worked-out section.

Production operations continued as usual.

791. ANON. President Hoover Directs Attention to Fire Loss. *Engineering & Mining Journal.* Vol. 128, Oct. 5, 1929, p. 535.

Proclaims "Fire Prevention Week" in an effort to underline the growing national cost of fire losses. Much of this loss due to stupidity and carelessness; and to the failure of mine superintendents to take adequate precautions.

792. ANON. Construction of a Mine Fire Door. *Engineering & Mining Journal.* Vol. 119, May 16, 1925, p. 813.

Describes the construction of a fire door that has proved satisfactory at the Plymouth Mine, California.

A sketch is provided. Door is made on a 2×4 frame covered with 22-gauge galvanised iron, and swung by three hinges from a 2×6 outer frame which is bolted to a concrete partition keyed into the sides, top and bottom of the drift.

793. YATES, B.C. Fighting the Fire at the Homestake Mine. *Engineering & Mining Journal.* Vol. 85, No. 13, March 28, 1908, pp. 633-640.

A fire started on March 25, 1907, presumably by blasting in a timbered stope.

After fighting with fire hoses, then steam, the mine was finally flooded.

See also Item #544.

794. ANON. Fire in Mine in Butte District. *Engineering & Mining Journal.* Vol. 91, Jan. 24, 1911, p. 190.

On Jan. 14, 1911 a fire broke out in the new workings between the Modoc and Butte-Ballaklava mines filling connecting workings of adjoining mines with smoke causing the death of one man in the High Ore and one in the Bell Mine.

795. RICE, C.T. Goldfield Consolidated Fire Equipment. *Engineering & Mining Journal.* Vol. 91, Feb. 11, 1911, pp. 311-312.

Since a fire in the mill in April, 1910 the Company has installed a comprehensive system of fire fighting equipment.

However, the amount of water available for underground fires is small. It is better to rely upon bulkheads so placed as to contain the fire. The mines are inspected each shift for incipient fires.

796. ANON. Fires in Mine Shafts. *Engineering & Mining Journal.* Vol. 92, No. 11, Sept. 9, 1911, p. 479.

Discusses the serious aspects of fire in a mine shaft, either from the surface or below or within the shaft and stresses the need for protection by fireproofing the timber and providing bulkheads on the level connections.

Timber headframes are also criticized.

797. ANON. Fire in Giroux Shaft, Nevada. *Engineering & Mining Journal.* Vol. 92, Sept. 2, 1911, p. 469.

An explosion, on Aug. 24, at the 1200-ft. station, set fire to the timbers in the new shaft. Four men who were working at the bottom of the shaft, about 1400 ft. below surface, were killed coming through the fire on the cage. A water spray turned into the collar of the shaft caused a reversal of the draft, suffocating two men who were climbing the Alpha shaft. Two missing men were thought to be underground. The fire has been extinguished. Although the timbering at the station was destroyed, the shaft was not seriously damaged.

798. ANON. Hartford Mine Fire. *Engineering & Mining Journal.* Vol. 91, May 27, 1911, also June 3, 1911, pp. 1075, 1126.

A fire in the No. 2 Shaft of the Hartford Mine on the Marquette Range broke out on the fourth level resulting in the deaths of seven men and the cessation of operations at this and the adjoining Cambria and Lillie mines.

Although little timber is used, the gas generated was sufficient to penetrate the adjoining mines.

The coroner's jury censured the Republic Iron and Steel Co. for not having a ladderway in No. 1 shaft thereby preventing the escape of the trapped men; and for pouring water into the burning shaft thereby forcing gas and smoke upon these men.

Most of the men were able to escape through the adjoining Cambria mine.

799. ANON. The Belmont Mine Fire. *Engineering & Mining Journal.* Vol. 91, April 15, 1911, p. 758.

A fire in the mine of the Tonopah-Belmont Development Co. was reported to the hoist engineer on Feb. 23, 1911.

The following facts were derived from the coroner's inquest.

Fire was found burning in mine timber on the 1166 ft. level. To reduce the draft, a bulkhead was planned. Shortly thereafter, the men were evacuated to the 1100 ft. station and then by cage to the surface. Smoke was already pouring from the collar. Apparently four men fainted in the cage and fell to the bottom.

In all, 17 men lost their lives. Lack of knowledge and experience were responsible for the inability of supervisors to realize the danger.

See also Item #683.

800. WALKER, S.F. Insulation of Cables in Mines. *Engineering & Mining Journal.* Vol. 91, March 4, 1911, pp. 476-479.

Gives detailed information regarding the different insulating materials, and a discussion of the problems caused by defective insulation. Also gives advisable precautions.

801. STAUBER, I.J. A Shaft Fire in the Shattuck Mine, Bisbee, AZ. *Engineering & Mining Journal.* Vol. 85, Jan. 25, 1908. p. 197.

Fire was noticed by the night watchman about midnight on Nov. 19, 1907. There was no one in the mine at the time. Three 2-in. fire hoses were hung in the shaft to diminish smoke and lower the temperature which reduced the air velocity in the upcast shaft. Three bulkheads were built, one at the collar, one at the surface sub-drift and one on the 800 Level connecting to the Cuprite mine. Within 1½ hours every opening was tightly closed. A broken steam pipe in the shaft helped to smother the fire with steam.

After 4½ days the shaft was unsealed and thoroughly wetted. Apparently the fire originated in the 800 ft. pump station. Its rapid spread was due to a large electric lighting cable, the covering of which was very flammable.

Undoubtedly the prompt use of hose and water quickly modified the fire, assisted by the later smothering action of the bulkheads.

802. PICKARD, B.O. The Copperopolis Fire. *Mining and Scientific Press.* Vol. 121, Nov. 20, 1920, pp. 737-738.

An underground fire at the Copperopolis Mine started about midnight on Sept. 29, 1920. It originated among surface buildings in the vicinity of the downcast shaft. The night shift crews were immediately withdrawn.

However, two men who went down with inadequate masks to operate the pumps were asphyxiated.

803. HARRINGTON, D. Ventilation in Metal Mines. *Mining and Scientific Press.* Vol. 123, Oct. 29, 1921, p. 612.

In the event of a fire in a metal mine, the lack of an efficient ventilation system may be disastrous. There should be a definite system of airsplit and doors to isolate any section of the mine. Shafts should be lined with concrete or the support system proofed with gunite.

804. ANON. Fire in Speculator Mine, Butte. *Mining and Scientific Press.* Vol. 114, June 16, 1917, p. 862.

A fire was started, it is reported, by the flame of a carbide-lamp igniting a frayed insulation of an electric wire, on the 2400-ft. level of the Speculator mine, on Anaconda hill at Butte, on Saturday. The fire communicated to the mine-timbers, and spread rapidly. Soon the Granite Mountain shaft, an upcast, with which the Speculator workings are connected, was a roaring chimney of flame. A large number of men were in the mine at the time, but despite the heroic efforts at rescue many lives were lost. A tool-boy, Manus Dugan, aged 20, directed a party of 27 men who, including himself, retired into a drift and built a bulkhead to keep out the deadly gases. After remaining imprisoned for 36 hours in the drift until nearly exhausted from lack of oxygen, young Dugan ordered the men to break down the bulkhead and make a dash for the shaft. All of this party were rescued alive except J.H. Adams and Manus Dugan, whose whereabouts were unknown. Rescue-crews made every effort to reach and save the miners in various parts of the mine, and numerous lives were thus saved, but many others, it is feared, were suffocated by the carbon dioxide that penetrated to every open place in the mine workings.

805. ANON. Rescue Work in Burning Mine. *Mining and Scientific Press.* Vol. 114, May 5, 1917, p. 641.

The use of oxygen breathing apparatus to rescue miners affected by gases from fires has now been well tested in the Butte district.

Describes the training facilities for rescue teams and a photo of a Bureau of Mines rescue vehicle.

806. SHAW, J.J. Fighting Mine Fires. *Mining and Scientific Press.* Vol. 114, Jan. 20, 1917, p. 78.

Explains a misconception regarding the use of the positive plenum system for extinguishing the fire at the United Verde Mine. The ventilating air pressure was not primarily maintained to force back the gas and cool the area so that miners could work, but to introduce sufficient *air to the fire to develop enough SO_2 gas to snuff the fire. The method founded on this theory was successful. Used also by the author at Iron Mountain, CA, and at United Verde previously.*

See also Item #761.

807. WAYLAND, R.G. The Homestake Fire of 1919. *Mining and Scientific Press.* Jan. 17, 1920, p. 84.

Fire began on the evening of Sept. 25, 1919, above the sixth floor of a small square-set stope above the 800 foot level. This stope had broken through into a large area of broken ore, waste and timber, which had arched over and hung up about 30 ft. above the grizzly. In blasting it down the men set fire to some of the timber. Efforts to draw out this burning timber failed and steps were taken to pipe water into the stope but smoke and gas made it impossible to work without breathing apparatus.

Wooden brattices, plastered with cement, and concrete bulkheads were later built and the mine was flooded. The fire was extinguished early in December.

See also Item #544.

808. RAHILLY, H.J. Fighting Mine Fires. *Mining and Scientific Press.* Vol. 121, October 30, 1920, pp. 625-627.

Discusses experiences in fighting fires underground in the Butte district. The chief causes are (a) defective electrical equipment, (b) incendiarism or carelessness, and (c) spontaneous combustion of the sulphide ore.

Describes the physical properties and physiological effects of the three main gases encountered in fighting a mine fire - carbon monoxide, carbon dioxide, and sulphur dioxide.

809. MITKE, C.A. A History of Mine Fires in the Southwest. *Mining and Scientific Press.* Part I, July 31, 1920, pp. 155-160; Part II, August 7, 1920, pp. 187-192.

Gives detailed description of fires in metal mines in Arizona and Mexico such as Lowell (1911, 1915), Holbrook (1912, 1913, 1915), Gardner (1914), Shattuck (1919), Briggs (1920, 1920), Irish Mag (before 1911), Cananea (1914 - nine fires in two large mines), Pilares (1918), Clay (1916, 1916), Copper Mountain (1916), Coronado (1917-1919), United Verde (over 22 years), United Verde Extension (1917, 1917).

Concludes with an analysis of causes of metal mine fires. The advantages of better ventilation control using mechanical fans is also discussed.

810. YOUNG, G.J. *Elements of Mining.* McGraw Hill, New York, 4th edition, 1946, pp. 688-691.

Includes a section on Fires in Metalliferous Mines.

Most fires in metalliferous mines are preventable. The causes are: the ignition of inflammable material; carelessness with open lights and smoking; smouldering fuse; overheated bearings; short-circuiting of electric wires; and spontaneous combustion when a fire has started. The first step is to evacuate the men as speedily as possible. Measures are then taken to fight the fire.

Discusses critical situations that may arise and accepted methods for dealing with them.

811. HOLMES, J.A. Lessons from Recent Mine Disasters. *Mining and Scientific Press.* Vol. 104, March 30, 1912, p. 462.

Two most notable recent disasters from mine fires are the Cherry Coal Mine (259 lives lost) and the Pencoast Mine (72 lives lost). In neither case was there a gas or dust explosion.

The two most important lessons are:

1. *inflammable materials should not be taken into mines, and*

2. *better methods should be found for fighting and extinguishing fires.*

812. BARBOUR, P.E. The Hero of the Argonaut Fire. *Mining and Metallurgy*. Vol. 4, 1923, pp. 174-175.

A tribute to the courage of G.S. Downing, assistant superintendent, who died in hospital following heroic efforts to save 46 miners in the recent Argonaut Mine fire disaster.

813. ANON. By-Passing Water into Air Lines for Fire Protection. *Mining & Metallurgy*. Vol. 11, January, 1930, p. 55.

At the mine of the United Verde Extension Mining Co., provision is made for by-passing water into the air line in case of a fire emergency.

It provides a quick method of getting a water stream to any isolated part of the mine. Sketch shows method of operating the valves.

814. BARBOUR, P.E. The Hecla Mine Fire. *Mining & Metallurgy*. Vol. 6, June, 1925, p. 269.

Describes a fire on the 2000 ft. station of the Hecla mine on April 23, 1925, discovered by a pumpman, and due to a short circuit in electric wiring. He exhausted all fire extinguishers and then went to the surface for help. Fourteen men were trapped but eventually escaped due to courage and good judgment of all crews in a critical situation.

815. HARRINGTON, D. Mine Ventilation in 1930. *Mining and Metallurgy*. Vol. 12, January, 1931, p. 15.

Deals with fires in metal mines, including the Glenn mine fire in California on July 14, 1930.

Five men were asphyxiated chiefly by fumes from a surface fire which extended a short distance into the mine portal.

Refers to a Code for Fire Fighting in Metal Mines drawn up by the American Mining Congress and the National Fire Protection Association and issued through the American Standards Association.

This Code was discussed in an article by O.A. Glaeser. See Item #844.

816. BARBOUR, P.E. Responsibility for the Argonaut Disaster. *Mining and Metallurgy.* Vol. 3, No. 190, October, 1922, pp. 3-4.

Refers to USBM Bulletin No. 75 which incorporates the recommendation of a committee which in 1915 drew up specific draft legislation offered as a model to the various states.

The proposed bill included specific provisions and penalties for non-compliance. Had California adopted such a law and enforced it, the lives of 47 men trapped in the Argonaut mine fire of 1922 would not have been sacrificed.

817. PICKARD, B.O. Rescue Work at Argonaut Mine Fire of 1922. *Mining and Metallurgy.* Vol. 3, No. 191, November, 1922, pp. 27-34.

Describes valuable lessons that should be learned from the efforts of entombed miners and of rescue crews to save human lives at the Argonaut Mine Fire, Jackson, CA where 47 men were trapped for 22 days before the bodies were recovered.

818. GLAESER, O.A. Protective Measures Against Gas Hazards at United Verde Mine. *American Institute of Mining Engineers.* Technical Publication No. 276, 1930, pp. 3-11.

Because of the high sulphur content of the ore, blasting is an extremely hazardous operation. It has led to metal-mine dust explosions, which may then cause a fire.

The origin of the fires of 38 years ago, embers of which are still glowing, may be attributed to dust explosions due to blasting in the massive sulphides in square-set stopes.

The mine is regularly patrolled by fire watchmen who have no other duties.

819. GOODALE, C.W. and BOARDMAN, J.L. Bureau of Safety of Anaconda Copper Mining Co. *American Institute of Mining Engineers*. Transactions, Vol. 68, 1922, pp. 8-32.

On pages 28-29, refers to the numerous fires in the Butte Mines and the consequent dependence on self-contained oxygen breathing apparatus. Mine rescue work is described in detail.

820. DALY, W.B. and BERRIEN, C.L. Mining Methods and Installation of Anaconda Copper Mining Co. at Butte, MT. *American Institute of Mining Engineers*. Transactions, Vol. 68, 1922, pp. 3-7.

Includes a section on Underground Fire Prevention; also on mine fires and hydraulic filling used to reclaim fire areas.

821. RICHARDSON, A.S. Ventilation of Butte Mine of Anaconda Copper Mining Co. *American Institute of Mining Engineers*. Transactions, Vol. 68, 1922, pp. 35-55, discussion, pp. 55-60.

In planning the ventilation for steeply dipping orebodies, the amount of air required per man per minute is not the only consideration. Other influences relate to the decay of mine timber, rock and water temperatures, oxidation of sulphide ores, heat from electrical equipment, and heat generated by mine fires.

