NBS CIRCULAR 580

# Bibliography on Ignition and Spark-Ignition Systems

UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

## PERIODICALS OF THE NATIONAL BUREAU OF STANDARDS

(Published monthly)

The National Bureau of Standards is engaged in fundamental and applied research in physics, chemistry, mathematics, and engineering. Projects are conducted in fifteen fields: electricity and electronics, optics and metrology, heat and power, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, data processing systems, cryogenic engineering, radio propagation, and radio standards. The Bureau has custody of the national standards of measurement and conducts research leading to the improvement of scientific and engineering standards and of techniques and methods of measurement. Testing methods and instruments are developed, physical constants and properties of materials are determined, and technical processes are investigated.

### Journal of Research

The Journal presents research papers by authorities in the specialized fields of physics, mathematics, chemistry, and engineering. Complete details of the work are presented, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Annual subscription: domestic, $4.00; $1.25 additional for foreign mailing.

### Technical News Bulletin

Summaries of current research at the National Bureau of Standards are published each month in the Technical News Bulletin. The articles are brief, with emphasis on the results of research, chosen on the basis of their scientific or technologic importance. Lists of all Bureau publications during the preceding month are given, including Research Papers, Handbooks, Applied Mathematics Series, Building Materials and Structures Reports, Miscellaneous Publications, and Circulars. Each issue contains 12 or more two-column pages; illustrated. Annual subscription: domestic, $1.00; 35 cents additional for foreign mailing.

### Basic Radio Propagation Predictions

The Predictions provide the information necessary for calculating the best frequencies for communication between any two points in the world at any time during the given month. The data are important to all users of long-range radio communications and navigation, including broadcasting, airline, steamship, and wireless services, as well as to investigators of radio propagation and ionosphere. Each issue, covering a period of one month, is released three months in advance and contains 16 large pages, including pertinent charts, drawings, and tables. Annual subscription: domestic, $1.00; 25 cents additional for foreign mailing.

---

Order all publications from the Superintendent of Documents
U. S. Government Printing Office, Washington 25, D. C.

UNITED STATES DEPARTMENT OF COMMERCE • Sinclair Weeks, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

# Bibliography on Ignition and Spark-Ignition Systems

George F. Blackburn

National Bureau of Standards Circular 580
Issued November 1, 1956

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

## Preface

This bibliography presents more than 425 references to published sources of information on ignition and spark-ignition systems. A majority of these references were assembled in the course of investigations sponsored by the National Advisory Committee for Aeronautics, the Navy Bureau of Aeronautics, and other national defense agencies. The scope and arrangement of the bibliography are discussed in the introduction.

A. V. Astin, *Director.*

## Contents





395575—56

# Bibliography on Ignition and Spark-Ignition Systems

George F. Blackburn

Approximately 425 references to books, papers, and reports are listed, on ignition of combustible gaseous mixtures and ignition apparatus. The ignition of gases includes ignition by electric sparks and arcs and by hot surfaces. The references on ignition apparatus are for the most part on ignition systems and components for internal-combustion engines, with spark plugs listed separately from other components.

## 1. Introduction

This list of publications supersedes National Bureau of Standards Letter Circular LC476, Bibliography on Spark Plugs, and is wider in scope than that publication. It covers the initiation of combustion in explosive gaseous mixtures by means other than compression ignition, as well as electric equipment for spark-ignition engines.

Part 2.1 lists books in which ignition or ignition equipment is either the main topic or is given fairly extensive treatment.

The references to other publications are presented under three main heads. The first concerns ignition of combustible mixtures of gases and vapors, and is subdivided into two parts, according to whether ignition is effected by an electric spark or arc or by a heated surface. Part 2.2.a includes references to work on measuring spark energy. Part 2.2.b covers both fundamental investigations of ignition by heated surfaces and ignition by hot spots in internal-combustion engines.

Although ignition is an essential stage in the combustion process, papers dealing primarily with the kinetics of combustion, flame propagation, and detonation, or with the flammability limits of composition, temperature, and pressure of gases, have not been included in this bibliography unless they were found to contribute also to an understanding of ignition phenomena.

Part 2.3 lists references on spark-ignition systems for internal-combustion engines, and their components. It includes work on testing and test equipment. Because there are so many references to spark plugs, these are listed separately as part 2.3.b.

Part 2.4 contains miscellaneous references on ignition that do not fall within the category of part 2.2. Included are a number of papers and reports concerning explosion hazards.

Within each topical subdivision the references are given in chronological order, and within each chronological subdivision, alphabetically by author, followed by anonymous references.

The journal abbreviations used are those employed in Chemical Abstracts, except that the abbreviation NACA is used for the National Advisory Committee for Aeronautics. An unpublished paper presented before a technical or professional society is designated by the abbreviation M. P. for "Meeting Paper." Volume numbers are in boldfaced type, and the date of issue is given in cases where page numbers do not run consecutively through a given volume.

In general, the reports and papers listed are available only in libraries, and none can be supplied by the Bureau. The Federal Specification for Spark Plugs, W–P–506a (listed in part 2.3.b), may be obtained for 5 cents from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Information as to the availability of other reports should be obtained from the author or from the sponsoring organization.

## 2. Bibliography

### 2.1. Books


E. L. Consoliver and G. S. Mitchell, Automotive ignition systems. McGraw-Hill, New York, 1920.

W. A. Bone and D. T. A. Townend, Flame and combustion in gases. Longmans, Green, London, 1927.

W. A. Kirkby, Flame. Methuen, London, 1936.

Automotive electricity. Technical Manual No. 10–580, War Department, Washington, 1941.

J. D. Morgan, The principles of ignition. Pitman, London, 1944.

R. F. Kuns and T. C. Plumridge, Automobile ignition and electrical equipment. American Technical Society, Chicago, 1945.

A. H. Packer, Electrical trouble shooting on the motor car. 5th ed. Battery Man Publishing Co., Terre Haute, 1945.

W. Jost, Explosion and combustion processes in gases. McGraw-Hill, New York, 1946.

Third symposium on combustion, flame and explosion phenomena. Williams and Wilkins, Baltimore, 1949.

B. Lewis and G. von Elbe, Combustion, flames and explosions of gases. Academic Press, New York, 1951.

F. P. Bowden and A. D. Yoffe, Initiation and growth of explosion in liquids and solids. Cambridge University Press, 1952.

Fourth symposium (International) on combustion. Williams and Wilkins, Baltimore, 1953.

Advisory Group for Aeronautical Research and Development, NATO, Selected combustion problems. Fundamentals and aeronautical applications. Butterworth Scientific Publications, 1954.


### 2.2. Ignition of Combustible Mixtures

#### a. Electric Ignition


P. J. Kirkby, The effect of the passage of electricity through a mixture of oxygen and hydrogen at low pressures. Phil. Mag. (6) **7,** 223 (1904).

P. J. Kirkby, The union of hydrogen and oxygen at low pressures through the passage of electricity. Phil. Mag. (6) **9,** 171 (1905).

P. J. Kirkby, Chemical effects of the electric discharge in rarefied hydrogen and oxygen. Phil. Mag. (6) **13,** 289 (1909).

P. J. Kirkby, A theory of the chemical action of the electric discharge in electrolytic gas. Proc. Roy. Soc. (London) [A] **85,** 151 (1911).

H. F. Coward, C. Cooper, and C. H. Warburton, The ignition of electrolytic gas by the electric discharge. J. Chem. Soc. **101,** 2278 (1912).