This latter source of heat is usually of such magnitude that special cooling arrangements are necessary for active mining operations near the fire zone.

822. NORRIS, E.M. Underground Fire Prevention by the Anaconda Copper Mining Co. *American Institute of Mining Engineers*. Transactions, Vol. 68, 1922, pp. 77-85, discussion, p. 72.

Describes five local conditions that contributed to a heavy fire risk that led to many underground fires in the Butte district in 1917, nearly all caused by the failure of electrical equipment.

A comprehensive plan of fire protection was begun in 1917, involving fireproofing, remodeling electrical installations, extensions to underground water systems, better control of ventilation, maintaining efficiency of fire fighting crews, and reorganization of the fire patrol.

823. HARRINGTON, D. Dust Ventilation Studies in Metal Mines. *American Institute of Mining Engineers.* Transactions, Vol. 66, 1922, p. 280.

One of the most important considerations in metal mine ventilation is its relation to fire protection and prevention. In addition to fans capable of ready reversal and a framework of airway splits, a system of well-constructed doors is necessary. Description of recommended door installations is given.

824. MITKE, C.A. Mining Methods of United Verde Extension Mining Co. *American Institute of Mining Engineers.* Transactions, Vol. 61, 1918-19, p. 199.

Describes the fire protection in the Edith, Little Daisy, and Audrey Shafts.

A number of portable fans and a supply of bulkheading material and firefighting equipment are kept on hand readily available in case of a fire warning.

825. NORRIS, E.M. Fireproofing Mine Shafts of Anaconda Copper Mining Co. *American Institute of Mining Engineers.* Transactions, Vol. 61, 1918-19, pp. 201-203.

Describes in detail the fireproofing of the main Tramway hoisting shaft at Butte by gunite applied to the timber and reinforced concrete lining at critical points in the shaft.

826. HARRINGTON, D. Progress in Metal-Mine Ventilation in 1930. *United States Bureau of Mines.* Information Circular No. 6469, July, 1931.

Ventilation in metal mines has been affected by the business depression of 1930.

Discusses the question of the Codes adopted by the American Standards Association for "Fire Fighting Equipment in Metal Mines."

Cites cases of a fire in the Glenn Mine, CA, with five deaths; and refers back to two early mine fires from which lessons have still not been learned.

827. ANON. Mine Fire at Gold Hill, NV. *Engineering & Mining Journal.* July 10, 1930.

The Comstock Lode (discovered in 1859) was the scene of considerable excitement in the spring of 1869, when fire broke out in the Kentuck mine, at Gold Hill, NV, and, spreading to the Yellow Jacket and Crown Point, was the cause of the death of 36 men. Many weeks passed before it was put out. The deaths were attributable to the same factor all too common today - lack of an emergency shaft and underground connections, with no prearranged ventilation system, in case of fire.

828. ANON. Fires in Witwatersrand Mines. *South African Engineering & Mining Journal.* May 24, 1930.

It is doubtful if there is a mine on the Witwatersrand which has been winning ore for, say, the last 20 years, which has not also had the experience of a fire underground. In some cases these fires have been of small scope and severity, but in others the results have been serious, in both loss of life and damage to property. It will be recalled, in the case of the Ferreira Deep Mine fire of some years ago, that a station collapsed, resulting in the loss of 14 lives, and the damage done must have cost the company thousands of pounds.

829. SCOTT, G.S. Mechanism of the Steam-Carbon Reaction. *Industrial and Engineering Chemistry.* Vol. 33, No. 10, pp. 1279-1285.

Studies of published data on the kinetics of steam decomposition by incandescent carbonaceous matter reveal one clear-cut case of a second-order reaction in the temperature range 700-1000° C. (for lignite char). The remaining data show local indications of a second-order reaction but, in general, show divergences when studied from the standpoints of initial gas composition and reaction velocities, respectively.

830. FENE, W.J. and HUMPHREY, H.B. Coal Mine Explosions and Coal- and Metal-Mine Fires in the United States in 1950, 1951, and 1952. *United States Bureau of Mines.* Information Circular No. 7661.

Sets out the statistics of coal mine and metal mine fires by states and causes in 1952. Ten deaths were reported. For the fiscal years 1929-1944 there were 356 mine fires reported, and 256 for the period 1944-1952. These include 55 metal mine fires and 12 outcrop fires.

831. ALLEN, C.A. and WATTS, A.C. Fighting a Mine Fire with Its Own Gases. *United States Bureau of Mines.* Report of Investigations No. 2325, Feb., 1922.

On August 17, 1920, a disastrous fire occurred in the No. 3 Sunnyside Mine of the Utah Fuel Co., which normally produced 1300 tons of coal per day. The shotfirer discovered the fire after the men had gone at the end of the shift. After making ineffective attempts to extinguish the fire, he went to the tipple for help, a distance of nearly three miles. After trying to fight the fire by direct methods for 36 hours, explosions forced a withdrawal.

The mine was then sealed at the portals by August 20, enclosing an area of 540 acres of workings. After monitoring the gas progressively, the mine was unsealed on Sept. 28.

Complete details are given.

832. JONES, G.W., ZABETAKIS, M.G. and SCOTT, G.S. Elimination of Ethyl Mercaptan Vapor-Air Explosions in Stench Warning Systems. *United States Bureau of Mines.* Report of Investigations No. 5090.

Ethyl mercaptan, although regarded as the most satisfying stench chemical, is highly volatile and flammable. It may present dangerous fire and explosion hazards when fed into compressed air lines, unless the rate of feed is controlled, or it is mixed with a suitable non-explosive flame-quenching material. Freons are used for this purpose. No toxic effects have been observed. Not corrosive.

Comprehensive details of physical and chemical properties are given. Recommended methods of eliminating explosions are given.

833. ANON. The Argonaut Mine Disaster. *Engineering News-Record.* Vol. 89, No. 18, Nov. 2, 1922, pp. 735-736.

Describes the workings of the Argonaut Mine and its connections with the Kennedy Mine and the critical events associated with the fire of August 27, 1922.

See also Items #529, #599, and #685.

834. McELROY, G.E. Natural Ventilation of Michigan Copper Mines. *United States Bureau of Mines.* Technical Paper No. 516.

Shows that most mines in the Keweenaw Peninsula, though deep, enjoy an adequate flow of natural ventilation.

The only apparent need to employ mechanical ventilation in certain mines is to promote better control for fire protection purposes.

835. HARRINGTON, D. Fire and Ventilation Doors in Metal Mines. *United States Bureau of Mines.* Report of Investigations No. 2426, December, 1922.

In the chain that assures safety, health and efficiency in metal mines, one of the most essential links is the mine door, yet only rarely are doors in metal mines properly situated, constructed, maintained or utilized. In coal mines, a multiplicity of doors generally indicates inefficiency of the ventilating system, that is, poor layout of air courses and lack of over-casts or air bridges, while on the other hand, in metal mining, it may and probably does indicate that a serious effort is being made to safeguard the mine and the health, efficiency and lives of the underground employees.

Gives a complete analysis of useful methods for and case studies of use of doors for general ventilation and mine fire requirements, including a summary.

Comments also given on the virtues of the Canton Automatic Mine Door.

836. MITCHELL, D.W., NAGY, J. and MURPHY, E.M. Rigid Foam for Mines. *United States Bureau of Mines.* Report of Investigations No. 6366.

To increase safety and productivity in mining, the potential uses and hazards of rigid foam were investigated by the Bureau of Mines Experimental Coal Mine. This research resulted in the development of chemical formulations, spraying equipment, and application procedures that permit safe and effective use of urethane foams for improving mine ventilation, for reducing weathering of mine rock and steel, for constructing seals in fire areas, and for thermal insulation.

Research and experience indicate that rigid foam will materially improve safety and productivity in mining. In most instances little or no surface preparation is required for spray application on dry, wet, or dusty surfaces of coal, rock, metal, wood, and concrete.

837. BROWN, C.L. Safety Aspects of Controls and Operations of Belt Conveyors in Coal Mines. *United States Bureau of Mines.* Information Circular No. 7749, June, 1956.

A belt conveyor system is an effective method of transporting coal in underground mines; but they were involved in a large number of fires in coal mines in the U.S. between 1947 and 1955.

The need for the proper selection of equipment and installation methods, together with good maintenance practice is underlined in order to reduce fire hazards. Fire-retardant belts and suitable control systems are recommended. The requirements of Article X, Section IL of the 1953 Federal Mine Safety Code are cited.

838. HARRINGTON, D. and EAST, J.H., JR. Stenches for Emergency Warnings in Metal Mines. *United States Bureau of Mines.* Information Circular No. 7246, July, 1943.

Fires in metal mines have resulted in some of the worst disasters in American Mining history insofar as loss of life is concerned. One fire caused the death of 163 miners. Less spectacular fires have cost the lives of scores of workers.

Metal mines are often very deep and working places are far removed from direct communication with the surface. In many instances they cannot be warned quickly of an emergency involving an order to evacuate. Alternative warning systems are described.

A quick effective method of warning is provided by a stench in the compressed air lines. Details are given together with four instances of their use in Canadian mines.

839. GARDNER, E.G. and PARKER, D.J. Shaft Fires - Magma Mine. *United States Bureau of Mines.* Report of Investigations No. 2882, July, 1928.

A fire broke out in the No. 2 Shaft of the Magma Mine at Superior, AZ on November 24, 1927.

Of the 49 men in the mine, 42 escaped but seven perished.

Another fire broke out in the No. 1 Shaft three days later. About 20 men were underground still fighting the first fire but all were safely withdrawn and the fire in No. 1 Shaft quickly controlled.

A detailed account of each fire is given, together with a summary of possible causes and 19 conclusions.

See also Item #686.

840. HARRINGTON, D. and DENNY, E.H. Gases That Occur in Metal Mines. *United States Bureau of Mines.* Bulletin No. 347, 1931.

Many gases harmful to man are widely prevalent in metal mines. They influence the health, safety and efficiency of miners. They can be detected by simple tests and equipment.

These gases can be controlled principally by a proper ventilation system throughout the mine.

Additional gases of vastly increased toxicity, are produced by mine fires, and ventilation control becomes much more critical. Adequate measures to minimize fire hazards and to control an incipient mine fire promptly are therefore called for.

841. JOLLEY, T.R. and RUSSELL, H.W. Control of Fires in Inactive Coal Deposits in Western United States, Including Alaska, 1948-58. *United States Bureau of Mines.* Information Circular No. 7932, 1959.

Numerous fires throughout the Western United States are continuously burning along coal outcrops. Some have been burning for over a hundred years whereas others are recent. Fires have different origins. They seldom extinguish themselves because of their ready access to atmospheric oxygen.

These fires have burned millions of tons of coal and destroyed thousands of acres of grazing land, presenting a hazard to cattle and wildlife.

Efforts to control the fires in these inactive deposits were begun by the Bureau of Mines in 1948 and are described.

Control by smothering has been found to be the best method.

842. PAUL, J.W., PICKARD, B.O. and VON BERNEWITZ, M.W. Erection of Barricades During Mine Fires or After Explosions. *United States Bureau of Mines.* Miners' Circular No. 25, 1923.

After mine explosions or during fires in mines deadly gases steal through the workings and imperil the men who survive the violence or the heat. At such times many miners have saved their lives by building barricades to protect themselves from the deadly gases, but many have lost their lives by neglecting to build barricades; also, imprisoned miners have built bulkheads or stoppings in an imperfect or inadequate way, and later on have perished. This circular has been written for the benefit of any miner who may be trapped sometime in a mine by an explosion or fire, in the hope he may escape death by knowing how others have saved their lives by promptly sealing themselves behind well-constructed barricades, bulkheads, or stoppings. Details of the incidents mentioned later have been taken from the reports of mine disasters filed by the Bureau of Mines, and are trustworthy in every respect.

Methods of construction of barricades of various types are given.

Description of barricades built in the case of coal mine fires at the Kathleen Mine, IL, 1921 and the Cherry Mine, IL, 1909. For metal mines, the Pittsburgh-Idaho Mine, ID, 1917; Argonaut gold mine, CA, 1922; North Butte mine, MT, 1917.

843. GLAESER, O.A., DENNISON, T. and MITCHELL, G.W. Ventilation and Protective Measures Against Mine Fire. *Mining Congress Journal.* Vol. 16, 1930, pp. 346-350.

Describes the Fire Protection facilities established at the United Verde Mine following a serious history of fires since 1895.

See also Item #526.

844. GLAESER, O.A. Mine Fire Prevention and Fighting. *Mining Congress Journal.* Vol. 16, 1930, August, 1930, pp. 649-653.

Discusses in detail the Code of American Standards for Fire-Prevention and Fighting as established by the American Mining Congress, under four headings: Prevention, Protection, Fighting, and Restoration. Relates these needs to mine fire experiences in Arizona. Underlines the need for a code of mine fire standards.

(This Code has since been superseded by the Mine Safety Act.)

845. SANDERSON, H.H. The Giroux Mine Fire. *Mines and Minerals.* February, 1912, pp. 435-436.

The fire in the Giroux upcast shaft at Kimberly, NV was discovered on August 23, 1911.

Men being hoisted slowly from the bottom were badly burned when passing through the fire zone, one falling out of the cage.

Both shafts were then tightly sealed. Subsequent details are given. The fire was extinguished within two weeks.

See also Item #797.

846. WILLIAMS, R.Y. Extinguishing the Majestic Mine Fire. *Mines and Minerals.* January, 1912, pp. 342-343.

On Sept. 20, 1909, a charge of black powder in the Majestic Mine, IL set fire to the coal and started a serious fire. Efforts to fight it with water were unsuccessful. Therefore it was decided to seal the mine.

Subsequent problems are discussed.

847. BRADY, F.W. The Carbondale Mine Fire. *Mines and Minerals.* January, 1912, pp. 340-341.

The fire was first reported in 1906. Fire is spreading at over 5 acres per year in badly fractured ground. Various methods suggested to limit the spread of the fire.

848. ANON. Fires in Metal Mines. *Mines and Minerals.* November, 1911, pp. 253-254.

Excerpts from a lecture given before the National Fire Protection Association in May, 1911.

Stresses the hazards of fires in metal mines which are more readily overlooked than fires in coal mines.

Gives a historical review of fires in metal mines, such as:

1803	*A quicksilver mine, Idria, Austria*
1846	*Same mine*
1869	*Several fires in the Comstock mines of Nevada*
1888	*Diamond mines in South Africa*
1888	*Calumet & Hecla Mine, Calumet, MI*
1889	*St. Lawrence Mine, Butte, MT*
1901	*Smuggler Union Mine, Colorado*
1895	*Block 11 Mine, Broken Hill, Australia*
1897	*Block 12 Mine, Broken Hill, Australia*
1906	*Junction Mine, Broken Hill, Australia*
1907	*Homestake Mine, Lead, SD*
1907	*Selbeck ore mines, Germany*
1907	*Youngs Mine, Menominee, MI*
1909	*London Mine, Tennessee*
1911	*Belmont Mine, Tonopah, NV*
1911	*Hartford Mine, Negaunee, MI*
1911	*Giroux Mine, NV*

849. PARKER, R.D. Ventilation and Safety Practices at the Frood Mine of the International Nickel Company of Canada, Limited. *American Institute of Mining Engineers.* Transactions, Vol. 109, 1934.