W. M. Thornton, Ignition of coal gas and methane by momentary electric arcs. Trans. Inst. Mining Engrs. (London) **44–1,** 145 (1912).
W. M. Thornton, The ignition of gaseous mixtures by momentary electric arcs. Brit. Assoc. Advancement Sci. Rept. 82d Meeting, p. 564 (1912).
H. F. Coward, C. Cooper, and J. Jacobs, The ignition of some gaseous mixtures by the electric discharge. J. Chem. Soc. **105,** 1069 (1914).
W. M. Thornton, Electric ignition of gaseous mixtures. Proc. Roy. Soc. (London) [A] **90,** 272 (1914).
W. M. Thornton, Ignition of gases by condenser discharge sparks. Proc. Roy. Soc. (London) [A] **91,** 17 (1914).
W. M. Thornton, Least energy required to start a gaseous explosion. Phil. Mag. **28,** 734 (1914).
J. D. Morgan, The ignition of explosive gases by electric sparks. J. Inst. Elec. Engrs. (London) **54,** 196 (1916); J. Am. Soc. Mech. Engrs. **39,** 86 (1917); and J. Chem. Soc. **115,** 94 (1919).
S. G. Sastry, The ignition of mixtures of methane and air and hydrogen and air by means of impulsive electric discharge. J. Chem. Soc. **109,** 523 (1916).
W. M. Thornton, Ignition of gases by impulsive electrical discharge. Proc. Roy. Soc. (London) [A] **92,** 381 (1916).
W. M. Thornton, Reaction between gas and pole in electrical ignition of gaseous mixtures. Proc. Roy. Soc. (London) [A] **92,** 9 (1916).
R. V. Wheeler, "Stepped" ignition. J. Chem. Soc. **111,** 130 (1917).
R. V. Wheeler, Influence of pressure on the ignition of a mixture of methane and air by the impulsive electric discharge. J. Chem. Soc. **111,** 411 (1917).
R. Wright, Spark length in various gases and vapors. J. Chem. Soc. **111,** 643 (1917).
N. R. Campbell, The influence of the electrode on the ignition of explosive mixtures by sparks. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 27 (1918).
C. C. Paterson and N. R. Campbell, Experiments on the ignition of explosive mixtures by sparks. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 43 (1918).
C. C. Paterson and N. R. Campbell, The characteristics of the spark discharge and its effect in igniting explosive mixtures. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 23 (1918).
C. C. Paterson and N. R. Campbell, The expenditure of current and energy required for ignition in an explosion engine. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 25 (1918).
G. E. Bairsto and J. A. Hughes, On the spark energy of electrical ignition systems. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 51 (1919).
C. C. Paterson and N. R. Campbell, Some characteristics of the spark discharge and its effect in igniting explosive mixtures. Proc. Phys. Soc. (London) **31,** 168 (1919).
F. B. Silsbee, L. B. Loeb, and E. L. Fonseca, Heat energy of various ignition sparks. NACA Rept. 56 (1919).
W. M. Thornton, Ignition of gases at reduced pressures by impulsive electric sparks. Phil. Mag. (6) **40,** 345 (1920).
W. M. Thornton, Ignition of gases at reduced pressures by transient arcs. Phil. Mag. (6) **40,** 450 (1920).
R. V. Wheeler, The ignition of gases: Part I. Ignition by the impulsive electric discharge—mixtures of methane and air. J. Chem. Soc. **117,** 903 (1920).
A. P. Young and H. Warren, The process of ignition. Automobile Engr. **10,** 115 (1920).
B. F. Bailey, Underlying principles of electrical ignition. S. A. E. Journal **8,** 570 (1921).
J. D. Morgan and R. V. Wheeler, Phenomena of the ignition of gaseous mixtures by induction coil sparks. J. Chem. Soc. **119,** 239 (1921).
H. A. Thornburgh and E. B. Weaver, A calorimeter for determining the heat of ignition sparks. Automotive Inds. **45,** 523 (1921).
A. P. Kratz and C. Z. Rosecrans, Study of explosions of gaseous mixtures. Univ. Illinois Eng. Expt. Sta. Bul. 133 (1922).
E. Taylor-Jones, J. D. Morgan, and R. V. Wheeler, On the form of temperature wave spreading from point and spherical sources, with a suggested application to the problem of spark ignition. Phil. Mag. (6) **43,** 359 (1922).
J. D. Morgan, Some observations on the ignition of combustible gases by electric sparks. (Phil. Mag. (6) **45,** 968 (1923).
W. M. Thornton, The mechanism of gas ignition. Brit. Assoc. Advancement Sci. Rept., 91st Meeting, p. 469 (1923).

D. W. Randolph and F. B. Silsbee, Flame speed and spark intensity. NACA Rept. 187 (1924).
R. V. Wheeler, The ignition of gases. III. Ignition by the impulsive electric discharge. Mixtures of the paraffins and air. J. Chem. Soc. **125,** 1858 (1924).
J. D. Morgan, The thermal theory of gas ignition by electric sparks. Phil. Mag. **49,** 323 (1925).
R. V. Wheeler, The ignition of gases. V. Ignition by inductance sparks. Mixtures of the paraffins with air. J. Chem. Soc. **127,** 14 (1925).
G. I. Finch, L. G. Cowen, D. L. Hodge, H. H. Thompson, and W. T. Patrick, Gaseous combustion in electric discharges. Proc. Roy. Soc. (London) [A] **111,** 257 (1926); [A] **116,** 529 (1927); [A] **124,** 303 (1929); [A] **129,** 314, 656, and 672 (1930).
R. V. Wheeler, The electric ignition of firedamp: alternating and continuous current compared. Gt. Brit. Safety in Mines Research Board, Paper 20 (1926).
W. A. Bone, The initial stages of gaseous explosions. III. The behavior of an equi-molecular methane-oxygen mixture when fired with sparks of varying intensities. Proc. Roy. Soc. (London) [A] **114,** 442 (1927).
H. F. Coward and E. G. Meiter, Chemical action in the electric spark discharge. The ignition of methane. J. Am. Chem. Soc. **49,** 396 (1927).
M. F. Peters, W. Summerville, and M. Davis, An investigation of the effectiveness of ignition sparks. NACA Rept. 359 (1930).
G. I. Finch and H. H. Thompson, The effect of frequency on the condensed discharge ignition of carbonic oxide-air detonating gas. Proc. Roy. Soc. (London) [A] **134,** 343 (1931).
J. D. Morgan, Some further experiments on the combustion of inflammable gases by electric sparks. Phil. Mag. (7) **11,** 158 (1931).
B. W. Bradford, G. I. Finch, and A. M. Prior, The coil ignition of some explosive gaseous mixtures. J. Chem. Soc. **1933,** 227.
B. Lewis and C. D. Kreutz, Influence of ionization on the ignition temperature of combustible gases. J. Chem. Phys. **1,** 89 (1933).
B. W. Bradford, G. I. Finch, and A. M. Prior, The ignition of some explosive mixtures by modified coil discharges. J. Chem. Soc. **1934,** 75.
G. I. Finch and G. Mole, The mechanism of electrical ignition. Proc. Inst. Automobile Engrs. (London) **29,** 71 (1934).
J. D. Morgan, Experiment relating to the thermal and electrical theories of spark ignition. Phil. Mag. (7) **18,** 827 (1934).
Te-Lou Tchang, A new method of ignition in internal combustion engines. Compt. rend. **198,** 542 (1934).
K. A. Browne, Aircraft spark-ignition versus compression-ignition engines. S. A. E. Journal **37,** 342 (1935).
R. V. Wheeler, Ignition of turbulent explosive mixtures by electric sparks. Fuel **14,** 147 (1935).
G. Mole, The ignition of explosive gases. Proc. Phys. Soc. (London) **48,** 857 (1936).
B. W. Bradford and G. I. Finch, The mechanism of ignition by electric discharges. Chem. Revs. **21,** 221 (1937).
H. G. Landau, The ignition of gases by local sources. Chem. Revs. **21,** 245 (1937).
R. Viallard, Ignition of explosive mixtures by electric sparks. Compt. rend. **207,** 1045 (1938); J. chim. phys. **40,** 54 and 101 (1943); J. Chem. Phys. **16,** 555 (1948).
H. Zeise, The physical-chemical problem of the ignition of gas mixtures in engines. Z. Elektrochem. **47,** 238 (1941).
R. Goto and K. Urakubo, The explosive reactions of gases. The pressure effect of spark ignition of oxy-hydrogen gas. Rev. Phys. Chem. (Japan) **16,** 28 (1942).
V. Toriyama and S. Saito, Ignition of flammable gases. Inst. Elect. Engrs. (Japan) **62,** 427 (1942).
P. G. Guest, Apparatus for determining minimum energies for electric-spark ignition of flammable gases and vapors. U. S. Bur. Mines Rept. Invest. 3753 (1944).
J. W. Linnett, E. J. Raynor, and W. E. Frost, The mechanism of spark ignition. Trans. Faraday Soc. **41,** 487 (1945); **44,** 416 and 421 (1948).
M. V. Blanc, P. G. Guest, G. von Elbe, and B. Lewis, Ignition of explosive gas mixtures by electric sparks. I. Minimum ignition energies and quenching distances of mixtures of methane, oxygen and inert gases. J. Chem. Phys. **15,** 798 (1947).