One of the objectives for an effective ventilation system at this mine, was to give adequate control of the air currents in case of a mine fire.

850. PICKARD, B.O. Organization for Mine Fire Fighting in Metal Mines. *Mining Congress Journal.* Vol. 11, April, 1925, pp. 158-160.

Fire in metal mines is a subject which has not received the consideration its importance warrants. Few mines *are organized to combat a fire even though ample fire fighting equipment is available.*

851. HARRINGTON, D. Reversibility of Air Currents for Metal Mines. *Mining Congress Journal.* Vol. 9, Sept. 23, 1923, pp. 316-318.

Draws attention to the need to install reversible fans. Whereas coal mine operators follow this practice, metal mines are slow to do so.

Quotes the many instances where lives have been saved by reversing the fan with a minimum of delay.

Also admits that a decision to reverse should only be taken after due consideration of the particular underground situation.

Gives a list of 14 points justifying the installation of a reversible fan.

See also Item #856.

852. CONIBEAR, W. Metal Mine Fire-Fighting Equipment. *Mining Congress Journal.* Vol. 8, April, 1922, pp. 671-673.

Notes that standardization of mine fire-fighting equipment would allow fire fighters to be given a standardized course of training. However, present need is more urgent to provide more effective equipment than to standardize.

Argues for more and better equipment to be maintained by operating companies.

853. ANON. Mine Fire Prevention is Aim of Code. *Mining Congress Journal.* Vol. 8, 1922, p. 1084.

A code of mine safety provisions drawn up by a committee at a Cleveland convention of the American Mining Congress. The rules were adopted as a basic code.

See also Item #844.

854. DENNY, E.H. Safety Report and Recommendations. *Mining Congress Journal*. Vol. 17, March, 1931, p. 161.

Relating to the investigation of the Colorado Mining Association and others; refers to fire hazards in mines and of surface fires spreading underground due to substandard conditions and practices observed in some Colorado mines.

855. MANNING, R.I.C. Portable Mine Fans. *Mining Congress Journal*. Vol. 17, 1931, pp. 430-431.

Describes portable mine fans used to fight mine fires in Arizona. Have been used intermittently since 1924 and have rendered valuable service.

856. MITKE, C.A. Reversibility of Air Currents for Metal Mines. *Mining Congress Journal*. Vol. 9, 1923, pp. 319-321, 334.

A critical discussion of Harrington's paper on the subject title and opposes his main views as not practicable. He prefers a system of well-constructed mechanically operated doors judiciously installed around the mine to control airflow, or to reduce the flow of air, or to isolate certain sections.

See also Item #851.

857. ROBERTS, A.F. Ultimate Analyses of Partially Decomposed Wood Samples. *Combustion and Flame*. Vol. 8, December, 1964, pp. 345-346.

Gives test results for burning wood, including an analyses of the products under known conditions.

858. MITKE, C.A. Solving Ventilation Problems by Mechanical Means. *Mining Congress Journal*. Vol. 14, July, 1928, pp. 489-490, 495.

The purpose of mechanical ventilation underground is to preserve health, increased working efficiency, and act as a safeguard to the miners in the event of mine fires by providing control of air currents.

Quotes examples of the advantages of mechanical over natural ventilation for this purpose.

859. HARRINGTON, D. Ventilation in Metal Mines. *United States Bureau of Mines.* Technical Paper No. 251, 1921.

Points out the effects of underground fires as a source of heat that raises the temperature of mine air.

860. BROWN, R.G. Fire Doors for Mine Shafts. *Engineering & Mining Journal.* April 7, 1894, p. 321.

The potential danger of a surface fire spreading to a mine downcast shaft has inspired the writer to design an automatic spring locked twin hinged safety door system. A sketch is provided.

861. ANON. Mine Fire Protection. *Mining and Scientific Press.* Vol. 105, August 10, 1912, pp. 171-172.

Discusses an inquiry conducted by the National Fire Protection Association and the Bureau of Mines on the problem of mine fire protection.

Sets out a schedule of responsibility relating to the committee or the Bureau as to which body can best give authoritative guidance on particular fire protection topics.

862. MITKE, C.A. Standardization of Mining Methods V - Fire Protection for Metal Mines. *Engineering & Mining Journal.* Vol. 106, No. 24, Dec. 14, 1918, pp. 1028-1030.

Various causes responsible for the 35 active mine fires in the Southwest in recent years. Similarly, varied methods have been adopted by different companies to combat fires, some being of questionable efficacy. A standard method of protection and procedure is outlined.

Shaft and station fires are treated separately from those in the workings. Advantages of mechanical ventilation for fire fighting is stressed.

863. MITKE, C.A. Standardization of Mining Methods III. Ventilation of Metal Mines. *Engineering & Mining Journal.* Vol. 106, No. 22, 1918, p. 940.

Discusses the objectives of a well-designed ventilation system. Should be developed hand in hand with development plans. Should be regarded primarily to improve the underground environment; and secondarily it should be adapted for fire fighting purposes.

864. RICKARD, T.A. Mine Fire Regulations. *Engineering & Mining Journal.* Vol. 115, No. 12, 1923, p. 524.

Comments on the regulations recently promulgated by the California Industrial Accident Commission following the loss of 47 lives in the Argonaut mine fire of 1922.

While supporting two of the safety orders he regards the rest as being too stringent, impractical and unnecessary.

The best protection for men in a mine is the management capability of an experienced superintendent. From a humanitarian as well as from an economic standpoint all mining companies should appoint experienced mining engineers to these positions.

865. HARRINGTON, D. Data on Metal Mine Ventilation in 1929. *United States Bureau of Mines.* Information Circular No. 6246, February, 1930.

During 1919 there were the usual number of fires in metal mines or tunnels, fortunately with no loss of life. The main causes were open lights and electricity. Advances a strong plea for electric cap lamps.

Also quotes amendments to the Mining Act of Ontario following the Hollinger Mine fire disaster.

Cites the case of a fire in an underground explosives magazine. Fortunately the explosives burned instead of exploding. Naked lights in magazines are deprecated.

At a conference in spontaneous heating it was shown that many substances in metal mines are subject to spontaneous combustion as well as being a fire risk. Among these are sawdust, timber bark, splinters, hay, and straw. Indicates the necessity for good housekeeping.

866. McADAM, R. and DAVIDSON, D. *Mine Rescue Work.* Edinburgh: Oliver and Boyd. 1955.

Describes the construction and action of various types of breathing apparatus and their associated applications such as fire fighting, stoppings, mine gases, and organization of rescue work.

867. ROBERTS, A., Ed. *Mine Ventilation.* London: Cleaver-Hume, 1960. pp. 102-106.

The use of the CO/O_2 ratio as an index of oxidation under conditions of spontaneous combustion that may lead to a fire, in advance of other physical indications. Interpretation of air analyses during fire fighting and after sealing.

Location of main fan on surface provides accessibility in event of fire (p. 200).

868. HARTMAN, H.L. *Mine Ventilation and Air Conditioning.* New York: Ronald. 1961.

Deals with gases from incomplete combustion arising from mine fires, and their analysis (pp. 25, 31); the prevention of fires (p. 35). In the event of fire, ventilation surveys to provide information that would be vitally needed (p. 104); the danger of reliance on natural ventilation (p. 160); the control of ventilation circuits by well-constructed doors (p. 252); the need to provide safe exits in fresh air (p. 256); the surface location of the main fan (p. 258); the reversibility of the main fan (p. 259); the need for proper design and control of the ventilation system (p. 264); the presence of an existing fire zone in the re-planning of ventilation circuits (p. 266).

Filled stopes, especially where timbered, generate sufficient heat to present a fire hazard (p. 296).

869. SPALDING, J. *Deep Mining.* London: Mining Publications. 1949.

Chapter VIII deals with mine fires in the areas of fire precautions, rescue work; procedure in the event of an outbreak of fire; and fire fighting.

870. LEWIS, R.S. and CLARK, G.B. *Elements of Mining.* 3rd ed. New York: Wiley. 1964, pp. 757-759.

Cites an analysis of causes; protective measures; escapeways; fire fighting equipment; fire warning systems; need for a well-controlled ventilation circuit; sealing and sampling; smothering with inert gases; and use of oxygen breathing apparatus.

√871. PENMAN, D. and PENMAN, J.S. *The Principles and Practice of Mine Ventilation.* 2nd ed. London: Charles Griffin. 1951, pp. 242-301.

Chapter XIV deals with underground fires including precautions; regulations; fire fighting services; gob fires; spontaneous combustion; fire detection; stoppings; gas analysis behind stoppings; re-opening stoppings; risk of explosions; and hydraulic stowing.

Chapter XV deals with rescue and recovery work including breathing apparatus; rescue training; and brigade work.

872. WEEKS, W.S. *Ventilation of Mines.* New York: McGraw-Hill. 1926, pp. 193-204.

Describes purpose and methods of construction of fire doors; control of ventilation in case of fire; auxiliary fans for fire fighting. Cites the case of the Huelva Pyrite Mine.

873. BROWN, A.O. Mineral Fires in the Huelva Pyrites Mine. *Institution of Mining and Metallurgy.* Transactions, Vol. 64, 1922-23.

In this mine a fire which followed a fall of ground was caused by the oxidation of pyrite in the presence of a limited supply of oxygen. It was found that if enough air could be blown through the burning sulphides, the cooling effect could extinguish the fire which was limited to the surface of the mineral.

If insufficient air was passed, it supplied oxygen without reducing heat and therefore the intensity of the fire was increased.

874. FREITAG, J.K. *Fire Prevention and Fire Protection.* New York: John Wiley & Sons. 1921, 1038 p.

875. ANON. Fire-Fighting Equipment in Metal Mines. *American Standards Association Committee.* Under joint sponsorship of National Fire Protection Association and The American Mining Congress, approved October 14, 1930; American Standards Association, March 17, 1930, 8 pp., same issued by National Fire Protection Association.

876. HARRINGTON, D. Ventilation Studies in Metal Mines. *American Society of Heating and Ventilating Engineers.* 1921.

A general discussion on mine ventilation, and the need for improvements in metal mines.

In mining, ventilation, fire protection and prevention, health, safety, and efficiency are very closely interlocked.

At the time of a metal mine fire, naturally ventilated mines are likely to be at a decided disadvantage through inability to control direction of air currents. Lack of an efficient ventilation system may be disastrous. Each mine should have fans so placed as to be inaccessible to the fire, have fireproof housing, be capable of quickly reversing air currents if desired, and preferably should be placed on the surface. There should be a definite system of air splits such that the fire in one place may not necessarily fill the entire mine with poisonous fumes. There should be a system of doors near shafts in levels leading from shafts such that the shaft or any part of mine may be readily isolated in case of fire.

877. WILDE, D.G. and THOMPSON, W. The Examination of Fire-Resistant Hydraulic Fluids for Use in Mines. *The Mining Engineer.* No. 43, April, 1964, Vol. 123, 1963-64 of the Transactions of the Institution of Mining Engineers, pp. 381-392.

The increasing use of hydraulic equipment in mines is reviewed and the hazard associated with mineral hydraulic oils described. The objects and requirements of tests of the fire resistance of hydraulic fluids are stated and British, American and Continental tests outlined.

It is shown that there are risks peculiar to the use of fluids whose fire resistance depends on the minimum water content.

878. KENNEDY, K. and TAYLOR, G. Temperature Distributions Downwind of Stationary Mine Fires. *British Journal of Applied Physics.* Vol. 18, 1967.

This paper describes an experimental and mathematical approach to the evaluation of the variation of temperatures with distance and time downwind of a fire in a ventilated passage through a medium of low thermal conductivity. The experimental results obtained in a 30 ft. long, 2½ in. square passage enabled a useful simplification to be made in the analysis. The method of analysis was applied to the similar problem of the air-cooling of a circular passage through a medium of low thermal conductivity and the results of this application agreed quite well with a previous analysis by Van Heerden.

879. GRIFFIN, O.G. Mine Rescue Breathing Apparatus: Consideration of Requirements, Existing Designs and Recent Developments. *Institution of Mining & Metallurgy*. Bulletin No. 734, Jan., 1968, Transactions, Vol. 77, Section A, 1968, pp. A27-A33.

Breathing apparatus used in rescue and recovery work in mines is almost entirely of the self-contained closed-circuit type. The physiological requirements that should be fulfilled by such apparatus are stated, and the standards prescribed for the approval of mine-rescue breathing apparatus in various countries are discussed. A number of apparatuses currently available in Western Europe are then described.

These apparatuses can be divided into two groups, according to the source of the oxygen supply - which may be either compressed oxygen or liquid air-oxygen. It is suggested that the liquid-oxygen type of apparatus has decided advantages over any other type.

880. KENNEDY, M. The Correlation and Calculation of Temperature Contours Round Small Fires. *British Journal of Applied Physics*. Vol. 16, 1965, pp. 109-114.

Results of experiments to test the ability of a fire detection device to give early warning of a fire while still small. The work is of practical importance in the siting of heat-sensitive fire detectors in ventilated surroundings.

881. HARRINGTON, D. Electric Mine Safety Lamps in All Coal Mines in Utah. *The Coal Trade Bulletin*. May 16, 1925, pp. 510-514.

In connection with the Order of the Industrial Commission of Utah Requiring the Use of Permissible Electric Lamps in Utah Coal Mines for Ordinary or Mine Workers' Lighting Purposes. Restricting Use of Flame Safety Lamps to Testing Purposes Only and Absolutely Barring Open Lights in the Large Mines, there is absolutely no question that the order was one of the most forward steps towards Coal Mine Safety in the History of Coal Mining in the United States.

882. WILDE, D.G. High Expansion Foam for Fighting Industrial Fires. *The Engineer*. March 8, 1968, pp. 719-721.

Describes a method of firefighting first developed in Britain. Foam was made by spraying a mixture of water and foaming agent on to a net stretched across the mine roadway. The ventilating air produced the foam and propelled it along the roadway towards the fire.

In this way, foam can be produced at a greater rate than by conventional methods. The technique was adopted by the U.S. Bureau of Mines which developed mobile foam-making units using powered fans independent of the ventilating air.

883. WOLFLIN, H.M. Fire Prevention and Fighting in Metal Mines. *National Safety Council*. Proceedings, 10th Safety Congress, 1921, pp. 445-454.

A fire in a metal mine constitutes the most serious hazard found in the industry. Cites 453 deaths from about 60 metal mine fires from 1866 to 1921.

Lists 8 categories of causes; discusses fire fighting methods including use of liquid CO_2, with 18 conclusions; offers general observations on 16 aspects of fire prevention and protection. Discussion follows.

884. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, 5th Revision, June, 1973.

Compilation of mine fires that occurred between 1945 and 1973. See following items for details.

885. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire on 26 Sept., 1945, at the Eagle Mine at Gilman, CO became active in an orebody and was sealed effectively.

886. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire at the Sunshine Mine at Kellogg, ID, supposedly caused by a short circuit, originated in a battery-charging station, on 17 Dec., 1945.

887. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire at the Sibley Mine, Ely, MN, was discovered on 26 March, 1946, in the timber mat accumulated during top slicing.

888. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire was discovered at the Montreal Mine, Montreal, WI, on 17 Dec., 1946, in timbered area near an electric slusher. Mine officials believed fire could be extinguished by direct methods and permitted day shift to go to work. Two men and one mining captain became sick from exposure to CO_2 *in their working place. All men were taken out of mine.*

889. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 31 Dec., 1947 at the Edwards Ore Mine, Bessemer, AL, was caused by a short circuit in an armored power cable.

890. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 19 July, 1948, at Triumph Mine, Triumph, ID, was caused by heater used to heat hoisting station.

891. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 20 January, 1949, at Chisholm, MN, caused by short circuit.

892. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 18 February, 1949, at the Empire Star Mine, Grass Valley, CA, caused by sparks of hot metal from cutting and welding operations.

893. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-73. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire, on 27 April, 1949, at Banner Mine, Lordsburg, NM. Cause not indicated in report. Damage was confined to about 50 ft. of timbered drift.

894. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 3 May, 1949, at Eureka Mine, Ramsay, MI, caused by failure of electric wiring and equipment. Three officials, assisting in locating the fire, were affected by smoke and fire, and had to be assisted from the mine.

895. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 26 November, 1949, at Penokee Mine, Ironwood, MI, had three possible origins: (1) hot bolt head dropped down the shaft; (2) smoking; (3) spontaneous combustion.

896. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 5 June, 1950, at Copper Canyon Mine, Battle Mountain, NV, caused by ignited hot metal. Of the 15 men who escaped, only one was injured when he lost footing and fell while climbing from one raise to another.

897. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 9 January, 1951, at Pioneer Mine, Ely, MN, possibly caused by electricity.

898. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 19 April, 1951, at Sunday Lake Mine, Wakefield, MI, caused by a cigarette thrown or dropped into the shaft or sucked into the shaft through fan duct. (This was consensus of opinion.)

899. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 18 June, 1951, at Cary-Odanah Iron Co. Mine, Hurley, WI, caused by electricity.

900. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 10 November, 1951, at Gossan Mine, Galax, VA, started in manway where tailings were deposited.

901. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 20 November, 1951, at Magma Mine, Superior, AZ, possibly caused by a piece of burning fuse or a discarded cigarette butt. Also the possibility of a sulphide explosion must be considered as source of ignition.

902. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 30 June, 1952, at Shattuck Mine, Bisbee, AZ, started in surface plant and burned out the shaft timbers. Mine connected by tunnels to active area.

903. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, June, 1973.

Fire on 23 June 1952, at Live Oak Division Mine, Inspiration, AZ, in electric motor in hoist room. Crew (100 men) laid off month for repairs.

904. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, June, 1973.

Fire on 10 July, 1952, at Ray No. 2 Mine, Ray, AZ, of electric origin, started on sublevel drift; was extinguished by rescue crew.

905. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, June, 1973.

Fire on 15 May, 1953, at United Verde Mine, Jerome, AZ, started in an abandoned mine. Workers were using truck to salvage material. Sparks from torch ignited oil in ditch. Five-man rescue crew extinguished fire.

906. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, June, 1973.

Snow shed at portal ignited by cutting torch, on 7 June, 1953, at Idarado Mine, Ouray, CO.

907. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines*. Unpublished Report, June, 1973.

Fire in Belmont Mine, Butte, MT, in September, 1953, of unknown cause, extinguished in February, 1954, by seals and water through diamond drill holes.

908. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in December, 1953, at Lion No. 1 Shaft, Bayard, NM, was presumably set by someone, burned shaft timbering and headframe caved in.

909. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 1 January, 1954, at Original Sixteen to One Mine, Alleghany, CA, caused by electrical arc from transformer room. Cables were not insulated.

910. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Shaft of Hillside Mine, Bagdad, CA (nonworking) destroyed by fire on the 4th of July, 1954.

911. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire started on 23 May, 1955, at the Normet Mine, near Matheson, CA, and was confined to an abandoned stope. Resulted from rapid oxidation of pyrite.

912. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Electrical fire, probably. Reported on December 16, 1955, at the Zenith Mine, Ely, MN.

913. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on May 27, 1955, at Montreal Mine, Montreal, WI, started in motor of a temporary electric pump. Area was sealed; then reopened month later.

914. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Logging ignited by electricity on November 29, 1955, at Dando Clay Mine, Beaver, PA.

915. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on March 24, 1956, at Peterson Mine, Bessemer, MI, was caused by a short circuit. It occurred on a Saturday. Fire extinguished by direct attack, without use of respirators.

916. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on 4 February, 1956 at Champion Mine, Negaunee, MI. "Electrical - House destroyed - skip fell into shaft."

917. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on May 4, 1956, at Potash Mine, Carlsbad, NM, started in oil and grease pit in underground shop by hot metal and slag during cutting operation.

918. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Explosive fire on trip car on May 25, 1956, at Federal No. 17 Shaft, Flat River, MO. Motorman inhaled some smoke and fumes from burning explosives and was hospitalized; released for duty following day.

919. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in August, 1956, at Mather - B Shaft Mine, Negaunee, MI, was probably ignited when hot material from cutting torch contacted combustibles behind side lagging in drift.

920. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 29 October, 1956, at Peterson Mine, Bessemer, MI, was caused by overhead transformer. Was extinguished by de-energizing transformer.

921. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 2 November, 1956, at Tracy Mine, Negaunee, MI, occurred from friction of a tugger rope rubbing on lagging during scraping operations.

922. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Short-circuit fire occurred on 1 January, 1957, at Sunday Lake Mine, Wakefield, MI.

923. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire due to underground converter occurred on February 6, 1957, at Montreal Mine, Montreal, WI.

924. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire caused by cutting torch occurred on February 19, 1957, at Penokee Mine, Ironwood, MI.

925. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A shaft fire of electrical origin occurred on 25 February, 1957, at Humboldt Mine, Tungsten, NV.

926. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire was ignited when hot material from cutting torch dropped down a raise and ignited combustible material. Fire occurred on 8 May, 1957, at the Montreal Mine, No. 5 Shaft, Montreal, WI.

927. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 4 June, 1957, at Greenwood Mine, Ishpeming, MI, was ignited when hot material from cutting torch ignited combustible material.

928. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 15 July, 1957, at Pioneer Mine, Ely, MN, ignited during an oxy-acetylene cutting operation in the head frame.

929. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred in loading machine on 17 July, 1957, at White Pine Mine, White Pine, MI.

930. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on 22 July, 1957, at White Pine Mine, White Pine, MI, when headlight wires on speed grader short-circuited.

931. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 26 November, 1957, at Godfrey Mine, Chisholm, MN, was due to an electrical failure in pump starting machine.

932. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Shaft fire; friction of hoist rope on roller shafting ignited grease and wood chips. Fire occurred on November 28, 1957, at Ahmeek No. 3 Mine, Ahmeek, MI.

933. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Origin of fire unknown. A fall of ground may have ruptured or short-circuited a cable. Fire reported on March 31, 1958, at Montreal Mine, Montreal, WI.

934. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire, in pump house, was believed to have been caused by short circuit. It occurred on November 18, 1958, at Morris Mine, Ishpeming, MI.

934. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire believed to have been caused by an electrical failure. It occurred on January 1, 1959, at Newport Mine, Ironwood, MI.

936. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire caused by short circuit in a power cable on 3 February, 1959, at Newport Mine, Ironwood, MI.

937. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Inrush of hot gases and steam caused a fire on June 1, 1959, at Sherwood Mine, Iron River, MI.

938. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire probably caused by electrical failure at shaft station. Occurred on 21 July, 1959, at Buck Mine, Caspian, MI.

939. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire started immediately after seven boxes of deteriorated explosives were destroyed, on 17 November, 1959, at Sunday Lake Mine, Wakefield, MI.

940. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 16 December, 1959, at Godfrey Mine, Chisholm, MN, probably caused by short circuit in a power cable. No men in mine at time fire started.

941. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Shaft fire, in May, 1960, at Black Jack #1 Mine, McKinley County, NM. Cause unknown. No one in mine at time of fire.

942. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Abandoned mine used for storage of equipment. Fire was reported in November, 1960, at Limestone Mine, LaSalle County, IL.

943. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Gas ignition, after blasting caused a fire on December 5, 1960, at West Vaco Mine, Green River, WY.

944. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire was reported on November 14, 1961, at the Golden Queen Mine, Kern County, CA (inactive).

945. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred in abandoned shaft of Quincy #3 Mine, Houghton County, MI, on November 11, 1961.

946. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in inactive area. Two men suffered CO poisoning. Fire reported on December 2, 1961 at Magma Mine, Superior, AZ.

947. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Explosion in steel tank; testing for leaks with open flame caused fire at White Pine Mine, White Pine, MI, in April, 1962.

948. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Shaft fire on May 8, 1963, at the Burro Mines, San Miguel Co., CO. Two men working at time.

949. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Gas explosion on August 27, 1963, at Cane Creek Mine, Grant County, UT.

950. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in urethane foam developed spontaneously on August 15, 1963, in White Pine Mine, White Pine, MI.

951. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Underground shop fire due to sparks from torch igniting oil and grease occurred on January 29, 1964, at Blackstone Mine, Schullsburg, UT.

952. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Conveyor belt fire occurred on May 12, 1964, at White Pine Mine, White Pine, MI.

953. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in underground shop occurred in June, 1964, at Blackstone Mine, Lafayette Co., WI.

954. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire and subsequent explosion occurred in a main air intake raise of Climax Mine, Climax, CO, on 8 July, 1964, due to welding operations.

955. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Gas explosion caused a fire in Mineral King Mine, Mineral Co., MT, in August, 1964.

956. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Electrical fire in timbered adit occurred on 23 October, 1964, at United Park City Mines, Wasatch Co., UT.

957. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in timbered stope. Probable cause: lighted cigarette. Fire occurred in October, 1964, at the Bunker Hill Mine, Kellogg, ID.

958. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Underground shop fire, reportedly caused by welding, destroyed the fourth level shop and supplies. The fire cut off communication and escape up the main shaft - underground personnel trapped for about six hours. Fire burned out and smoke and heat cleared in the shaft. Rescue squads, local fire department, equipped with respiratory protective equipment, assisted with fire control and rescue procedure. Fire occurred at Johnson Mine, Johnson, VT, on January 28, 1965.

959. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Spontaneous fire in sulfide minerals in sand backfill occurred on February 13, 1965 at Homestake Mine, Lead, SD.

960. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Gas explosion during dewatering abandoned mine caused a fire in Coalton Stone Mine, Boyd County, KY, during May, 1965.

961. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on 24 September, 1965, at Cordero Mine, Humboldt Co., NV, in an abandoned stope; probably occurred by spontaneous combustion in sulfide ore.

962. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire at Richard Iron Ore Mines, Wharton, NJ, in October, 1966, in inactive shaft; unknown origin.

963. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in old stope area occurred on 28 October, 1966, at New Idria Mine, San Benito Co., CA.

964. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in empty dynamite cartons, near explosives magazine. Occurred at Carlyle Clay Mine, Lawrence Co., OH, on March 22, 1967.

965. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire caused by cutting torch igniting tar-like seepage material. Occurred at Little Greenback Mine, Cardin, OK, on April 13, 1967.

966. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Timber ignited after being blasted to remove it at the Sunshine Mine, ID, on 6 July, 1967.

967. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Mine fire, at the Bonney Mine, Hidalgo Co., NM, on 11 October, 1967, sealed Miser's Chest shaft; cause unknown.

968. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Explosion in conduit caused a fire in Saunders Mine, Carlsbad, NM, on March 11, 1968.

969. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire at bottom of timbered shaft of unknown origin, occurred at the Belle Isle Salt Mine, St. Mary Parish, LA on March 5, 1968.

970. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Minor fire around electric tugger occurred on May 13, 1968, at Bunker Hill Mine, Kellogg, ID.

971. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Shaft fire occurred in Tom Reed Mine, Mohave Co., AZ, in December, 1968.

972. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in battery charging station occurred at Section 17 Mine, Grants, NM, on December 22, 1968.

973. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire on February 11, 1969, at Dead Horse Mine, San Benito Co., CA, reported by State Inspector.

974. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Surface buildings, headframe and upper portions of shaft caught fire on February 22, 1970, at Resurrection #2 Mine, Leadville, CO.

975. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on diesel powered truck caused by battery cable arc burning through hydraulic hose. Occurred at Pleasant Gap Mine, Centre County, PA, on May 17, 1970.

976. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Methane ignition caused a fire at Dead Horse Mine, San Benito Co., CA, on May 20, 1970.

977. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire started on June 30, 1970, at Nil Mine, Montrose Co., CO, on previous shift when mine was idle; miners entering adit on next shift detected smoke and were evacuated. Cause unknown.

978. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on 8 August, 1970, at Bunker Hill Mine, Kellogg, ID, in pump room. Extinguished same day.

979. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on 27 November, 1970, at Lakeshore Mine, Hecla Mining Co., Casa Grande, AZ on wrecked Scooptram; burned diesel fuel and fan tubing. Fire burned out in about 6 hours; operator was run over and killed by unit before wreck and resultant fire. Men evacuated using self-rescuers from caches.

980. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on January 20, 1971, at Star Mine, Burke, ID, in fiberglass ventilation tubing; started by acetylene cutting torch.

981. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire in Tracy Mine, Negaunee, MI, on March 11, 1971, caused by hot metal during capping of exhaust shaft in abandoned mine. Extinguished in 35 minutes.

982. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Electrical fire on 22 April, 1971, at Sunshine Mine, Kellogg, ID, was reported by State Inspector. Believed to be short in 2,300 v. cable at connection to oil switch. Ignited timbers 6 ft. from oil switch on 2700 level, 160 ft. from Jewell Shaft and 100 ft. from No. 3 Shaft. One drift set of timber burned.

983. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Spontaneous fire occurred on 9 June, 1971, at Eagle Mine, Gilman, CO, in sulphide minerals; discovered when two stope miners became ill.

984. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire was reported on July 16, 1971, at Galena Mine, Wallace, ID. Cause unknown; probably due to spontaneous combustion, or cigarette.

985. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred on August 17, 1971, at Climax Mine, Climax, CO, while dismantling abandoned grizzly chutes, chute timbers ignited by cuttings from acetylene torch.

986. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June,

Fire occurred on 9 September, 1971, at Dragon Mine, Eureka, UT. Probable cause: spontaneous combustion of sulfide minerals used as backfill.

987. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Surface facilities located within 75 feet of portal of Battitt Mine, Thompson Falls, MT, destroyed by fire on 31 December, 1971; probable cause was oil heater in trailer house. No one working at time of fire.

988. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A serious fire occurred at the Sunshine Mine, Kellogg, ID on May 2, 1972. Probable cause: spontaneous combustion in abandoned area.

989. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Transformer fire was reported at Pea Ridge Mine, Sullivan, MO, on May 15, 1972. Short circuit caused by dripping water. Fire went out when power disconnected.

990. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred at Free Enterprise Mine, Boulder, MT, on May 24, 1972. Old timbers burned below 85-foot level while retimbering shaft. Extinguished in 3 days.

991. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire occurred at Magma Mine, Superior, AZ, on June 15, 1972. Spontaneous combustion in mined out area. Smoldering fire contained by seals. Continued tests required by order.

992. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Electrical fire on shuttle car ignited trailing cable and tire at the Federal Division #10 Mine, Bonne Terre, MO, on July 20, 1972.

993. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Trash ignited by diesel-powered ore truck at White Pine Mine, White Pine, MI, on August 16, 1972.

994. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

A fire occurred at Burgin Mine, Dividend, UT, on October 22, 1972. Pump starter motor arcing ignited cable insulation. Men to rescue chamber while fire extinguished.

995. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred in the compressor house on surface near adit portal of the Schwartzwalder Mine, Golden, CO, on October 26, 1972. Mine evacuated safely. No fire or fumes reached mine.

996. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Welding equipment hoses were ignited at the Sterling Mine, Ogdensburg, NJ, on November 7, 1972. Mine evacuated safely.

997. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Short circuit in motor ignited wood platform and conveyor belt at the Grand Saline Mine, Grand Saline, TX, on 17 November, 1972. Mine evacuated safely. Shaft and ventilation airways closed 3 days to allow fire to burn itself out.

998. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Cutting torch sparks ignited wooden lagging at the Mather B Mine, Negaunee, MI, on January 29, 1973. Discovered at start of night shift.

999. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Arcing trolly pole of locomotive ignited dry headboard at the Mather B Mine, Negaunee, MI on 30 January, 1973. Discovered at start of night shift.

1000. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Electrical fire on jumbo drill occurred during idle night shift on February 21, 1973, at the Retsof Mine, Retsof, NY.

1001. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

No. 9 shaft contractor using cutting torch caused a fire at the Magma Mine, Superior, AZ, on March 22, 1973. Slag ignited acetylene hoses. Stench system activated and men evacuated to fresh air for 1-1½ hours until fire burned itself out.

1002. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire on electric slusher, extinguished in 1-1½ hours at the Continental No. 2 Mine, Silver City, NM, on April 13, 1973.

1003. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Spontaneous combustion in area above or behind present stopes occurred at the Eagle Mine, Gilman, CO, on May 5, 1973.

1004. WAXVIK, J.N. Metal and Nonmetal Mines: Underground Mine Fires, 1945-1973. *United States Bureau of Mines.* Unpublished Report, June, 1973.

Fire occurred in engine compartment of haulage truck at the White Pine Mine, White Pine, MI, on May 17, 1973. About 50 men from 3 areas evacuated. Men from one area used self-rescuers to travel through smoky area. Extinguished in 40 minutes.

1005. NAGY, J., MURPHY, E.M., and MITCHELL, D.W. Controlling Mine Fires with High-Expansion Foam. *United States Bureau of Mines.* Report of Investigations No. 5632, 1960.

Experiments were begun in 1957 to study foam generation and transport, to evaluate the effectiveness of high expansion foam on fires and to develop techniques for its use in mines of the United States.

A progress report was prepared in July, 1958 summarizing initial achievements (see Item #661). Subsequent experiments are now analyzed. Procedures are suggested for applying the method to control fires in mines. Experiments showed that foam will expand from a 7 to a 17 ft. high entry and pass an obstacle restricting 90% of the area, provided foam velocity does not exceed 100 fpm.

1006. ANON. Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention. *Commission of the European Communities, Mines Safety and Health Commission.* International Seminar for Mining Engineers Held at Saarbrücken, Germany, 12-14 October, 1971. Luxembourg, 1972.

Presents proceedings of the Seminar together with 13 technical papers dealing with fire fighting and fire prevention, appended as Annexes. See Items #1007-1017.

1007. CZECH, G. General Survey of the Structure and Activities of the Mines Safety and Health Commission. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex II of Questions relating to Mines Safety With Particular Reference to Fire-Fighting and Prevention.

Makes brief reference to the mine fire disaster at the Bois de Casier pit at Marcinelle, Belgium on 8 August, 1956 in which 262 miners lost their lives. Fire was caused by a shaft collision which simultaneously damaged a 5 kw cable and a hydraulic oil pipe, an electrical short circuit setting fire to the oil. The downcast shaft and station, the main crosscut and the timbered upcast shaft were soon in flames.

Following this Marcinelle disaster, a Committee was appointed leading to the appointment of the ECSC Mines Safety and Health Commission of 24 members in 1957. Reports of its various working groups are referred to.

1008. BOTH, W. Prevention of Spontaneous Combustion by Eliminating Slow Moving Airstreams in Mine Workings. *International Seminar for Mining Engineers*. Saarbrücken, Germany, October 12-14, 1971. Annex IV of Questions Relating to Mines Safety With Particular Reference to Fire-Fighting and Prevention.

Discusses the incidence of coal mine fires and shows that 80% arise from spontaneous combustion. However since 1960 the frequency of major mine fires in the Ruhr district has been declining due to:

1. *Increased output per working face providing fewer possibilities for spontaneous combustion; also a reduced output from steep seams in which spontaneous combustion is more likely to arise.*

2. *Early detection of heatings and fires following the introduction of continuous carbon monoxide monitoring.*

3. *The practice of sealing abandoned workings and otherwise eliminating slow-moving airstreams.*

Details are given of the methods applied or proposed. Nineteen illustrations.

1009. ZEIDLER, U. Objective Pursued in the Use of CO-Monitoring and Warning Devices and Experience Gained in Practice in the German Coalfields. *International Seminar for Mining Engineers*. Saarbrücken, Germany, October 12-14, 1971. Annex V of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

As a means of detecting coal mine fires at the earliest possible stage, the use of continuous carbon monoxide monitoring and telemetering devices is recommended.

Describes the development of these instruments; following experience gained over a ten-year period, they present a high degree of reliability.

Figures and charts are included.

1010. CRETIN, M.J. Possibilities of Using a Remote Infrared Ray Thermometer. *International Seminar for Mining Engineers*.

Saarbrücken, Germany, October 12-14, 1971. Annex VI of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

This device, presently used to measure temperatures in normal roadways, should be adaptable for the early detection of fires and heatings especially at the early stage where CO monitors are likely to be of little use because CO concentrations are low.

Instrument is described together with modifications and improvements. Test programme outlined. Progress results given.

1011. MUELLER, R. Significance and Scope of Graham's Ratio in Practical Application. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex VIi of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Describes the development of Graham's Ratio expressed as the ratio of CO produced by a source of oxidation to the oxygen adsorbed by it. The ratio varies according to the temperature of the oxidation source and the duration of the oxidation.

Analyzes the use of Graham's Ratio in German mines, as an extremely valuable supplementary aid in the many cases it may be the decisive determining factor.

However its efficacy may be affected by ventilating currents and by errors in gas analysis procedures.

Gives a list of nine recommendations for its application as a fire protection and fire fighting tool. References. Illustrations.

1012. KOCK, F.J. Methods of Determining the Explosibility of Mine Gas. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex VIII of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Following the sealing of coal mine fires it is important to protect the fire fighting team from the possibility of an ensuing gas explosion.

Discusses methods of assessment of explosibility.

Lists requirements for assessment.

Underlines the need for ventilation surveys as well as the monitoring of gas composition for avoidance of an explosion.

Bibliography (in German). Diagrams.

1013. STENUIT, R. Stabilisation of Ventilation - Professor Budryk's Theory. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex IX of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Professor Budryk, a Polish professor of mining engineering, advanced a theory designed to avoid the reversal of ventilation in fighting coal mine fires.

It leads to a formula for ventilation stabilisation for fires that occur in an ascensional ventilation circuit. It is scientifically correct. It applies particularly to the main circuit. An analysis and discussion of the basic formula is given with three recommendations for its application in ascensional ventilation circuits. An announcement by the author for a similar stabilisation formula for fires in descensional ventilation circuits is given. Diagrams.

1014. HAUSMAN, A. Diagrammatic Representation of a Ventilation System Giving Rapid Indication of Early Measures in the Event of Fire - Significant Change in Resistance of Airflow in a Roadway. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex X of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Gives a mathematical analysis of the Budryk and Bystrom matrices for ventilation circuits in which mine fires may occur. Diagrams.

1015. CASADAMONT. Stabilisation of Ventilation - Professor Budryk's Theory. *International Seminar for Mining Engineers.* Saarbrücken, Germany, October 12-14, 1971. Annex XI of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Offers results of a computer study of the stability of ventilation in the particular case of a fire in a colliery in the Loire coalfield. Objectives were (a) to determine the threshold of stability of various roadways in case of fire, and (b) to find fire fighting methods that ensure absolutely safe operation. Advances the view that only the computer can successfully carry out the necessary calculations. A good fire protection tool.

Diagrams and tables.

1016. MUELLER, R. Experience with the Use of the Saaralit-Bergbaugips Process in the Pits of Saarbergwerke, AG. *International Seminar for Mining Engineers.* Saarbrücken, Germany, 12-14 October, 1971. Annex XII of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Describes the Saaralit-Bergbaugips process of applying this special plaster for the construction of explosion-proof roadway stoppings. Process now widely used in the Saar mining district following proven experience. Its simplicity and the rapidity of construction has favored its widespread acceptance.

Bibliography. Illustrations.

1017. CRETIN, M.J. The Rescue of Trapped Men by Means of Boreholes. *International Seminar for Mining Engineers.* Saarbrücken, Germany, 12-14 October, 1971. Annex XIII of Questions Relating to Mines Safety with Particular Reference to Fire-Fighting and Prevention.

Where men are trapped underground following a fire, or explosion, or major fall of ground, the rescue difficulties become exaggerated in terms of effort and time if their location is far removed from regular access openings.

In many of these cases, the excavation of a large diameter borehole may represent a more expeditious approach, to avoid death through hunger and exhaustion.

However, in case drilling problems present undue delays, a parallel conventional roadway recovery method is also conducted.

Small preliminary boreholes are advisable for location and communication purposes and for the transfer of food and medical supplies.

Detailed description is given of basic principles of recovery, of location by various instruments (with results of trials), of drilling equipment and methods, of final exit of the trapped men.

Future prospects of evacuation by drilling are discussed.

Illustrations and diagrams.

1018. EATON, L. *Practical Mine Development and Equipment.* New York: McGraw-Hill, 1934. pp. 394-398.

Underlines the fact that unless proper precautions are taken there is always danger of fire underground, and mine fires seldom fail to have serious consequences. Discusses fire protection and fire prevention in detail, listing nine important points. "Eternal vigilance is the price of safety."

1019. PEELE, R., Ed. *Mining Engineer's Handbook.* 3rd ed., 2 Vols. New York: Wiley, 1941, p. 23-11, 23-17.

Deals with gases from mine fires (p. 23-11 and 23-17).

Statistics of mine fire accidents (p. 23-33, 23-36, 23-40, 23-41).

Fires in mines containing much timbering are next in importance as disasters to mine explosions. Risk is minimized by good plan design, good housekeeping, and by fireproof construction at exposed points. Discusses causes, fire prevention, equipment, organization, and *fire fighting methods. Table 27 lists 21 mine fires up to 1922 in which ten or more lives were lost (pp. 23-48 to 23-53).*

These mines are:

Avondale	*Plymouth, PA*	*1869*
Hill Farm	*Dunbar, PA*	*1890*
Diamondville	*Diamondville, WY*	*1901*
Hailey-Ola No. 1	*Haileyville, OK*	*1903*
St. Paul No. 2	*Cherry, IL*	*1909*
Leyden	*Leyden, CO*	*1910*
Price-Pancoast	*Throop, PA*	*1911*
Villa	*Charleston, WV*	*1918*
Amsterdam No. 2	*Amsterdam, OH*	*1919*
Kleophas	*Upper Silesia*	*1896*
Whitwich	*England*	*1898*
Hanastead	*England*	*1908*
Cadder	*Scotland*	*1913*
Kentuck	*Gold Hill, NV*	*1869*
Osceolo	*Calumet, MI*	*1895*
Smuggler Union	*Pandora, CO*	*1901*
Fremont	*Daytown, CA*	*1907*
Belmont	*Tonopah, NV*	*1911*
Pennsylvania	*Butte, MT*	*1916*
Granite Mountain	*Butte, MT*	*1917*
Argonaut	*Jackson, CA*	*1922*

Deals also with mine rescue work and apparatus (pp. 23-55 to 23-59 and 23-61 to 23-62). Bibliography (pp. 23-71, 23-72).

(NOTE: The fourth edition is currently in press.)

1020. MAC FARLANE, D. *Mine Ventilation with Reference to Fan Types and Their Application.* Davidson & Co., Belfast. Pub. Ref. SF 369. pp. 24-25.

Describes with a diagram an arrangement for reversing the airflow through a centrifugal fan, in case of a mine fire.

Axial flow fans do not require any reversing gear because the direction of rotation can be changed with a reversing switch.

See also "Ventilation Engineering," Pub. Ref. SF 376.

1021. ANON. Principles of Mine Rescue. *United States Bureau of Mines*. Instruction Guide No. 16, 1972.

Describes a plan of the surface organization and procedure necessary in case of a mine fire. Every mine should have a perfect firefighting and rescue organization with practice drills held at least twice yearly. Plans of procedure should be developed in detail in advance. Workers should be instructed in the use and construction of barricades and should be familiar with the ventilation circuit.

Procedures are listed in the event of a coal mine fire.

Further procedures are provided to control and extinguish mine fires, including sealing/unsealing methods.

1022. DEKTAR, C. Southern Pacific Tunnel Fire. *Fire Engineering*. August, 1963, p. 619.

On February 14, 1963, a fire was reported in a 925 ft. tunnel of the Southern Pacific Railroad just west of the San Fernando Valley.

By the time three County and a Los Angeles fire engine arrived at the east portal, the tunnel was completely involved.

The tunnel which was built in 1904 was supported by 12×12 timbers. It was decided to let the fire burn itself out. Three portable fans were used to accelerate this procedure.

The tunnel bore was later lined with concrete.

1023. WALLIS, G.E. An Underground Safety Story of Zinc. *National Safety News*. June, 1924, pp. 11-14.

Describes the fire protection methods used in the Franklin Mine of the New Jersey Zinc Company, including the system of fire patrols during the night shift.

1024. D'OLIVE, C.R. First Aid Fire Appliances. *National Safety News*. January, 1924, pp. 33-35.

Describes the various hand fire appliances for fires of different classes and provides a table of characteristics of the various types available, including maintenance aspects and inspection practices.

1025. MARKS, R.H. Mine Rescue Work in the Southwest. *National Safety News*. May, 1923, pp. 33-34.

Underlines the value of the heroic work undertaken by mine rescue crews in the case of mine disasters. Need to be trained under conditions of an actual mine fire. An abandoned section of an old mine still afire is used for this purpose in Arizona.

1026. COLBURN, C.L. Mine Safety Methods of the Ford Collieries Company. *National Safety News*. July, 1924, pp. 31-33.

Describes the safety organization of this group of coal mines including the corps of competent first aid men equipped for mine rescue or fire fighting.

1027. HARRINGTON, D. Metal Mines Have Fire Hazards. *National Safety News*. December, 1928, pp. 14-16.

Although the ore is not necessarily flammable, combustible material is brought into every mine, exposing the workers to risk of fire.

Cites several instances of metal mine fires due to extraneous causes. Fires may also result from blasting. A greater amount of and more virulent types of fumes result from fires in metal mines than coal mines.

1028. DENNY, E.H. Metal Mines Need Good Ventilation. *National Safety News*. October, 1929, pp. 83-85, 145-147.

Mechanical ventilation is of importance to metal mines from the standpoint of fire protection, gas removal, and promoting the health and efficiency of workers. In many instances, it is also valuable in preventing decay of timbers that would otherwise become a fire risk.

1029. KINGERY, D.S. Bureau of Mines Research on Mine Safety. *The Mine Inspectors' Institute of America.* Proceedings, 55th Annual Convention, p. 163.