A. R. Boyle and F. J. Llewellyn, The electrostatic ignitability of various solvent vapor-air mixtures. J. Soc. Chem. Ind. (London) **66,** 99 (1947).
A. E. Hoerl, Jr., Ignition of gases and vapors by sparks. Gas **23,** 60 (1947).
B. Lewis and G. von Elbe, Ignition of explosive gas mixtures by electric sparks. II. Theory of the propagation of flame from an instantaneous point source of ignition. J. Chem. Phys. **15,** 803 (1947).
H. Mache, Increasing ignition power of electric sparks by locally changing the gas mixture. Österr. Ing.-Arch. **1,** 273 (1947).
C. Cipriani and L. H. Middleton, A modern approach to ignition. S. A. E. Journal **56,** 47 (Oct. 1948).
B. Lewis and G. von Elbe, Ignition and flame stabilization in gases. Trans. Am. Soc. Mech. Engrs. **70,** 307 (1948).
C. C. Swett, Jr., Investigation of spark gaps subjected to altitude and air-velocity conditions. NACA Research Mem. E8I17 (Nov. 1948).
G. Allsop and E. M. Guenault, The incendivity of electric sparks in relation to the characteristics of the circuit. Third symposium on combustion, flame and explosion phenomena, p. 341, Williams and Wilkins, Baltimore (1949).
M. V. Blanc, P. G. Guest, G. von Elbe, and B. Lewis, Ignition of explosive gas mixtures by electric sparks. III. Minimum ignition energies and quenching distances of mixtures of hydrocarbons and ether with oxygen and inert gases. Third symposium on combustion, flame and explosion phenomena, p. 363, Williams and Wilkins, Baltimore (1949).
R. Friedman and E. Burke, Spark ignition of gas mixtures. J. Chem. Phys. **17,** 667 (1949).
J. W. Linnett and D. M. Nutbourne, The spark ignition of nitrous-oxide hydrogen mixtures. Third symposium on combustion, flame and explosion phenomena, p. 336, Williams and Wilkins, Baltimore (1949).
H. Morris, Ignition of gas mixtures by electric sparks. Third symposium on combustion, flame and explosion phenomena, p. 361, Williams and Wilkins, Baltimore (1949).
C. C. Swett, Jr., Effect of gas stream parameters on the energy and power dissipated in a spark and on ignition. Third symposium on combustion, flame and explosion phenomena, p. 353, Williams and Wilkins, Baltimore (1949).
C. C. Swett, Jr., and R. H. Donlon, Spark ignition in flowing gases. NACA Research Mem. E9E17 (Aug. 1949); E51J12 (Dec. 1951); E52J28 (Jan. 1953); E54F29a (June 1954); E55I16 (Nov. 1955).
G. von Elbe and B. Lewis, Theory of ignition, quenching and stabilization of flames of non-turbulent gas mixtures. Third symposium on combustion, flame and explosion phenomena, p. 68, Williams and Wilkins, Baltimore (1949).
G. von Elbe and B. Lewis, Theory of inflammation, extinction and stabilization of flames. Rev. inst. franç. pétrole **4,** 374 (1949).
Y. B. Zel'dovich and N. N. Simonov, Theory of the spark ignition of explosive gas mixtures. Zhur. Fiz. Khim. **23,** 1361 (1949).
K. Bechert, The theory of ignition limits and the ignition of combustible gas mixtures. Ann. Phys. **7,** 113 (1950); Chem. Zentr. **1950, II,** 1669.
W. Jost and L. Sieg, Ignition of explosive gas mixtures by sparks. Z. physik. Chem. **196,** 298 (1950); Z. Elektrochem. **55,** 13 and 17 (1951).
H. Lötsch, Ignition of flowing propane-air mixture by an electric spark. Monatsh. **82,** 714 (1951).
W. Roth, P. G. Guest, G. von Elbe, and B. Lewis, Heat generation by electric sparks, and rate of heat loss to the spark electrodes. J. Chem. Phys. **19,** 1530 (1951).
H. F. Calcote, C. A. Gregory, C. M. Barnett, and R. B. Gilmer, Spark ignition; effect of molecular structure. Ind. Eng. Chem. **44,** 2656 (1952).
A. J. Metzler, Minimum ignition energies of six pure hydrocarbon fuels of the $C_2$ and $C_6$ series. NACA Research Mem. E52F27 (Aug. 1952).
H. L. Olsen, R. H. Edmonson, and E. L. Gayhart, Microchronometric schlieren study of gaseous expansion from an electric spark. J. Appl. Phys. **23,** 1157 (1952).
M. W. Sims and A. M. Krakower, Simple calorimeter for measurement of spark energy. Automotive Inds. **107,** 65 (Oct. 1, 1952).
J. S. Arnold and R. K. Sherburne, Observations of the ignition and incipient flame growth in hydrocarbon-air mixtures. Fourth symposium on combustion, p. 139, Williams and Wilkins, Baltimore (1953).
S. Kumagai, T. Sakai, and I. Kimura, Effect of ultrasonic waves on flame propagation and spark ignition. Fourth symposium on combustion, p. 148, Williams and Wilkins, Baltimore (1953).
P. Lafitte and R. Delbourgo, Ignition by condenser sparks. Regions of flammability of ethane, propane, *n*-butane and *n*-pentane. Fourth symposium on combustion, p. 114, Williams and Wilkins, Baltimore (1953).

395575—56——2

A. J. Metzler, Minimum spark-ignition energies of 12 pure fuels at atmospheric and reduced pressure. NACA Research Mem. E53H31 (Oct. 1953).
H. L. Olsen, E. L. Gayhart, and R. B. Edmonson, Propagation of incipient spark-ignited flames in hydrogen-air and propane-air mixtures. Fourth symposium on combustion, p. 144, Williams and Wilkins, Baltimore (1953).
J. K. Richmond and A. L. Furno, Production and measurement of surge ignition sparks. Rev. Sci. Inst. **24,** 1107 (1953).
G. von Elbe, The problem of ignition. Fourth symposium on combustion, p. 13, Williams and Wilkins, Baltimore (1953).
P. Lloyd and B. P. Mullins, The problem of combustion at high altitude. AGARD Selected combustion problems, p. 405, Butterworth Scientific Publications, London (1954).
F. E. Marble and T. C. Anderson, Jr., Ignition and combustion in a laminar mixing zone. AGARD Selected Combustion Problems, p. 111, Butterworth Scientific Publications, London (1954).
B. P. Mullins, Combustion in vitiated air. AGARD Selected Combustion Problems, p. 447, Butterworth Scientific Publications, London (1954).