Discusses the research program of the Bureau of Mines in relation to mine safety, including the conditions for use of flame spread retardants for conveyor belts and rigid foam coatings.

1030. ANON. Fire Resistant Hydraulic Fluids. *National Coal Board. Mining Research Establishment. Great Britain.* Report for 1965/66, p. 32.

Gives results of studies on the lubricating properties of the various fire-resistant hydraulic fluids.

1031. ANON. Fire and Electrostatic Hazards. *National Coal Board. Mining Research Establishment. Great Britain.* Report for 1965-66, p. 36.

Discusses the application of numerous plastic materials that have been examined to see if they involve fire or electrostatic hazards.

1032. COWARD, H.F. Explosibility of Atmospheres behind Stoppings. *Institute of Mining Engineers.* Transactions. Vol. LXXVII, 1928-29, pp. 94-115.

Discusses the conditions under which certain proportions of methane, oxygen, nitrogen, and carbon dioxide may form explosive mixtures when allowed to accumulate behind a stopping or seal.

1033. STATEHAM, R.M. and MERRILL, R.B. Detection of Hazardous Conditions in Mine Operations through Infrared Techniques. *Conference on Underground Mining Environment.* Proceedings, Rolla, MO, Oct. 27-29, 1971. pp. 53-67.

Infrared techniques and instruments have been used for remote sensing of several potentially hazardous conditions in mining operations. Among these are the locations of waste areas and stockpiles in which combustion is taking place. The temperature build-up can be detected. Describes the instrumentation. Illustrations.

1034. BROWNE, H.F., O'CONNOR, J.A., DOVIDAS, C.M. and CAPPS, R. Final Report on Major Mine-Fire Disaster, Belle Isle Salt Mine, LA. *United States Bureau of Mines.*

An underground fire occurred on May 5, 1968 at the Belle Isle Salt Mine while 21 men were working underground. There were no survivors.

The mine was opened by a single shaft 16 ft. inside diameter and about 1250 ft. deep, divided into two compartments for ventilation purposes. The large (upcast) compartment was divided by timbering into two skipways and an electric cable compartment. The smaller (downcast) compartment contained a self-service cage for personnel travel. The shaft was concrete-lined to a depth of 369 ft. Below this point the salt walls were self-supporting with timber sets at 7 ft. spacing. A plywood curtain wall separated the two compartments.

The cause and point of origin of the fire could not be established but probably in the upcast compartment of the shaft below the mining level.

Conclusions and recommendations are drawn.

1035. JEPPE, C.B. *Gold Mining on the Witwatersrand.* 2 Vols. Pub. by Transvaal Chamber of Mines, Johannesburg. 1946.

Describes decaying timber as a most serious fire hazzard. It can be fired even by a cigarette butt. It gives off a much higher percentage of CO than sound burning timber. Discusses the methods used to inhibit fires in timbered workings (pp. 835-836).

Discusses the detailed organisation set up in South Africa to deal with major disasters such as fires, under the headings of fire prevention, reporting of fires (and fire patrols), and firefighting procedures (pp. 1809-1813).

1036. ANON. *Handbook of Requirements Governing the Operation of Mines.* Toronto, 1962.

Provides regulations dealing with mine rescue stations; fire protection; stench warnings; accumulation of flammable refuse; prohibition of fire building; precautions with open flame lights; need for underground structures to be fire resistant; the designation of fire hazard areas, precautions where flammable gas encountered; the provision of fire fighting equipment; precautions in storage and handling of carbide; fire protection when using compressed gases; the provision and maintenance of escape exits; the need for fireproof construction of buildings near mine entrance; the provision of a system of fire doors underground; the need for refuge stations; and the advisability of connections between mines.

1037. ANON. *Idaho Minimum Safety Standards and Practices for Mining and Mineral Industry.* Safety Code No. 5, July, 1963.

Includes sections dealing with escape routes, first aid and rescue, and fire prevention.

1038. ANON. Anaconda Safety Rules: Mining Operations. *Bureau of Safety.* The Anaconda Company, pp. 9-12.

Includes a section dealing with mine fires. Prevention and emergency procedures.

1039. ANON. *The Mines Regulation Act of 1964 (with Regulations).* Queensland, Australia. 1965.

Section 56 deals with precautions against fire underground.

1040. SHEVYAKOV, L. *Mining of Mineral Deposits.* Moscow: Foreign Language Publishing House.

States that the Silesian Method of mining coal may call for the abandonment of coal pillars near the goaf. This may lead to fires which need to be isolated by seals for their extinguishment (p. 370).

Underground fires may be caused by spontaneous combustion of sulphide ores, especially in the caving methods, or where timber is present, or where broken ore has access to air. The best control method is to seal the area and fill. This has become an important problem in the cupreous pyrite deposits of the Ural Mountains (p. 462).

The best preventive measure against self-ignition or heating of a coal face is to stop the access of air by sealing with bulkheads, especially goaf areas (p. 569).

1041. ANON. Mining Equipment. *Mine Safety Appliances Catalogue.* #889687-1, Section 9. Pittsburgh, PA.

Gives details of firefighting equipment.

Foamaker.
Mine Fire Truck Model 2100.
Mine Fire Truck Model 1000.
Mine Fire Control Dry Chemical.
McCaa 2-hour Oxygen Breathing Apparatus.
Mine Rescue Communication System.

1042. ANON. Technical Information. *Mine Safety Appliances Catalogue*. 8810674-4, Section 10. Pittsburgh, PA.

Provides discussion on the application of threshold limit values of gas, etc. concentrations to which workers may be exposed without adverse effect. Also provides lists of recommended values for a wide range of gases and particulates.

1043. ANON. MSA Self Rescuer Respirator W65. *Mine Safety Appliances*. Bulletin 1013-1. Pittsburgh, PA.

Features the W65 Self Rescuer Respirator for emergency underground protection from carbon monoxide as approved (14F-76) by the U.S. Bureau of Mines.

1044. DIERKS, H.A., WHAITE, R.H. and HARVEY, A.H. Three Mine Fire Control Projects in Northeastern Pennsylvania. *United States Bureau of Mines*. Information Circular No. 8524, 1971.

The work and costs involved in controlling three large fires in abandoned mines in the anthracite region of Pennsylvania are presented in detail. Three basic control techniques were successfully employed by the Bureau of Mines: (1) forming underground fire-containing barriers by systematically flushing incombustible material into mine voids, (2) excavating an isolation trench around the fire area, and (3) complete excavation of hot and burning material in the fire area.

1045. MITCHELL, R.R. Notes on Venterspost Gold Mining Company, Ltd. Fire. *Association of Mine Managers of South Africa*. Papers and Discussions, 1968-69. 1970, pp. 603-629.

On 15 November, 1967 smoke was reported in 16 Main Reef Drive, No. 1 Shaft, by the regular fire patrol. Timber sets had been set alight by blasting activities at the bottom of 18 S8 Stope.

The opportunity for early extinguishment by fire equipment cars was lost, through delay in locating the fire.

The fire zone was barricaded with vermiculite bricks, sealed with Rigiseal. Foam from high expansion foam generators was applied to the fire by Proto teams.

The fire burned itself out on 13 December, 1967. Contributed remarks follow, including the outline of a new fire policy adopted by Western Deep Levels Ltd.

1046. HONNET, N.A. Some Aspects of the Fighting of an Underground Fire at Harmony with Particular Reference to the Use of Foam. *Association of Mine Managers of South Africa.* Papers and Discussions, 1968-69. 1970, pp. 631-646.

On 6 February, 1969 a fire broke out at the Harmony Gold Mine in stopes below 17 Level. It spread rapidly into mined area above.

Fire is thought to have originated at an electric scraper winch, probably five hours before it was reported. Valuable time was therefore lost.

Describes the procedures under the headings of fire fighting; practical considerations in the use of foam; indirect effects of the use of foam; and gives a number of leading conclusions.

1047. WALLACE, P.A.N. Some Considerations in the Use of Foam for Fighting Underground Fires. *Association of Mine Managers of South Africa.* Papers and Discussions, 1968-69. 1970, pp. 647-651.

An underground fire broke out on President Brand No. 2 Shaft on 5th February, 1969 in an extensively mined-out area near a pillar being extracted.

Intake airways were sealed and foaming units installed to contain the fire.

Many important comments on the after-effects of foam usage are given.

1048. ANON. F.E.M.A. Handbook of Safety Codes. *Fire Equipment Manufacturers' Association, Inc.* Pittsburgh, PA. 1959.

Based on standards issued by National Fire Protection Association.

Provides safety codes for inspecting, recharging and maintaining portable fire extinguishers, and fixed high pressure carbon dioxide fire extinguishing systems; also safety codes for inspection, maintenance and protection of standpipe and inside hose systems; fixed foam systems.

1049. VAN DER WALT, N.T. Reports on Work Carried Out at the Fire Detection Test Station - President Brand Gold Mining Company Limited. *Journal of the Mine Ventilation Society of South Africa.* Vol. 26, No. 4, April, 1973, pp. 46-51.

At an early stage of the fire detection research program conducted by the Anglo American Electronics Laboratory, it was realized that properly controlled tests had to be conducted on all the different types of fire detection heads to find which head was most suitable for mining conditions with respect to sensitivity, reliability, price, and availability. A number of tests were conducted in different mines in the Anglo American Corporation Group, to try to establish some of the above mentioned properties for each type of detection head. It was, however, soon realized that it was very difficult and sometimes even impossible to control the different variables underground. Furthermore, the making of mock-fires always creates some form of danger and discomfort for the people who conduct the tests, as well as to the other mining staff. An attempt was made to eliminate the last problem by using chemical fumes and/or a portable smoke generator, neither of which was successful. Taking all these problems into account, it was decided to construct a test station on the surface where controlled tests could be conducted on a more scientific basis. Layout of the station is shown and results of tests are reported.

1050. LEE, R.S. New Electronic Detection System Uses Sight, Sound Warning of Fire. *Coal Age.* Vol. 78, No. 9, August, 1973, pp. 71-73.

Prototype of an emergency fire detection system designed by Gammaflux Inc., was installed last April in Omar Mining Co's Chesterfield No. 5 Mine, near Madison, WV. System consists of a monitor console located in the mine office, one transmitter located at each belthead, and heat sensors, spaced 125 ft. apart over the entire length of each belt-haulageway, from the belthead to the tailpiece. One pair of transmission lines simultaneously supplies the dc power to the transmitters and provides a path for the tones generated by the transmitters to the tone receivers located at the monitor console. Block diagram of the system is shown.

1051. ANON. Routine Mine Ventilation Measurements. *Chamber of Mines of South Africa.* 1972, pp. 67-68.

Describes the procedures for air sampling and gas analysis during an underground fire (a) to safeguard helmet personnel and (b) to determine the progress of a fire burning in a sealed area.

1052. EATON, L. and CONIBEAR, W. Fire Prevention and Fire Fighting in Metal Mines. *Lake Superior Mining Institute.* Proceedings, Vol. 23, 1923, pp. 34-46.

In proportion to the men employed, fires in metal mines since 1869 have caused greater loss of life than those in coal mines. The lessons taught by fire disasters are soon forgotten.

To offset this trend, a set of rules is presented under the headings of prevention, extinction, segregation, notification, and extraction. These measures are explained in detail. A copy of fire organization instructions is given. Sketches of suitable fire doors are included.

1053. GRAHAM, J.I. The Use of Gas Analysis in the Study of Mining Problems. *International Congress of Mining, Metallurgy, and Geology.* Report, 1930, Liege.

1054. JONES, T.D. Constitution of Atmosphere Behind Stoppings. Record of Recent Data. *National Association of Colliery Managers*. Mining Proceedings, Vol. 28, 1931, p. 307.

1055. EISNER, H.S. Firefighting in Mine Roadways. *Mining Society Magazine*. Llamorgan College of Technology, Treforest, Vol. 4, 1961, pp. 34-37.

1056. COLLETT, H. Lunar Rover Sensors Direct Mine Fire Fighter. *Coal Mining & Processing*. Vol. 10, No. 12, December, 1973, pp. 61-62, 70.

A coal mine fire-fighter unit developed by the University of Kentucky College of Engineering under a special grant from the U.S. Bureau of Mines with a three-wheeled underground mining vehicle as its basis.

A demonstration was set at their squad training site. Although the sophisticated, much-altered vehicle successfully extinguished three wooden fires, making the thousand yard or so trip to the three pallet piles set on fire with complete, trouble-free remote control, the demonstration was not without its flaws.

1057. ANON. Fire Resistant Conveyor Belting. *Coal Mining & Processing*. Vol. 10, No. 12, December, 1973, p. 74.

Fenaplast SR, a PVC impregnated, solid woven conveyor belting with rubber covers, has been designated fire resistant by the U.S. Bureau of Mines.

1058. WILLIS, R.H. Selecting the Right Fire-Resistant Hydraulic Fluid. *Coal Mining & Processing*. Vol. 10, No. 11, November, 1973, pp. 42-43.

Coal mine operators, in compliance with the recently enacted U.S. Bureau of Mines regulations for underground equipment, are scurrying to convert to fire-resistant hydraulic fluids and to install fire suppression devices.

Offers tips for selecting the proper fluids and for installing, operating and maintaining the fluids in hydraulic systems to assure optimum equipment performance and mine safety.

1059. ANON. Fire Detector and Alarm System for Underground Belt Conveyors from MSA. *World Mining.* Vol. 9, No. 9, August, 1973, p. 22.

A new automatic fire detection system called Thermotect that eliminates the need for an operator to walk mine belts to inspect for fire has been developed by Mine Safety Appliances Company.

1060. KENNEDY, M. and ROBERTS, A.F. *2nd International Fire Seminar, V.F.D.B.* Karlsruhe, September, 1964.

1061. ANON. *Central Mining Research Station.* Annual Report, 1971-1972. Bihar, India.

Deals with research activities under the four headings of mine technology; mine safety; mine engineering; and mine health.

1062. CHAKRABORTY, R.N., BANERJEC, S.C., NANDY, D.K. and BANERJEC, D.D. Factors Influencing Carbon Monoxide Evolution at Low Temperature for Different Coals. *Central Mining Research Station.* Annual Report, 1971-1972. Bihar, India. pp. 84-85.

Accurate estimation of carbon monoxide is one of the most useful methods for early detection of spontaneous heating. But the assessment of heating in a fire area and making the proper interpretation of the analysed results of mine air are intriguing problems.

It was observed from preliminary investigations that the amount of carbon monoxide evolved from a highly susceptible coal is higher than that of the poorly susceptible one.

1063. CHAKRABORTY, R.N., BANERJEC, S.C., NANDY, D.K. and BANERJEC, D.D. Laboratory Methods for Classifying Coals with Respect to Their Spontaneous Combustion Susceptibility. *Central Mining Research Station.* Annual Report, 1972-1973. Bihar, India, p. 84.

Coals, which are considered to be highly susceptible to spontaneous heating, have the following characteristics: (1) crossing point temperature values between 120 and 140°C, (2) a very steep rise in exothermicity after the initial endothermic lag due to elimination of moisture in DTA thermograms, (3) the frequency factor of aerial oxidation usually greater than 10,000 sec^{-1} and (4) the peroxy complex values greater than $2{\cdot}0{\times}10^{-5}$ equivalent per gramme of coal.

1064. CHAKRABORTY, R.N., BANERJEC, S.C., NANDY, D.K. and BANERJEC, D.D. Determination of Crossing Point Temperature for Classifying Coals with Respect to Their Susceptibility to Spontaneous Combustion. *Central Mining Research Station.* Annual Report, 1972-1973. Bihar, India, p. 85.

Classification of coals with respect to their spontaneous combustion susceptibility may be made from the determination of the crossing point temperature. This method was successfully employed for a number of other materials, liable to spontaneous combustion.

1065. CHAKRABORTY, R.N., BANERJEC, S.C., NANDY, D.K. and BANERJEC, D.D. Assessment of Self-heating Tendency of the Materials Proposed to be Used for Stowing Purposes. *Central Mining Research Station.* Annual Report, 1972-1973. Bihar, India, pp. 85-86.

It was observed from earlier studies that as long as there is coaly matter in a sample, it cannot be considered to be absolutely safe from the point of view of spontaneous heating; though the chances may be much reduced with the addition of inerts. Thus, before using boiler ash as a stowing material, its tendency to spontaneous heating should be properly assessed. If necessary, the inert content might be increased till it indicated negligible tendency toward spontaneous heating.

Comments regarding the spontaneous combustion susceptibility of these materials and of those admixed with sand in different proportions, as observed from the crossing point temperature determinations, were duly forwarded.

1066. CHAKRABORTY, R.N., BANERJEC, S.C., NANDY, D.K., SINGH, R.G., and BANERJEC, D.D. Field Studies on Mine Fire. *Central Mining Research Station.* Annual Report, 1971-1972. Bihar, India, pp. 86-87.

Three studies are listed, involving the monitoring of temperatures in collieries affected by fire or spontaneous heatings.

1067. BERL, W.G., ed. *International Symposium on the Use of Models in Fire Research.* November 9-10, 1959. National Academy of Sciences. Pub. 786, 1961.

Includes papers dealing with modeling principles; liquid surface model fires; full scale studies and tests; aerodynamics of fires; and experimental techniques.

1068. ANON. Fire Prevention and Firefighting. *Mining Congress Journal.* Vol. 16, 1930, p. 632.

Refers to the Code of Recommended practice for firefighting sponsored by the AMC and NFPA.

See also Item #844.

1069. HENDRIE, J. Some Experiences of Gob Fires in Fife Coalfields. *Iron & Coal Trades Review.* April 25, 1913.

Paper read before the National Association of Colliery Managers. Describes gob fires in Scotland.

1070. ANON. Fire Resistant Conveyor Belts. *United States Bureau of Mines*. Schedule No. 28, Federal Register. Sept. 4, 1957 and Dec. 10, 1957.

Sets out requirements governing investigations leading to the suitability of fire resistant conveyor belts. The procedure for a flame test is provided.

1071. ANON. Fire Resistant Hydraulic Fluids. *United States Bureau of Mines*. Schedule No. 30, Federal Register. Dec. 17, 1959, pp. 10201-4.

Prescribes procedures for testing and approving hydraulic fluids for fire-resistant qualities.

1072. McGUIRE, L.H. Extinguishing Mine Fires by Dry Ice or Carbon Dioxide. *National Safety Council*. Transactions, Chicago, Oct. 8-12, 1951.

Discusses experiences of sealing and smothering a number of particular mine fires with solid carbon dioxide (dry ice).

Dry ice first used in January, 1944, on a spontaneous coal mine fire at Renton, WA. Technique later improved.

Experimental work by the Bureau of Mines shows that dry ice is effective in a well-sealed area. Special equipment is necessary for best results.

Conclusions are drawn.

1073. SIMODER, E. Contribution to the Stabilization of Ventilation Systems During Mine Fires. *European Coal and Steel Community*. Document #3532/70d.

Subject matter is available in French or German. There is no English translation.

1074. ANON. Stabilization of Mine Ventilation Systems During Open Fires. *European Coal and Steel Community*. Document #13797/1/67/1.

Subject matter is available in French or German. There is no English translation available.

1075. ANON. Mine Fires. *Universal Mining School*. Cardiff, Great Britain. Correspondence Lesson MG/12.

Notes relate to underground fires at collieries under the heading of causes, prevention, fire fighting materials and equipment, organization, and fire fighting procedures.

1076. HALDANE, J.S. The Spontaneous Firing of Coal. *Institute of Mining Engineers*. Transactions. Vol. 53, p. 194.

1077. BROWN, A.O. Mineral Fires in the Huelva Pyrites Mine, Spain. *Institute of Mining Engineers*. Transactions. Vol. 64, p. 249.

1078. HALDANE, J.S. Spontaneous Combustion of Coal. *Institute of Mining Engineers*. Transactions. Vol. 68, p. 473.

1079. MACGREGOR, D. Alteration in the Composition of the Air Contained in a Sealed-Off Area in the Barnsley Bed. *Institute of Mining Engineers*. Transactions. Vol. 75, p. 280.

1080. HORSLEY, J.A.B. Fire Risks Associated with the Use of Electricity in Mines. *Institute of Mining Engineers*. Transactions. Vol. 95, p. 188.

1081. ATKINSON, F.S. The Use of Steel Doors in Fire Stoppings. *Institute of Mining Engineers.* Transactions. Vol. 102, p. 240.

1082. WILDE, D.G. Fires in Mines: Recent Experiences. *Colliery Guardian.* Dec. 1, 1967, pp. 629-632.

Mine fires differ from surface fires in certain particulars and call for special preventive measures.

Causes of mine fires are limited in number. The range of combustible materials is smaller. Fatalities are likely to be much greater, and usually further from the seat of the fire.

Analyses statistics of sites of underground fires, causes of open fires, other causes, materials burned.

Conclusions are drawn.

1083. COWARD, H.F. Fires Caused by Leaking Compressed-Air Pipes. *Colliery Guardian.* June 30, 1944, p. 182.

Air leaking through pipe joints may cause rubber washers to vibrate. The resulting friction may be sufficient to generate enough heat to set adjacent materials afire.

1084. ANON. Handling Mine Fires. *Mining Congress Journal.* Vol. 9, 1923, pp. 288-289.

Draws attention to the two papers in this issue on the reversibility of mine fans.

Summarizes the opposing views held by these two experts; and recommends these articles for close study by operators.

See also Items #851 and #856.

1085. ANON. Tamarack Mine Fire, Michigan. *Engineering & Mining Journal*. June 3, 1911, p. 1126.

A fire broke out at the 72nd level of the No. 5 shaft of the Tamarack Mine on May 24, 1911.

All the men were taken out without any fatality and the shaft sealed in the hope of smothering the fire.

1086. ANON. Miner Rescued Alive after 16 Days in Aurora Mine. *Engineering & Mining Journal*. Vol. 125, No. 13, 1928, p. 548.

Following a fire in the Aurora Copper Mine in Teziutlan, Mexico in which 26 miners perished from poison gases, one miner was rescued alive after having been entombed for 16 days in an abandoned shaft. He managed to survive on water alone.

1087. OLZER, J.C. High Expansion Foam Plug. *Coal Mining Institute of America*. USBM Paper, Pittsburgh, PA, Dec. 16, 1960, p. 134.

Describes this new tool as a practical instrument for combatting underground fires by denying oxygen and cooling the flames until they can be brought under control.

1088. ANON. Mine Fires. *Colliery Guardian*. Vol. 152, No. 3920, Feb. 14, 1936, pp. 304-305.

Makes reference to the interim report of the joint committee at the annual general meeting of the Institution of Mining Engineers on Jan. 30, 1936, dealing with cause, prevention and methods of dealing with underground fires (in coal mines).

1089. WILDE, D.G. Polyurethane Foam. *Colliery Guardian*. Vol. 216, August, 1968, pp. 587-590.

Describes tests carried out to determine the fire resistance of polyurethane foam when used as a sealant in mine roadways and for preventing spontaneous combustion.

A summary of results and general conclusions is offered.

1090. GRAHAM, J.I. Reopening of a Working District After Spontaneous Combustion. *American Institute of Mining Engineers.* Transactions, Vol. LXXIII, 1926-1927, pp. 177-187.

Contributed notes following a paper by Maynard.

The ratios of carbon monoxide production expressed as a percentage of the oxygen adsorbed during vitiation of the air gives valuable information regarding the occurrence of spontaneous heating. The figure for "oxygen adsorbed" is obtained by calculating the amount of oxygen originally mixed with the percentage of nitrogen found by analysis and deducting from this the actual amount of oxygen found by analysis.

The percentage of CO_2 *(less 0.03%--the amount present in fresh air) and the percentage of CO are each multiplied by 100 and divided by the figure for oxygen absorbed.*

When the CO production figure exceeds 1, oxidation of coal is occurring at a dangerous temperature. This may also be the case when the figure is less than 1.

1091. GRAHAM, J.I., MORGAN, C.E. and EABRY, N.C. The Influence of Barometric Changes in Promoting Spontaneous Combustion. *American Institute of Mining Engineers.* Transactions, Vol. LXXIII, 1926-1927, pp. 258-287.

Spontaneous combustion is now well known to be due primarily to the absorption of oxygen by carbonaceous or pyritic matter, with resultant production of heat. If the latter be not dissipated, the temperature of the material will rise and in so doing become capable of absorbing still more oxygen at an increased rate, with consequent further rise of temperature. If the necessary supply of oxygen be available, the absorption of the latter may be sufficient to raise the temperature of the carbonaceous material to such a point that actual fire finally results.

The manner in which oxygen finds access to coal heatings has been traced generally to barometric changes.

The paper reports results of investigations made to determine barometric effects and pressure differences on the spontaneous heating of coal.

1092. GRAHAM, J.I. Spontaneous Combustion in the South Wales Coalfield. *Institute of Mining Engineers.* Transactions, Vol. LXIX, 1924-1925, pp. 413-425.

Examines the factors determining the liability of various South Wales seams to spontaneous combustion.

The thickness of the seam, the method of working and the friable nature of the coal are important considerations. For seams of normal thickness, the presence of finely disseminated pyrites is a regular cause of spontaneous combustion.

1093. GRAHAM, J.I. The Gaseous Products Resulting from Fires and Underground Heatings. *Institute of Mining Engineers.* Transactions, Vol. LXXIX, 1929-1930, pp. 92-111.

Reports results of tests made to examine the oxidation products of heating and combustion of coal. The production of CO_2 and CO is conveniently expressed in each case as a ratio in terms of the oxygen absorbed. These ratios are useful for monitoring coal heatings and for determining the progress of a fire behind stoppings. For heatings, the CO/O_2 is more applicable than the CO_2/O_2 ratio, which reflects full combustion conditions to better effect.

1094. GRAHAM, J.I. Pyrites as a Cause of Spontaneous Combustion in Coal Mines. *Institute of Mining Engineers.* Transactions, Vol. LXVII, 1923-1924, pp. 100-113.

Tests show that any form of pyrites in finely divided condition will absorb oxygen rapidly from the air with production of heat; that in many cases pyrites is the *primary cause of spontaneous combustion; and that heating due to oxidation of pyrites will probably develop more rapidly than that of coal alone.*

1095. JONES, G.W. and SCOTT, G.S. Effect of Hydrogen-Ion Concentration on Growth of Hydrogen and Carbon Monoxide Bacteria. *United States Bureau of Mines.* Information Circular No. 7133, Sept., 1940.

Usual practice is to assume that fire is out when carbon monoxide is no longer present in fire area; it is now evident that such assumption may be misleading and at times dangerous; tests reported indicate that disappearance of carbon monoxide from gaseous atmosphere can take place as result of bacterial action.

1096. ROGERS, T.A. Underground Fire at Auchengeich Colliery. Lanarkshire. *Her Majesty's Stationery Office.* London, Command 1022, May, 1960.

Gives detailed analyses of an enquiry into subject fire which occurred on 18th Sept., 1959.

Fire originated in the transmission belt of an electrically driven booster fan as a result of frictional heat generated.

Forty-seven men were asphyxiated. Conclusions and recommendations are included.

1097. WILLETT, H.L. The Interpretation of Samples from Behind Stoppings with a View to Re-opening. *Institute of Mining Engineers.* Transactions, Vol. 111, 1951-1952, pp. 629-651.

Before reopening a district which has been sealed-off on account of fire or spontaneous combustion, it is vitally necessary to ensure that conditions within the sealed district are safe.

This paper reviews the generally accepted methods of interpreting the composition of the atmosphere in wastes *and in sealed-off districts, and gives the results of the author's practical research which appear to throw further light on the subject.*

It is shown that in some seams the carbon monoxide produced by fire or spontaneous combustion will disappear in a sealed-off district when the fire or heating becomes extinct. In these cases the most reliable indication of the condition of a fire or heating is the Graham CO/O_2 def. ratio.

It is shown that in other seams the carbon monoxide produced by normal oxidation in wastes does not disappear and that, in these seams, carbon monoxide does not readily disappear in sealed-off districts after a fire or heating is extinct. In these cases the CO/O_2 def. ratio is not a reliable indication of the condition of a fire or heating in sealed-off districts. A new method of interpretation is derived to meet the needs of these seams based on the trend of the figure of--

$$\frac{CO_2 \text{ Produced}}{\text{Blackdamp} + \text{Combustible Gas}} \%$$

1098. COLES, G. and THIRLAWAY, J.T. The Disappearance of Carbon Monoxide in the Mine. *Institute of Mining Engineers.* Transactions, Vol. 115, 1955-1956, pp. 768-785.

Possible causes for the disappearance of carbon monoxide in the mine are discussed in the light of the published experimental results. Laboratory tests are described which measured the changes in the concentration of the gas when confined over samples of fresh and sterilized coal, timber and mine waters. The conclusion is reached that the disappearance of carbon monoxide is caused mainly by bacterial action, and cannot be attributed, in the case of coal, to a chemical reaction with the oxidized coal substance.

Factors affecting bacterial growth are discussed in relation to the environmental conditions in mines, and evidence is presented which indicates that the relative humidity of the mine atmosphere, in so far as it reflects the dry or damp state of the workings, may be useful as a guide to the probable behavior of carbon monoxide in sealed fire areas where this is unknown. A continuation of the study of atmospheric changes, particularly with regard to carbon monoxide and humidity in wastes and sealed abandoned workings, is advocated.

1099. HARDWICK, F.W. Underground Fires. *Colliery Guardian.* July 31, 1903.

Discusses the dangers, causes and means of prevention of mine fires.

1100. HARRINGTON, D. and VON BERNEWITZ, M.W. How to Make Preparations Against a Fire or an Explosion and What to Do When It Occurs. *Coal Age.* Vol. 26, No. 20, Nov. 13, 1924, pp. 689-691.

Statistics based on 164 disasters of this kind as studied by engineers of Bureau of Mines; 500 lives saved by fan reversal; no lives lost by reversing fans.

1101. SINGHAL, R.K. British Firm Formulates Unique Fire-Resistant Underground Sealant. *Coal Mining & Processing.* Vol. 9, No. 2, Feb., 1972, pp. 44-46.

Mandoseal P. an underground sealant and fire resistant coating, has been formulated by a British company, Mandoval Ltd., in compliance with National Coal Board specifications for the use of sealant coatings and coatings underground. Mandoseal also has successfully undergone tests for fire resistance performed by the Safety in Mines Research Establishment at Buxton, England. Various applications for the sealant are described in the article.