### [b. Ignition by Hot Surfaces

H. Couriot and J. Meunier, Research on the explosion of firedamp by electric current. Compt. rend. **126,** 750 (1898).
W. A. Bone and R. V. Wheeler, The combination of hydrogen and oxygen in contact with hot surfaces. Phil. Trans. **A206,** 1 (1906).
H. Couriot and J. Meunier, Action of an incandescent electric conductor on the surrounding gas. Compt. rend. **145,** 1161 (1907).
W. M. Thornton, The ignition of gases by hot wires. Phil. Mag. (6) **38,** 613 (1919).
A. S. White and T. W. Price, The ignition of ether-alcohol-air and acetone-air mixtures in contact with heated surfaces. J. Chem. Soc. **115,** 1462 (1919).
W. Mason and R. V. Wheeler, The ignition of gases. II. Ignition by a heated surface. Mixtures of methane and air. J. Chem. Soc. **121,** 2079 (1922).
W. Mason and R. V. Wheeler, The ignition of gases. IV. Ignition by a heated surface. Mixtures of the paraffins with air. J. Chem. Soc. **125,** 1869 (1924).
H. F. Coward and P. G. Guest, Ignition of natural gas-air mixtures by heated metal bars. J. Am. Chem. Soc. **49,** 2479 (1927).
W. C. F. Shepherd and R. V. Wheeler, The ignition of gases by hot wires. Gt. Brit. Safety in Mines Research Board Paper 36 (1927).
P. G. Guest, Ignition of natural gas-air mixtures by heated surfaces. U. S. Bur. Mines Tech. Paper 475 (1930).
C. A. Naylor and R. V. Wheeler, The ignition of gases. VII. Ignition by a heated surface. Mixtures of methane with oxygen, nitrogen, argon or helium. J. Chem. Soc. **1931,** 2456.
G. Allsop and T. S. E. Thomas, The ignition of firedamp by the filaments of broken electric lamp bulbs. Gt. Brit. Safety in Mines Research Board Paper 80 (1933).
J. D. Morgan, An experiment on the combustion of an inflammable gas mixture by a hot wire. Phil. Mag. 15 Supp., 440 (1933).
C. A. Naylor and R. V. Wheeler, The ignition of gases. VIII. Ignition by a heated surface. Ethane, propane, butane; ethylene, propylene, butylene, with air. J. Chem. Soc. **1933,** 1240.
C. A. Naylor and R. V. Wheeler, The ignition of gases. IX. Ignition by a heated surface. Mixtures of methane and air at reduced pressure. J. Chem. Soc. **1935,** 1426.
M. Serruys, Experimental study of ignition by hot spot in internal combustion engines. Publs. sci. et tech. ministère air (France) 115 (1937); NACA Tech. Mem. 873 (1938).
R. S. Silver, The ignition of gaseous mixtures by hot particles. Phil. Mag. (7) **23,** 633 (1937).
S. Paterson, The ignition of inflammable gases by hot moving particles. Phil. Mag. (7) **28,** 1 (1939); **30,** 437 (1940).
R. C. Spencer, Preignition characteristics of several fuels under simulated engine conditions. NACA Rept. 710 (1941).
H. E. Alquist and D. W. Male, Trends in surface-ignition temperatures. NACA Wartime Rept. E–94 (1944).
A. Hundere and J. A. Bert, Preignition and its deleterious effects in aircraft engines. S. A. E. Quart. Trans. **2,** 546 (1948).

J. W. Mullen II, J. B. Fenn, and M. R. Irby, The ignition of high velocity gas streams of combustible gases by heated cylindrical rods. Third symposium on combustion, flame and explosion phenomena, p. 317, Williams and Wilkins, Baltimore (1949).
H. P. Stout and E. Jones, The ignition of gaseous explosive media by hot wires. Third symposium on combustion, flame and explosion phenomena, p. 329, Williams and Wilkins, Baltimore (1949).
A. Hundere, No harmful preignition from lead deposits. Automotive Inds. **103,** 50 (Sept. 1, 1950).
L. L. Withrow and F. W. Bowditch, Flame photographs of auto-ignition induced by combustion chamber deposits. S. A. E. Quart. Trans. **6,** 724 (1952).
E. Jones, Heat transfer in hot wire ignition. Fourth symposium on combustion, p. 151, Williams and Wilkins, Baltimore (1953).
J. R. Sabina, J. J. Mikita, and M. H. Campbell, Preignition in automotive engines. Proc. Am. Petroleum Inst. **33,** Part III, 137 (1953).
R. F. Winch and F. M. Mayes, A method for identifying preignition. S. A. E. Trans. **61,** 453 (1953).
C. L. Fleming, Jr., et al., The control of combustion chamber deposits. Natl. Petroleum Assoc. M.P., Cleveland (April 1954).
R. C. Bowers and A. R. Isitt, Observation of automotive preignition and knock. S. A. E. M. P., Atlantic City (June 1954). Abstract: S. A. E. Journal **63,** 178 (Feb. 1955).
S. D. Heron, Uncontrolled combustion in spark-ignition engines. S. A. E. Trans. **62,** 24 (1954).
D. A. Hirschler, J. D. McCullough, and C. A. Hall, Deposit-induced ignition-evaluation in a laboratory engine. S. A. E. Trans. **62,** 40 (1954).
J. R. Landis, Detection of abnormal flame-fronts in road tests with an engine using independent ionization gaps. S. A. E. M. P., Atlantic City (June 1954).
A. O. Malby, D. R. Diggs, and B. M. Sturgis, An investigation of preignition in engines. S. A. E. Trans. **62,** 32 (1954).
L. B. Shore and J. F. Kunc, Jr., The effect of simulated surface ignition on engine performance. S. A. E. M. P., Atlantic City (June 1954). Abstract: S. A. E. Journal **62,** 58 (Dec. 1954).
H. W. Sigworth and R. K. Stone, Controlling preignition by deposit removal. S. A. E. M. P., Atlantic City (June 1954). Abstract: S. A. E. Journal **62,** 85 (Dec. 1954).
R. K. Williams and J. R. Landis, Some effects of fuels and lubricants on auto-ignition in cars on the road. S. A. E. Trans. **62,** 57 (1954).
R. F. Winch, Occurrence of preignition in present-day cars in normal service. S. A. E. Trans. **62,** 50 (1954).
Combustion terms defined by CRC. S. A. E. Journal **62,** 46 (Oct. 1954).
Researchers marshal combustion study weapons to arrest power-robbing pre-ignition. S. A. E. Journal **62,** 17 (Oct. 1954).
C. A. Hall, J. A. Warren, and J. D. McCullough, Practical yardsticks for deposit effects. S. A. E. Trans. **63,** 53 (1955). Abstract: S. A. E. Journal **63,** 98 (Jan. 1955).
R. Meagher, R. L. Johnson, and K. G. Parthemore, Correlation of engine noises with combustion phenomena. S. A. E. Trans. **63,** 481 (1955). Abstract: S. A. E. Journal **63,** 29 (March 1955).

## 2.3. Spark-Ignition Systems and Components

### a. Exclusive of Spark Plugs

H. Armagnat, Magneto for electric ignition. Rev. élec. **23,** 321 (1915).
J. F. Henderson, Magneto ignition. Automobile Engr. **5,** 51 (1915).
A. Campbell and D. W. Dye, Summary of researches on magnetos at the National Physical Laboratory. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 1 (1916).
E. A. Griffiths, Tests on high-tension magnetos. Gt. Brit. Advisory Comm. Aeronaut., Repts. and Mem. 275 (1916).
G. E. Bairsto, A method of intensifying the spark of a defective spark plug by the use of an additional spark gap in series with the plug. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 17 (1917).
G. E. Bairsto, Magneto faults. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 18 (1917).
G. E. Bairsto, On the synchronism of the spark of a magneto as affected by the method of coupling. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 21 (1917).

C. C. Paterson and N. R. Campbell, An investigation of certain spark gaps for magnetos for the Air Board. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 14 (1917).
E. A. Watson, The magneto: its functions, design and construction. Automobile Engr. **7,** 137 (1917).
J. A. Williams, Magneto vs battery ignition. S. A. E. Journal **1,** 375 (1917).
A. P. Young, The high-tension magneto. Automobile Engr. **7,** 191 (1917).
A. P. Young, Safety spark gap in magnetos for super-compression engines at high altitudes. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 7 (1917).
G. E. Bairsto, On the rate of rise of secondary potential of an ignition system. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 31 (1918).
G. E. Bairsto, On the effect of shunted resistance or plug leakage on the sparking performance of an ignition system. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 34 (1918).
G. E. Bairsto, Notes on the relation between the output of a magneto and its size and weight. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 42 (1918).
N. R. Campbell, The theory of the magneto. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 40 (1918).
N. R. Campbell, The potential waveform of a magneto. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 47 (1918).
N. R. Campbell, Notes on the "break" of a magneto. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 49 (1918).
C. C. Paterson and N. R. Campbell, Notes on the sparking of two gaps in series. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 28 (1918).
H. R. Van Deventer, Ignition magneto construction. S. A. E. Journal **3,** 257 (1918).
J. G. Zimmerman, Magneto ignition for farm tractors. S. A. E. Journal **2,** 419 (1918).
G. E. Bairsto, On the relation between the number of secondary turns on a magneto armature and the secondary voltage with shunted resistance. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 52 (1919).
W. S. Gorton, The subsidiary gap as a means for improving ignition. NACA Rept. 57 (1919).
P. M. Heldt, Tests of ignition apparatus. Automotive Inds. **40,** 578 (1919).
N. W. McLachlan, On the effective inductance, effective resistance and self-capacity of magneto windings. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 45 (1919).
C. C. Paterson and N. R. Campbell, The effect of capacity and shunt resistance on the peak voltage of a magneto. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Repts. 29 and 30 (1919).
F. B. Silsbee, Characteristics of high-tension magnetos. NACA Rept. 58 (1919).
F. B. Silsbee, Ignition work at the Bureau of Standards. Automotive Inds. **40,** 1294 (1919).
G. E. Bairsto, The relationship between the number of secondary turns on a magneto armature and the secondary voltage with shunt resistance. Measurements on a rotary armature magneto. Gt. Brit. Aeronaut. Research Comm. Repts. and Mem. 724 (1920).
A. D. T. Libby, Advantages of magneto ignition. S. A. E. Journal **7,** 277 (1920).
A. P. Young, Magneto testing and the choice of spark gap. Engineering **110** 729 (1920).
F. B. Silsbee, Simplified theory of the magneto. NACA Rept. 123 (1921).
E. A. Watson, Magnetos for ignition purposes in internal-combustion engines. J. Inst. Elec. Engrs. **59,** 445 (1921).
F. B. Silsbee, Mathematical theory of induced voltage in the high-tension magneto. BS Sci. Pap. **17,** 424, 407 (1922).
R. B. Brode, D. W. Randolph, and F. B. Silsbee, Electrical characteristics of spark generators for automotive ignition. NACA Rept. 241 (1926).
F. L. Haushalter, Corona tests of ignition cable. S. A. E. Journal **19,** 361 (1926).
F. B. Silsbee and D. W. Randolph, Linkage-current diagram for representing magneto operation. BS Sci. Pap. **21,** 647 (1926–27) S543.
F. G. Shoemaker, Recent developments in aircraft ignition systems. S. A. E. Journal **21,** 28 (1927).
A. P. Young and L. Griffith, The high-tension magneto. Automobile Engr. **17,** 188 (1927).

F. W. Lanchester, Coil ignition. Proc. Inst. Automobile Engrs. (London) **23,** 214 (1928).
E. A. Watson, Effect of hydrocarbon vapors on contact points of ignition apparatus. Automobile Engr. **18,** 347 (1928).
J. T. Fitzsimmons, Ignition requirements for high-compression engines. S. A. E. Journal **24,** 306 (1929).
E. A. Robertson and L. M. Hull, Suppressing ignition interference on radio equipment of aircraft. S. A. E. Journal **27,** 78 (1930).
T. H. Darnell, The automotive ignition coil. NACA Rept. 374 (1931).
E. A. Watson, Coil ignition systems. J. Inst. Elec. Engrs. (London) **70,** 105 (1932).
G. I. Finch and R. W. Sutton, Control of ignition coil discharge characteristics. Proc. Phys. Soc. (London) **45,** 288 (1933).
Coil ignition at 10,000 rpm. Automobile Elec. **10,** 6 (1934).
Coil ignition testing. Automobile Elec. **10,** 38 (1934).
Temperature increase of ignition coils. Automobile Elec. **10,** 68 (1934).
M. F. Peters, G. F. Blackburn, and P. T. Hannen, Electrical character of the spark discharge of automotive ignition systems. J. Research NBS **19,** 401 (1937).
J. Cook, The ignition coil. Automobile Elec. **14,** 82 (1938).
R. M. Critchfield, Effect of application on maintenance of automotive electrical equipment. S. A. E. Journal **43,** 403 (1938).
C. C. Keane, Ignition systems for internal combustion engines. Petroleum Engr. **9,** 41 (Mar. 1938).
Effect of the design and installation of high tension ignition cables on ignition system performance. Ethyl Gasoline Laboratories, Eng. Labs. Rept. 100 (1938).
P. E. Turchiebash, Working of the magneto and spark plugs during high altitude flights (in Russian). Aeronaut. Engr. (Moscow) **1939,** 39.
G. E. Bairsto, Some factors controlling the development of electrical ignition of aero engines. J. Roy. Aeronaut. Soc. **44,** 119 (1940).
N. Hendry, Radio interference. Automobile Engr. **30,** 167 (1940).
J. C. Chaston, Materials for electrical contacts. J. Inst. Elec. Engrs. (London) **88,** 276 (1941).
C. P. Kidder, Synthetics. Automobile Engr. **31,** 455 (1941).
C. E. Swanson, Supercharged aircraft ignition harnesses. S. A. E. Trans. **48,** 107 (1941).
J. T. Fitzsimmons, The ignition system as influenced by fuel characteristics. S. A. E. Trans. **50,** 15 (1942).
D. W. Randolph, Ignition shielding. Automotive Inds. **86,** 24 (Apr. 1, 1942); S. A. E. Trans. **50,** 538 (1942).
A. V. Alvino, Battery booster coils for airplane engine ignition systems. Trans. Am. Inst. Elec. Engrs. **63,** 672 (1944).
J. R. Harkness, Design of an ignition system for an 18-cylinder aircraft engine. Trans. Am. Inst. Elec. Engrs. **63,** 1321 (1944).
M. F. Peters, J. J. Philips, M. Kronstein, and H. B. Jealous, Cable used for transmitting electric energy in airplanes. Trans. Am. Inst. Elec. Engrs. **63,** 1271 (1944).
A. W. Robinson, Jr., Analysis of high-frequency ignition circuits. Elec. Eng. **63,** 916 (1944).
H. L. Hartzell, Effect of post-war automotive practices on ignition performance. S. A. E. Trans. **53,** 427 (1945).
N. Rohats, Testing magneto coils. Gen. Elec. Rev. **48,** 49 (1945).
D. M. Ross, Low-tension high-frequency ignition systems. Tech. Data Digest **11,** 53 (1945).
C. C. Swett, Jr., and F. A. Rodgers, Effect of high-resistance ignition cable on the erosion of spark-plug electrodes. NACA Mem. Rept. E5I21 (Sept. 1945).
Ignition testing unit. Flight **48,** 47 (1945).
W. E. Berkey, Electrical measurements on aircraft engine ignition circuits. Elec. Eng. **65,** 49 (1946).
Ignition problems. Automobile Engr. **36,** 413 (1946).
H. L. Hartzell, Coming car engine ignition. S. A. E. Journal **55,** 69 (July 1947).
J. E. Lindbergh, Jr., and C. Sackett, Engine trouble shooting in the air. S. A. E. Quart. Trans. **1,** 630 (1947).
A. J. Poole, Electronic ignition. Automotive Inds. **96,** 37 (Feb. 1, 1947).
J. K. Rudd, Low tension whips plane ignition woes. S. A. E. Journal **55,** 79 (Feb. 1947).
A. C. Wall, Low tension system cures ignition ills. S. A. E. Journal **55,** 73 (Jan. 1947).