1102. FIELDNER, A.C. and KATZ, S.H. Stench Warnings in Metal Mines. *United States Bureau of Mines.* Report of Investigations No. 2153, August, 1920.

Fire warnings for underground workers depend on reactions of one of the five senses. Most devices have been devised for visual or audible signals. But a stench warning involving the sense of smell is effective if the stench liquid is injected into the compressed air lines. The air current quickly vaporizes the stench liquid and carries it to all parts of the mine where compressed air is used. In coal mines it is not applicable.

Practical tests have given excellent results at five named mines. Ethyl mercaptan is regarded as the most effective stench liquid. Details are given.

1103. PICKARD, B.O. Fire Hazards in Metal Mines. *United States Bureau of Mines.* Report of Investigations No. 2194, Dec., 1920.

The casual attitude by managements towards fire risks in metal mines is underlined.

Lists 26 dangerous conditions noted in a visit to several mines in western U.S.

Refers to mine fire prevention suggestions in TP 59 and Bulletin 75. See Items #587 and #588.

1104. HANSON, E.F. Control of Underground Mine Fires at Tintic Standard Mine. *American Institute of Mining & Metallurgical Engineers.* Technical Publication No. 718, meeting Feb., 1937. Transaction, Vol. 126, 1937, pp. 248-260, (discussion) pp. 260-262.

Mine at Dividend, Utah; mine layout; mining and ventilation methods; fire protection; fire discovered July 17, 1934; investigation; sealing off; filling with waste rock and slime; use of carbon monoxide detector, smoke tube, gas masks, Orsat gas-testing apparatus, and oxygen breathing apparatus; pressure control that confines products of combustion within fire area, depleting oxygen supply, will stop progress of fire.

Bulkheads should be as close to the fire as possible and should be well bonded to the ground on all sides to prevent leaks. If the sealing is perfect, combustion is soon extinguished in the enclosed area by depletion of oxygen. Perfect sealing is impossible. Though the bulkheads may be airtight, air percolates through the fractured and porous strata. Bulkheads used in connection with sliming must be strong enough to withstand the hydrostatic pressure developed.

When combustion stops, the heat of a large fire surrounded by its ashes dissipates very slowly, thus making the opening of a fire area extremely hazardous even several months after the fire has been brought under control.

Water, when used, caused rapid disintegration of hanging wall and country rock, causing caves to develop. The slime mixture does not do this.

The cost of doing work with helmet crews is approximately three times that done by men working in fresh air. Therefore, considerable ventilation equipment and work is justified to eliminate the use of oxygen breathing apparatus.

A phenomenon observed was that when an area near a given bulkhead has apparently become filled or blocked with slimes, it may yet admit slimes from another area through a different bulkhead.

Only comparatively few men make efficient underground fire fighters. Just because a man has had mine safety training, it does not necessarily mean that he will make a good fire fighter.

The employing of experienced men, to check on all operations and to put into operation all that has been learned from other mine fires, is endorsed.

Fire-fighting is a strenuous, hazardous undertaking and a job on which consistent, steady progress must be made in order to protect life and property. Mine fires do occur even where unusual fire-prevention measures are used, and for that reason every mine in which a number of men are employed should have fire-fighting equipment and fire-control plans ready for any emergency.

1105. BREDENBRUCH, E. Origin and Prevention of Mine Fires. *Great Britain. Safety in Mines Research Establishment.* Paper No. 34, 1956.

Types and frequency of mine fires in Ruhr Basin between 1947 and 1953. Self-ignition and its causes. Open fires. Methods of preventing fires. Equipment used for combatting fires.

1106. ANON. Vermiculite Plasters for Ventilation and Fire Control. *Journal Mine Ventilation Society of SA.* Oct., 1973.

Advertisement by D. J. Adhesives (Pty) Ltd. quoting fire-proofing tests carried out at the South African Bureau of Standards Laboratories in Pretoria in May, 1970.

1107. GRUMER, J. Recent Developments in Coal Mine Fire and Explosion Prevention Research. *United States Bureau of Mines.* Information Circular No. 8616, 1973.

Reports studies of fires to develop capabilities during mining operations to detect and quench ignitions of gas in the working face by means of passive or triggered barriers. Also to detect incipient fires early enough for easy extinguishment.

1108. ANON. The Fire in the Smuggler Mine at Aspen, Colorado. *Engineering and Mining Journal.* Jan. 15, 1898.

From a report by the mine manager to the State Mine Inspector.

The fire of unknown cause was first reported in a square set stope in November 14, 1897 between the sixth and seventh levels.

Fire was eventually brought under control by the use of water and steam and by bulkheads.

1109. ANON. Fire Fighting Equipment in Metal Mines. American Standards Association. Code M17-1930.

Represents a code of recommended practice for fire fighting equipment, preventive measures, fire signals and fire-fighting personnel adopted by a joint committee of the National Fire Protection Association and the American Mining Congress.

See also item Nos. 844, 875, 1048 and 1068.

1110. ANON. Study of Mine Fire Fighting Using Inert Gases. Contract S0231075. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV, No. 10, October, 1973, p. 10-22.

To evaluate theoretically the usefulness of fighting coal mine fires with inert gases.

1111. ANON. Design and Fabrication of Instruments Used in Remote Sealing of Underground Coal Mine Passages. Contract H0144004. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV, No. 10, Oct., 1973, p. 10-1.

To develop, design and fabricate sonar probing and seal checking units for use in remote sealing of coal mine passage-ways.

1112. ANON. Evaluation of Materials for Protecting Existing Urethane Foams. Contract H0144009. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV, No. 10, Oct., 1973, p. 10-1.

To define the minimum requirements for scientific coating materials to render foam incombustible.

1113. ANON. Ignition Suppression Device. Contract H0122020. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV,No. 10, Oct. 1973, p. 10-17.

To develop IR and UV detectors on continuous miners as protection against fire and explosion.

1114. ANON. Extinguishing Coal Mine Fires by Remote Sealing. Contract H0122046. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV No. 10, Oct., 1973, p. 10-17.

To develop an effective sealing system that can be operated remotely from the surface.

1115. ANON. Suppression of Fire on Underground Coal Mine Conveyor Belts. Contract HO122086. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV, No. 10, Oct., 1973, p. 10-19.

To develop and evaluate fire detection and automatic water sprinkling extinguishing devices on conveyor belt systems.

1116. ANON. Extinguishment of Rock Covered Mine Fires. Contract HO122119. *United States Bureau of Mines.* Mining Research Contract Review. Vol. IV, No. 10, Oct., 1973, p. 10-20.

To investigate possible methods for extinguishing coal fires under massive roof falls.

1117. ANON. Expanding Ceramic Foam. *Compressed Air Magazine.* Dec. 1973, p. 16.

Describes a ceramic foam that expands to nine times its original volume, dries rock hard, and bonds to brick, concrete, etc.

Is said not to flame or give off toxic gases.

1118. McHALE, E.T. Extinguishment of Rock-Covered Mine Fires. *United States Bureau of Mines.* OFR 73-73, Sept. 30, 1973.

Research demonstrates that high pressure water jets were superior to other agents for extinguishing covered coal fires.

1119. ANON. Ansul A-101 Mine Fire Control Systems. Ansul Co., 1973.

Intended to aid mining industry users with selection of dry chemical fire protection equipment for both underground and surface mining equipment.

1120. WILDE, D.G. High Expansion Foam for Fighting Mine Fires. *Fire International.* April, 1965, p. 66-78.

Describes in considerable detail results of tests with sprayed high expansion foam to seal and smother mine fires, using water and ventilating air to disperse the foam and move the foam net towards the fire. Fire control is achieved by cooling the fire with the water content of the foam and by denying oxygen.

Describes water supplies, foaming agents, spraying nozzles and nets, air supply, and foam transport. Sets out results of experimental work and construction of portable foam generators. Diagrams and references. Also in French and German.

1121. MATSUGUMA, K., UMEZU, M. and YAMAO, S. On High-Expansion Foam for Use in Underground Fire Fighting. *Mining and Safety.* 15(1), 1969, p. 3-13.

About fifty foam agents were examined to select the most suitable for the foam-plug method.

The primary extinguishing effect is sealing; the secondary effect is for cooling the fire. These effects vary with the forward speed of the plug and the quantity of water used in the foam.

Gives test results of the extinguishing effect of the foam plug in relation to its forward speed.

Diagrams and references. Japanese text.

1122. SMITH, P.B. A New Method of Suppressing Fires in Mines. *Journal Royal Society of Arts.* Oct. 25, 1957, p. 938-40.

A mine fire usually becomes well established before detection. Ventilating currents carry flames downwind at a rate faster than fire fighters can progress. It is then necessary to abandon direct methods, seal off the fire zone and deny oxygen to the fire.

A new technique is needed. The method propounded is to form a foam plug upstream and project it towards the fire, to cool and snuff the fire.

Details are described.

1123. GRAHAM, J.I. The Spontaneous Combustion of Coal. *Journal Society of Chemical Industry.* Vol. 43, No. 14, April 4, 1924, p. 79-87.

The spontaneous combustion of coal presents a high fire risk for coal mining operations.

Analyzes the principles determining the susceptibility of various coals to spontaneous combustion.

1124. LINACRE, E.T. Practical Aspects of the Foam-Plug Method of Fighting Large Mine Air-Way Fires. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 171, Feb., 1959.

1125. LINACRE, E.T. and JONES, D.H. Materials and Equipment for the Foam-Plug Method of Mine Firefighting. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 179, Aug., 1959.

Report describes the development of materials and equipment for the foam-plug process.

A satisfactory nozzle and net have been developed. The properties of a suitable foam agent are specified. An apparatus is described for testing the stability of foams made from foam-agent samples in water containing various impurities. Diagrams and references.

See also Items #253 and #1124.

1126. ANON. International Symposium on Deep Mine Ventilation. Sept. 24-27, 1968. The Mining Institute of the Czechoslovak Academy of Sciences.

1127. Second International Fire Proection Seminar. Karlsruhe. 1964.

1128. GRICE, C.S.W. The Exchange of Publications, Bibliographies and Abstracts on Mine Safety Research. *Proceedings. Seventh International Conference of Directors of Mines Safety Research.* 1952.

Paper No. 3.

1129. BARCLAY, J.T. and WALKER, D.N. Fire Hazards. *Proceedings. Seventh International Conference of Directors of Mines Safety Research.* 1952.

Paper No. 32.

1130. HARDY, V.O. The Smouldering of Coal Dust and the Effect of Lubricants. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 136, 1956.

Accumulations of fine coal dust can readily be set smouldering by contact with overheated machinery, and this has been the origin of many mine fires. In order to guard against this danger it is important to know the least temperature necessary to initiate smouldering combustion in a wide variety of circumstances. Report covers an investigation of the initiation of smouldering in deposits of coal dust and of the effect on the minimum ignition temperature of the dust in the presence of oil and grease.

1131. HARDY, V.O., HATTERSLEY, R. and TAIGEL, P.G. Diesel Locomotives in Mines: The Fire Hazard from Hot Surfaces on the Exhaust System. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 126, 1956.

Gives results of experiments on the cooling of the exhaust system on a diesel locomotive. Part of an investigation of the fire hazard arising from the heating of coal dust and oil on hot surfaces.

1132. EISNER, H.S. and SMITH, P.B. Fire Fighting in Underground Roadways: Experiments with Foam Plugs. *Great Britain. Safety in Mines Research Establishment.* Research Report No. 130, 1956.

Report describes the first stages in the development of a new method of fighting fires in ventilated underground roadways and some experiments made to assess its advantages and limitations. References.

1133. COWARD, H.F., Ed. A Discussion on Fire Hazards in Coal Mines. *Part 4 of Proc. Seventh International Conference of Directors of Safety in Mines Research.* Buxton, England. July, 1952.

A record of translated discussions on the subject title appears in SMRE Research Report No. 67.

1134. ANON. Seminar on Mine Fires. *The Australasian Institute of Mining and Metallurgy, Southern Queensland Branch.* November 12, 1973.

Seminar was conducted by Dr. H. L. Willett.

1135. WILSON, J.E. Air Quality and Quantity Controls. *Mining Engineering.* Feb., 1974, p. 93.

Under title heading, discusses a system of ventilation control monitoring developed at West Virginia University. System was developed primarily for fire prevention purposes.

Also discusses an electronic fire detection system developed by Gammaflux.

1136. FELLMAN, C.M. Fires and Fire Prevention Practices in Lake Superior District Iron Mines. *Proc. 23rd Annual Mine Safety Conference, Duluth, MN.* June 19-20, 1947. Lake Superior Mining Section of National Safety Council, pp. 46-94.

Following the report of 43 mine fires in the Lake Superior District between 1931 and 1941, 88 more occurred up to 1947, eleven of which were regarded as serious fires, although without loss of life. This is a measure of the effectiveness of the fire fighting organizations involved. But mining companies must remain alert in fire prevention work.

Detailed information is given on the 88 recent fires, 64% of which were of electrical origin.

Conclusions. Appendices.

1137. Chambers, F.D. The Insurance Angle--Mine Fires and Loss of Profits. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 11. Nov., 1973, pp. 172-73.

Apart from claims relating to personal injury and death, fires can involve financial losses due to (a) destruction of property, (b) disruption of normal operations, and (c) costs of fire-fighting. Details are given.

1138. DEACON, T. Underground Fire Detection--Smell Pipe System. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 11, Nov., 1973.

For ease in fire patrol work on off-shift periods, sampling pipes drawn from the return air on each level are permanently led to a common observation point. This enables the fire patrol to "sniff" each pipe at regular intervals and to identify the level from which smoke might be arising.

Details are given.

1139. TURNBULL, M. Gas Analysis in Gold Mines. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 12, Dec., 1973, pp. 184-85.

Mine fires produce copious volumes of gases. Of these the most sensitive indicator of fires is carbon monoxide. Gives detailed discussion on the advances made in monitoring and telemetering CO gas concentrations, and the value of such an installation in fire detection.

1140. ANON. Practical Fire Prevention. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 12, Dec., 1973, pp. 186-88.

Defines high risk zones and lists prevalent daily starting times for fires, and causes of underground fires in gold mines and their prevention.

Compiled by the Rescue Training Station.

1141. ANON. Fire Fighting Record for 1972. *Journal of Mine Ventilation Society of South Africa.* Vol. 26, No. 12, Dec., 1973, pp. 189-90.

Tabulates number of fire occurrences in gold, coal and diamond mines. Also tabulates causes of fires in three different mining centres. General composition of rescue teams is also given.

Compiled by the Rescue Training Station.

1142. ANON. Fire in Louisville Mine, Lake County, Colorado. *Engineering and Mining Journal.* Aug. 29, 1891, p. 249.

Subject fire was discovered in the main shaft at the 500 Level at 2 p.m. Aug. 17. Fire could have smothered in early stages but for 25 miners working on 700 Level. By the time these were evacuated the flames had rushed up the shaft, aided by the dry timbers, and the headframe was afire. Fire probably caused by the explosion of a lamp.

GENERAL INDEX

(Numbers quoted refer to Item Numbers in the Bibliography)

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INDEX OF ACTUAL MINE FIRE REPORTS

Entries appear in the following sequence:

(a) Name of mine, in alphabetical order
(b) American state or other country
(c) Type of mine: C = coal, NC = non-coal, T = tunnel
(d) Year of occurrence
(e) Item number in the bibliography

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AUTHOR INDEX

Referred to Item Numbers in the Bibliography

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