H. C. Welch and J. V. McNulty, An ignition analyzer for internal-combustion engines. S. A. E. Quart. Trans. **1,** 662 (1947).
M. M. Comber, Recent advances in aircraft ignition systems. Aircraft Eng. **20,** 282 (1948).
P. J. Kent, The automotive industry's participation in reduction of radio and television interference. S. A. E. Journal **57,** 17 (Mar. 1949).
C. J. Watters, The case for high frequency ignition systems. Aviation Week **50,** 20 (Apr. 25, 1949).
W. M. Bauer and L. G. Sands, Aircraft ignition tester. Electronics **23,** 87 (Oct. 1950).
C. W. Rainey, Ford's new ignition system. S. A. E. Journal **58,** 28 (Apr. 1950).
G. L. Christian, Engine analyzers gain wider acceptance. Aviation Week **54,** 34 (Apr. 2, 1951).
C. C. Eaglesfield, Car ignition radiation. Wireless Engr. **28,** 17 (Jan. 1951).
H. L. Hartzell, Ignition systems for future high-compression engines. S. A. E. Journal **59,** 45 (Nov. 1951).
H. L. Hartzell and B. H. Short, Ignition problems in damp weather. S. A. E. Quart. Trans. **5,** 207 (1951).
M. Marchisio, Effect of temperature on the ignition vibrators of turbojet engines. Aerotechnica **31,** 84 (1951).
D. C. Peroutky, High frequency ignition needs no breaker points. Automotive Inds. **104,** 34 (Jan. 1, 1951).
M. F. Peters and L. H. Middleton, Optimum rate of voltage rise for minimum energy loss in ignition systems. S. A. E. Quart. Trans. **5,** 309 (1951).
W. Beye Smits and P. F. H. Maclane Pont, The Smitsvonk low-tension capacity ignition system. S. A. E. Journal **59,** 61 (Apr. 1951).
M. A. Zipkin, H. E. Sheets, and C. N. Scott, High energy multiple spark ignition systems for jet engines. S. A. E. Journal **59,** 70 (Apr. 1951).
Distributed resistance ignition cable. Electronics **24,** 204 (Jan. 1, 1951).
T. M. New, Analyzing ignition problems of piston and jet engines. Automotive Inds. **107,** 46 (Sept. 1, 1952).
Bibliography and abstracts on electrical contacts, 1835–1951. Am. Soc. Testing Materials Special Technical Publication 56–G (1952).
High energy spark ignition units for gas turbines. Gas Oil Power **47,** 314 (1952).
C. Moret, New ignition methods: electrostatic ignition. J. soc. ing. automobile **26,** 284 (1953).
E. Frederick, Electric ignition for high-compression engines. Diesel Power **32,** 28 (June 1954).
E. A. Martin and J. H. Goffe, A new engine analyzer. S. A. E. M. P., Atlantic City (June 1954); Abstract: S. A. E. Journal **62,** 24 (Nov. 1954).
S. M. Terry, 12 volts presents its case. S. A. E. Journal **62,** 29 (Feb. 1954).
New magneto uses battery current for starting. Automotive Inds. **111,** 52 (Oct. 1, 1954).
R. W. Boland, A fresh approach to ignition analysis. S. A. E. M. P., St. Louis (Nov. 1955).

### b. Spark Plugs

J. O. Fisher, Spark plugs. J. Am. Soc. Naval Engrs. **28,** 828 (1916).
R. H. Cunningham, Resistance of hot spark plug insulators. Automotive Inds. **39,** 907 (1918).
J. D. Morgan, The effect of temperature on the resistance of spark plug insulations. Engineering **106,** 513 (1918).
C. C. Paterson and N. R. Campbell, The sparking potential of spark plugs. Gt. Brit. Advisory Comm. Aeronaut., Internal Combustion Engine Sub-Comm. Rept. 48 (1918).
A. V. Bleininger and F. H. Riddle, Special spark plug porcelains. J. Am. Ceram. Soc. **2,** 564 (1919).
C. S. Cragoe, Temperatures in spark plugs having steel and brass shells. NACA Rept. 52 (1919).
L. B. Loeb and F. B. Silsbee, Effect of temperature and pressure on the sparking voltage. NACA Rept. 54 (1919).
A. M. Low, Spark plug efficiency. Autocar **42,** 655 (1919).
F. B. Silsbee, L. B. Loeb, L. G. Sawyer, E. L. Fonseca, H. C. Dickinson, and P. G. Agnew, Spark plug defects and tests. NACA Rept. 51 (1919).
F. B. Silsbee, R. K. Honaman, E. L. Fonseca, A. V. Bleininger, and H. F. Staley, Properties and preparation of ceramic insulators for spark plugs. NACA Rept. 53 (1919).

H. Warren, The operation and design of sparking plugs. Automobile Engr. **9,** 59 and 94 (1919).
H. S. Rawdon and A. I. Krynitsky, A study of the deterioriation of nickel spark-plug electrodes in service. Tech. Pap. BS **13,** (1920) T143.
S. W. Sparrow, Preignition and spark plugs. S. A. E. Journal **6,** 129 (1920).
H. F. Staley, Cements for spark-plug electrodes. Tech. Pap. BS **13,** (1920) T155.
Manufacture of spark plugs. Clay-Worker **74,** 324 (1920).
Sparking plugs. Automobile Engr. **13,** 10 (1922).
W. Buckseth, Shock tester for porcelain insulators. Elektrotech. Z. **44,** 943 (1923).
F. B. Silsbee, The effect of electrode temperature on the sparking voltage of short spark gaps. NACA Rept. 179 (1923).
A. G. Wikoff, Manufacture of spark plug porcelain. Chem. Met. Eng. **28,** 150 (1923).
N. L. Bowen and J. W. Greig, The system $Al_2O_3$·$SiO_2$; a study of the equilibrium relations of pure alumina at high temperatures. J. Am. Ceram. Soc. **7,** 238 (1924).
N. L. Bowen, J. W. Greig, and E. G. Zies, Mullite, a silicate of alumina. J. Wash. Acad. Sci. **14,** 183 (1924).
A. C. Burgoine, Sparking plugs. Automobile Engr. **14,** 301 (1924).
F. B. Silsbee, The sparking voltage of spark plugs. NACA Rept. 202 (1924); Automotive Inds. **52,** 539 (1925).
R. Twells, Jr., Preparing and spraying a glaze slip with especial reference to the control of the various operations. J. Am. Chem. Soc. **7,** 465 (1924).
M. Wataza, Spark plugs. Repts. Osaka Ind. Research Inst. (Japan) **5,** 1 (1924).
J. W. Greig, Formation of mullite from cyanite, andalusite and sillimanite. J. Am. Ceram. Soc. **8,** 465 (1925).
J. T. Norton, An X-ray study of natural and artificial sillimanite. J. Am. Ceram. Soc. **8,** 401 (1925).
A. B. Peck, Changes in andalusite, cyanite and sillimanite at high temperatures. J. Am. Ceram. Soc. **8,** 467 (1925).
A. S. Watts, Spark plug insulation. Ind. Eng. Chem. **19,** 1123 (1927).
H. Rabezzana, Spark plug problems. Automotive Inds. **59,** 900 (1928); Aviation **26,** 798 (1929).
E. A. Watson, The electrical characteristics of spark gaps and sparking plugs. Automobile Engr. **18,** 140 (1928).
H. Rabezzana, Spark plug examination. Aero Dig. **15,** 152 (Nov. 1929).
H. Rabezzana and D. W. Randolph, Sparking plugs. Automobile Engr. **20,** 224 (1930); Automotive Inds. **62,** 83 (1930).
O. S. Duffendack, R. A. Wolfe, and D. W. Randolph, The development of an electron emitting alloy. Trans. Electrochem. Soc. **59,** 181 (1931).
Production of sparking plugs. Machinery (London) **38,** 339, 365, and **39,** 1 (1931).
V. Gavino, Profitable methods and equipment for salvaging and reconditioning used spark plugs. Riv. Aeronaut. **8,** 61 (1932).
R. M. Hall, Selection, care and maintenance of porcelain spark plugs. Aviation Engr. **6,** 35 (1932).
E. Seiler, Spark plug insulators for high compression and high-speed engines. Brennstoff- u. Wäermewirt. **14,** 21 and 43 (1932).
E. Seiler, Effect of design and composition of spark plug electrodes on ignition process in spark ignition engines. Brennstoff- u. Wäermewirt. **14,** 100 and 113 (1932).
C. F. Greene, Rapid firing of spark plug porcelain. Ceram. Ind. **23,** 72 (1934).
Testing spark plugs. Automobile Elec. **10,** 276 (1934).
E. A. Keeler, Procedure for rating spark plugs for resistance to fouling. Automotive Inds. **72,** 604 (1935).
H. Naviatiel, Spark plugs and their improvement. Brennstoff- u. Wäermewirt. **17,** 21 (1935).
H. Rabezzana, Spark plug fouling analysis. Automotive Inds. **73,** 754 (1935).
W. R. Debenham and F. G. Haydon, On the erosion of sparking plug electrodes and the variation of sparking plug voltage. British Air Ministry, Aeronaut. Research Comm. Repts. and Mem. 1744 (1936).
E. A. Keeler, Simulated leakage gages ability of spark plugs. Automotive Inds. **75,** 182 (1936).
Electron device used in spark plug industry. Electronics **9,** 44 (1936).
Sparking plugs with platinum points. Engineer **161,** 211 (1936).
A. G. Arend, Sparking plugs and their manufacture. Electrician **118,** 63 (1937).
F. R. Banks, Sparking plugs. J. Inst. Petroleum Technol. **23,** 84 (1937); S. A. E. Journal **45,** 397 (1939).

G. D. Boerlage and A. C. Cattaneo, Thermocouple spark plug. Automotive Inds. **76,** 114 (1937); Automobile Engr. **27,** 64 (1937).
S. Okazaki, Y. Hanawa, and B. Ichijo, Relation between gap length and missing pressure of spark plugs. Bul. Inst. Phys. Chem. Research (Tokyo) **16,** 519 (1937).
M. F. Peters, H. K. King, and J. P. Boston, Government investigates mica spark plugs. Automotive Inds. **76,** 777 (1937).
H. Rabezzana and H. Kalmar, Benefits from longer gaps in spark plugs. Automotive Inds. **76,** 222; Automobile Engr. **27,** 260 (1937).
A. L. Beall and L. M. Townsend, Hi-duty spark plug testing. S. A. E. Journal **43,** 465 (1938).
F. R. Ramsey, Sparking plugs in aero engines. Flight **33,** 557 (1938).
Spark plug endurance tests. Automotive Inds. **78,** 87 (1938).
Bibliography of spark plugs. Works Progress Administration Bibliography of Aeronautics, Part 35, Engine Parts and Accessories (1939).
A. H. Allen, Polonium spark plugs. Steel **106,** 37 (Mar. 18, 1940); Discussion **106,** 4 (Apr. 22, 1940).
G. E. Bairsto, Some factors controlling the development of electrical ignition of aero engines. J. Roy. Aeronaut. Soc. **44,** 119 (1940).
V. Cronstedt, Shortcomings of mica insulation for aviation spark plugs. S. A. E. Journal **46,** 233 (1940).
J. H. Dillon, Polonium alloys for spark plug electrodes. J. Appl. Phys. **11,** 291 (1940).
F. H. Riddle, Ceramic insulators for spark plugs. S. A. E. Journal **46,** 236 (1940).
H. C. Chandler, Ceramic insulators for aviation spark plugs. NACA OCR Rept. 3 (1941).
Method of determining rate of spark plug gas leakage during actual engine operation. Ethyl Corp. Rept. A. R. 67 (1943).
Effect of spark plug design details on electrode erosion. Ethyl Corp. Rept. A. R. 76 (1943).
Effect of low and high values of capacitance on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 100 (1943).
Effect of internal resistors on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 101 (1943).
Effect of ignition source on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 102 (1943).
Effect of spark polarity on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 103 (1943).
Method of measuring the resistance of spark plugs while the plugs are firing in an engine. Ethyl Corp. Rept. A. R. 104 (1944).
Effect of electrode geometry on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 105 (1944).
Effect of nose well ventilation on spark plug electrode erosion. Ethyl Corp. Rept. A. R. 106 (1944).
J. L. Sloop, G. R. Kinney, and W. H. Rowe, Process of lead-deposit accumulations on aircraft engine spark plugs. NACA Wartime Rept. E 181 (1945).
Effect of different center electrode materials on sparking voltage during actual engine operation. Ethyl Corp. Rept. A. R. 139 (1945).
Effect of spark polarity on sparking voltage during actual engine operation. Ethyl Corp. Rept. A. R. 140 (1945).
Effect of heat range on electrode erosion of spark plugs having identical electrode design. Ethyl Corp. Rept. A. R. 144 (1945).
Test procedure for determining oil fouling characteristics of aircraft spark plugs in the SC 17.6 engine. Ethyl Corp. Repts. A. R. 145 and A. R. 146 (1945).
Effect of varying load conditions on the sparking voltage requirements of current production ceramic spark plugs. Ethyl Corp. Rept. A. R. 148 (1945).
Spark plugs. War Department Tech. Bul. TB ORD 313 (1945).
Sparking plugs. Automobile Engr. **35,** 208 (1945).
Technical reports on spark plug electrode materials. Battelle Memorial Institute (1945).
W. A. Bychinsky, Factors affecting the functioning of spark plugs. S. A. E. Quart. Trans. **2,** 254 (1948).
W. Eitel, Ceramic spark plug insulators rich in alumina. Ceram. Ind. **50,** 66 (1948).
P. G. Pigneguy and J. G. Dawson, Spark plug fouling and mixture distribution. Shell Aviation News **117,** 14 (1948).
Airline tests gage spark plug erosion. S. A. E. Journal **56,** 70 (Apr. 1948).

Effect of tetraethyl lead content on preignition ratings of aviation spark plugs with platinum alloy electrodes. Ethyl Corp. Rept. A. R. 193 (1948).
Federal specification for spark plugs, W-P-506a (1948).
Spark plug manufacture. Elec. Rev. (London) **142,** 721 (1948).
H. B. Barlett and K. Schwartzwalder, Trends in the chemical and mineralogical constitution of spark plug insulators. Bul. Am. Ceram. Soc. **28,** 462 (1949).
G. R. Furman and B. Corrigan, All-important spark plug. Aero Dig. **59,** 20 and 92 (Oct. 1949).
F. H. Riddle, Ceramic spark plug insulators. J. Am. Ceram. Soc. **32,** 333 (1949).
K. Schwartzwalder and C. F. Schaefer, Internal sealing of spark plug insulators. Bul. Am. Ceram. Soc. **28,** 455 (1949).
Cold tests with arctic oil at temperatures ranging to −40°F. Delco-Remy Division, General Motors Corp. Eng. Rept. 2918-B (Oct. 28, 1949).
Investigation of the effect of resistor-suppressors upon cold starting. Signal Corps. Eng. Labs. Tech. Mem. M-1189 (Mar. 24, 1949).
Spark plugs for internal combustion engines. Lubrication **35,** 61 (1949).
G. L. Christian, New trends at plug conference. Aviation Week **53,** 19 (Sept. 18, 1950).
C. Cipriani, Modern spark plugs permit wider gaps. S. A. E. Journal **58,** 65 (June 1950).
A. R. Griffin and J. G. Dawson, The effect of fuel factors on spark plug performance. Shell Aviation News **143,** 8 (May 1950).
Annular electrode spark plug. Aero Dig. **60,** 58 (May 1950).
Comparative cold starting characteristics of resistor and non-resistor type spark plugs. The Electric Auto-Lite Co., Eng. Rept. 3 (Jan. 19, 1950).
Spark plug competition keen. Aviation Week **53,** 33 (Oct. 2, 1950).
C. E. Swanson and J. W. Miller, How large can the gaps be? S. A. E. Quart. Trans. **5,** 283 (1951). Excerpts: S. A. E. Journal **59,** 32 (Feb. 1951).
New anti-fouling spark plug. Aviation Week **55,** 48 (Oct. 15, 1951).
R. C. Beaubier, H. J. Chalk, and M. M. Roensch, Spark Plug problems in automotive service. S. A. E. M. P., Detroit (Mar. 1952).
A. R. Griffin, Control of lead fouling in aero engines. Shell Aviation News **165,** 17 (Mar. 1952).
D. N. Harris, F. R. Watson, and T. Frame-Thompson, Pre-planned tests exemplified by flight research. Shell Aviation News **168,** 14 (June 1952).
H. N. Metzel, Spark plug fouling from a car manufacturer's viewpoint. S. A. E. M. P., Detroit (Mar. 1952).
H. H. Vogel, Operation of spark plugs in present-day engines. S. A. E. M. P., Detroit (Mar. 1952).
V. E. Yust and E. A. Droegemueller, Aviation spark plug fouling—its cause and control. S. A. E. Journal **60,** 65 (May) and 37 (June 1952); Shell Aviation News **164,** 14 (Feb. 1952).
Four ways to combat auto spark plug fouling. S. A. E. Journal **60,** 66 (July 1952).
Spark plug testing. Automobile Engr. **42,** 113 (1952).
R. J. Greenshields, Spark plug fouling studies. S. A. E. Trans. **61,** 3 (1953).
Experts study misfiring, fouling; Champion's aircraft spark plug and ignition conference. Aviation Week **59,** 58 (Oct. 26, 1953).
"De-glamorized" spark plug is big news at Champion conference. Am. Aviation **18,** 58 (Nov. 8, 1954).
High-altitude spark plug. Aero Dig. **68,** 48 (Apr. 1954).
Improved ceramic insulating material. Engineer **197,** 289 (1954); Engineering **177,** 253 (1954); Flight **65,** 207 (1954).
Spark plug fouling and preignition. Petroleum Processing **9,** 53 (1954).
1954 aircraft spark plug data chart. Am. Aviation **18,** insert (Nov. 8, 1954).
New developments highlight spark plug conference. Am. Aviation **19,** 34 (Nov. 7, 1955).
Preignition rating of spark plugs for ground vehicles. S. A. E. Recommended Practice. S. A. E. Handbook, p. 817 (1955).
Spark plugs. S. A. E. Standard. S. A. E. Handbook, p. 815 (1955).
Standard methods of testing electrical porcelain ASTM Designation D116-44. Am. Soc. Testing Materials, Standards, part 6, p. 778 (1955).
Temperature governs spark plug performance. S. A. E. Journal **63,** 107 (Dec. 1955).
Vital spark (KLG's plug for jet engines). Elec. J. **154,** 1856 (1955).

## 2.4. Miscellaneous


L. Bairstow, E. F. Relf, and E. A. Griffiths, Tests on magnetos immersed in an explosive mixture of petrol and air. Gt. Brit. Advisory Comm. for Aeronautics, Repts. and Mem. 186 (1914).

The prevention of fire in single-engined aeroplanes. Rept. of the Fire Prevention Sub-Committee, Gt. Brit. Aeronaut. Research Comm., Repts. and Mem. 795 (1922).

The possible causes of fire in an aeroplane crash and the means that can be taken to lessen the fire risk. Rept. of the Fire Prevention Sub-Committee, Gt. Brit. Aeronaut. Research Comm., Repts. and Mem. 796 (1922).

N. S. Walls, R. V. Wheeler, W. Rintoul, and A. G. White, The ignition of firedamp by momentary flames. Gt. Brit. Safety in Mines Research Board, Paper 24 (1926).

N. S. Walls and R. V. Wheeler, The ignition of gases. VI. Ignition by flames. Mixtures of the paraffins with air. J. Chem. Soc. **1927,** 291.

S. C. Blacktin, Spontaneous electrification in dust clouds, with special reference to coal dust clouds. Gt. Brit. Safety in Mines Research Board, Paper 43 (1928).

M. J. Burgess and R. V. Wheeler, The ignition of firedamp by the heat of impact of rocks. Gt. Brit. Safety in Mines Research Board, Paper 46 (1928).

M. J. Burgess and R. V. Wheeler, The ignition of firedamp by the heat of impact of metal against rock. Gt. Brit. Safety in Mines Research Board, Paper 54 (1929).

H. F. Coward and R. V. Wheeler, The ignition of firedamp. Gt. Brit. Safety in Mines Research Board, Paper 53 (1929).

M. J. Burgess and R. V. Wheeler, The ignition of firedamp by the heat of impact of hand picks against rock. Gt. Brit. Safety in Mines Research Board, Paper 62 (1930).

S. C. Blacktin and H. Robinson, Spontaneous electrification in coal-dust clouds. Gt. Brit. Safety in Mines Research Board, Paper 71 (1931).

M. J. Burgess and R. V. Wheeler, The ignition of firedamp by the heat of impact of coal cutter picks against rocks. Gt. Brit. Safety in Mines Research Board, Paper 70 (1931).

H. C. Grimshaw and W. Payman, The ignition of firedamp by coal-mining explosives. Part I. Gallery experiments. Gt. Brit. Safety in Mines Research Board, Paper 69 (1931).

W. A. Kirkby, Ionization in gaseous explosions. J. Chem. Soc. **1931,** 878.

M. J. Burgess and R. V. Wheeler, The prevention of ignition of firedamp by the heat of impact of coal-cutter picks against hard rocks. Gt. Brit. Safety in Mines Research Board, Paper 81 (1933).

P. G. Guest, Static electricity in nature and industry. U. S. Bur. Mines Bul. 368 (1933).

R. O. King and G. Mole, The explosions of mixtures of combustible gases with air by nuclear drops of water and other nuclei and by X-rays. J. Inst. Petroleum Technol. **20,** 791 (1934); **21,** 838 (1935).

B. A. Greene, The hazard of fire and explosion in anesthesia. Anesthesiology **2,** 138 (1941).

J. W. Horton, Present status of the problem of preventing anesthetic explosions. Anesthesiology **2,** 121 (1941).

G. W. Jones and G. J. Thomas, The prevention of cyclopropane-oxygen explosions by dilution with helium. Anesthesiology **2,** 138 (1941).

G. J. Thomas and G. W. Jones, Clinical experiences in the prevention of cyclopropane-oxygen explosions by the addition of helium. Current Researches Anesthesia & Analgesia **20,** 121 (1941).

F. B. Silsbee, Static electricity. NBS Circ. **438** (1942).

G. W. Jones, R. E. Kennedy, and G. J. Thomas, Explosion hazards of combustible anesthetics. U. S. Bur. Mines Tech. Paper 653 (1943).

Studies of explosives and explosions. U. S. Bur. Mines Rept. Invest. 4031 (1946).

R. O. King, The cause of detonation or combustion knock in engines. Can. J. Research [F] **26,** 228 (1948).

R. O. King, W. A. Wallace, and B. Mahapatra, The hydrogen engine and the nuclear theory of ignition. Can. J. Research [F] **26,** 264 (1948).

R. O. King, W. A. Wallace, and B. Mahapatra, The prevention of preignition and detonation in gas engines. Can. J. Research [F] **26,** 366 (1948).

E. Jones, The ignition of solid explosive media by hot wires. Proc. Roy. Soc. (London) [A] **198,** 523 (1949).

R. O. King and E. J. Durand, The cause of preignition (surface ignition)—undoped liquid fuel. Can. J. Research [F] **27,** 337 (1949).

R. O. King, E. J. Durand, and A. B. Allan, The concentration of finely divided carbon in town gas-air mixtures required to induce severe knocking combustion. Can. J. Research [F] **28,** 177 (1950).
W. E. Scull, Relation between inflammables and ignition sources in aircraft environments. NACA Tech. Note 2227 (Dec. 1950).
R. O. King, E. J. Durand, and A. B. Allan, The nuclear ignition of *n*-pentane in the CFR engine and the effect on performance. Can. J. Technol. **29,** 52 (1951).
R. O. King, E. J. Durand, A. B. Allan, and E. J. T. Hansen, Optimum timing of compression or spark ignition as determined by compression ratio; acetaldehyde and diethyl ether as engine fuels. Can. J. Technol. **30,** 29 (1952).
R. O. King and A. B. Allan, The adverse effect on thermal efficiency of the endothermic reaction required for nuclear ignition as shown by engine experiments with methanol, acetaldehyde and diethyl ether. Can. J. Technol. **30,** 44 (1952).
R. O. King, E. J. Durand, A. B. Allan, E. J. T. Hansen, and V. E. Bowen, Nuclear ignition as illustrated by the characteristics of compression and spark ignition. Can. J. Technol. **30,** 222 (1952).
D. Altman and A. F. Grant, Jr., Thermal theory of solid-propellant ignition by hot wires. Fourth Symposium on Combustion, p. 158, Williams and Wilkins, Baltimore, 1953.
A. M. Busch, Electrostatic spark ignition-source hazard in airplane crashes. NACA Tech. Note 3026 (1953).
F. P. Bowden, The development of combustion and explosion in liquids and solids. Fourth Symposium on Combustion, p. 161, Williams and Wilkins, Baltimore, 1953.
R. O. King and A. B. Allan, The characteristics of the ignition and combustion of benzene in a carburetor engine as affected by heat load. Can. J. Technol. **32,** 22 (1954).
G. Grabowski, Developments in explosion- and fire-suppression techniques. S. A. E. Trans. **63,** 803 (1955).
I. Hartmann, Frictional ignition of gas by mining machines. U. S. Bur. Mines, Information Circ. 7727 (1955).
R. O. King and A. B. Allan, The transition from spark to nuclear ignition as compression ratio is raised. Can. J. Technol. **33,** 335 (1955).
R. O. King and M. Rand, The hydrogen engine. Can. J. Technol. **33,** 445 (1955).

WASHINGTON, April 30, 1956.



U. S. GOVERNMENT PRINTING OFFICE: 1956


DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA