BIBLIOGRAPHY

Electrostatic Phenomena

This compilation is the result of a bibliography search on electrostatic phenomena from the standpoint of theory and application.

An asterisk indicates that the original reference is available in the Goodyear Tire and Rubber Company Research Library.

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Supplementary bibliography

A listing of references is given in which the originals are not available in the Goodyear Tire and Rubber Company Research Library. Furthermore, the Chemical Abstracts when available did not supply any information.

BIBLIOGRAPHY

ELECTROSTATIC PROPERTIES OF PLASTICS AND RUBBER

I. ELECTROSTATIC INVESTIGATIONS
A. In the rubber industry

TRIBO-ELECTRIC PROPERTIES
P.E.Shaw — Proc. Roy. Soc. 94A, 16 (1917); Davis & Blake, "Chemistry and Technology of Rubber", Reinhold, c. 1937, p. 589

Investigators have been trying to arrange materials, both solid and liquid, in triboelectric series, usually from positive to negative, such that any given material is positively charged when rubbed with any one of those below it in the series, and is negatively charged when rubbed with any one of those above. A series in which a number of materials are listed is this by Shaw. In this series crude rubber, gutta-percha, vulcanized rubber and ebonite occupy positions toward the negative end, though the sequence varies considerably from one series to another.

FIRE HAZARDS AND STATIC ELECTRICITY IN RUBBER FACTORIES
F.J.Hoxie — Rubber Age 10, 90-1 (1921)

It is shown that the fire hazard is greatest at the time of least humidity, and that 3/4 of the fires in rubber factories are caused by deficiency in atmospheric humidity.

PIEZOELECTRICITY
Proc. Phys. Soc. (London) 36, 81-93 (1924); Memmler, D.K., ed., "Science of Rubber", Reinhold, c.1934, pp. 471-2

Piezoelectric investigations on ebonite, vulcanized soft rubber, glass, horn, etc., were made by K.R.Brain, who was able to study the behavior of electric charges of the same order of magnitude as those to which Curie had subjected crystals. For small loads, the charge was found to be proportional to the load, but for larger loads, the charge increased more slowly. Hysteresis and fatigue phenomena were also observed. Cubical test pieces of milled stock for insulation purposes and other types of rubber behaved in an anisotropic manner in relation to their piezo-electric effect.

THE INFLUENCE OF THE SURROUNDING MEDIUM ON FRICTIONAL ELECTRICITY
J.H.Jones — Phil. Mag. 50, 1160-77 (1925); C.A. 20, 333 (1926)

The metal wheel gives the best result in air, ebonite the poorest, while the ebonite wheel gives the best result in oil, metal the poorest. The order of the gaseous media for the best production of frictional electricity is SO_2, air, N_2, coal-gas, H_2, CO_2, O_2, O_3.

TRIBOELECTRIFICATION

Deodhar, Indian Assoc. Cult. Sci. 9, 210 (1926); Davis & Blake, "Chemistry & Technology of Rubber", Reinhold, c. 1937, p. 589

Careful observations on the triboelectrification of rubber disclosed many discrepancies and anomalies. A hard rubber rod in contact with flannel, for example, sometimes acquired a positive charge, sometimes a negative charge, and on occasion showed a reversal of charge on prolonged rubbing. Pieces of rubber which were supposedly identical developed opposite charges when rubbed together. Various anomalies of both hard and soft rubber and sulfur were described in some detail.

THE OBSERVATION OF CATAPHORESIS IN COLORLESS SOLS. I. THE CHARGE ON RUBBER IN BENZENE

R.H.Humphry and R.S.Jane Trans. Faraday Soc. (advanced proof), Oct., 1926; C.A. 21, 846 (1927)

The path of a stream of rubber sol dispersed in benzene flowing down through benzene was rendered visible by means of the Toepler "Schlieren" method (utilizing the difference in refractive index).

When such a stream is allowed to pass between 2 electrodes dipping into the benzene, the presence of charged particles is revealed by an appropriate deviation from a vertical path on applying a p.d. to the electrodes. When rubber containing traces of moisture is dispersed in ordinary laboratory benzene, charged particles of both signs are present, since the stream spreads into a fan shape.

In confirmation of this, a deposit is obtained on both electrodes dipping into such a sol. The addition of small amounts of electrolyted, sufficient to change the viscosity, has no effect on the charges. When carefully dried rubber is dispersed in moisture-free benzene, no charged particles are found. In metal sols stabilized by rubber from which water has not been excluded, particles of both signs may be present.

DANGERS FROM STATIC ELECTRICITY IN THE HANDLING OF SOLVENTS

A.A.Bachhaus Am. Dyestuff Rept. 16, 645-6, 660-1 (1927); C.A. 22, 127 (1928)

Static electricity may develop in a liquid solvent flowing through pipes, air or other gaseous medium, solvent vapor issuing into air or other gaseous medium, or gas passing through a liquid solvent. These solvents which are comparatively good conductors are safe statically when flowing through pipes.

With solvents which are poor conductors the pipe lines should be good conductors and well grounded. Sprays should be avoided by discharging the liquid at the bottom of the receiving vessel. If the spray cannot be avoided, the air should be ionized by means of ultraviolet light or x-rays, or moisture.

*ACCUMULATION OF STATIC ELECTRICITY IN TIRES
Gummi Zeitung 44, 2591 (1930)

Investigations have shown that electrical charges are influenced by two main causes: (a) by the compounding ingredients in tire rubber which have high dielectric properties, and (b) by the form and nature of the tread design. Treads with sharp edges gave the most brouble. It was also noticed that on wet days this problem was not present because the wet surface of the tire is a better conductor than the dry surface.

*MASTICATION - A PRELIMINARY STUDY
F.H.Cotton   Trans. I.R.I. 6, 487-515 (1931)

It is thought probable that ionization of oxygen both on the surface and throughout the mass of rubber on a masticating mill, caused by static charges produced by friction, plays some part in promoting oxidation during mechanical working.

*MASTICATION OF RUBBER - AN OXIDATION PROCESS
W.F.Busse   Ind. Eng. Chem. 24, #2, 140-146 (1932)

The rate of oxidation is increased by the activation of oxygen during milling owing to the electrical charge which develops. Since the rubber acquires a charge on going through the mill, the oxygen probaly tends to form ion clusters on the surface of the rubber which could easily cause the formation of a rubber peroxide.

The charge on the rubber may reach a potential sufficiently high not only to form ion clusters on the surface of the rubber, but also to form ionized oxygen molecules, O_2^- and O_2^+ and even ionized oxygen atoms and ozone. In these cases the oxygen would be even more strongly activated than when it was in the form of ion clusters and it would combine more readily with the rubber.

The importance of the electrical effect in the breakdown of rubber during milling is accompanied by luminescence effects. When rubber is milled with cold rolls, no electrical discharge takes place underneath the bite, but there is a more or less even glow over the surface of the rubber where the rubber enters the bank, and occasionally tiny sparks. Most of the frying and crackling noise heard on a small mill is due to these sparks. If the rolls are heated this effect disappears.

STATIC ELECTRICITY AS A FIRE CAUSE
E.E.Turkington   Quart. Natl. Fire Protect. Assoc. 28, 16-25 (1934); C.A. 28, 7533 (1934)

Examples of many unusual cases of static electricity are given. In one instance flow of crude oil through a 2" pipe at high velocity with a clear drop of 20 feet is said to have produced discharges up to 4 feet in length. Static generated by discharge of carbon dioxide from cylinders is negligible unless solid particles are mixed with the gas. Thus when discharged upright no sparks resulted, but when inverted sparks up to 3" long were obtained.

There is a variation in the hazard from individual operators according to skin dryness. In one instance cited, five shoe machine fires from rubber cement were attributed to one operator, and the difficulty was corrected by changing operators.

Grounding, humidity control to maintain over 40% relative humidity, and ionization as preventives are discussed. Analysis of the fire record of 147 static fires is shown graphically to be seasonal and in rough inverse ratio to relative humidity. 6% of such fires in this record were in dust and lint, 94% in inflammable liquids, 39% involving rubber cement operations, 25% other spreading and coating operations, 14% in cleaning, 7% in printing presses and 9% in miscellaneous operations.

PRODUCTION OF ELECTRIC CHARGE BY PULLING APART PLIES OF RUBBERIZED FABRIC

Dawson, T.R. and B.D.Porritt, "Rubber-Physical and Chemical Properties", R.A.B.R.M., England, c.1935, p. 431.

Tests on rubberized balloon fabric by stripping off one ply and measuring the charge on the remaining piece. Capacity of measuring system (electroscope): 127 micro-micro-farads. Data given in tabular form.

PRODUCTION OF ELECTRIC CHARGE DURING RUNNING OF TIRES

Dawson, T.R. and B.D.Porritt, "Rubber-Physical and Chemical Properties", R.A.B.R.M., England, c.1935, p. 431.

With speeds up to 35 m.p.h. on new clean asphalt roads, atmospheric temperature 70° F. and relative humidity 60%, potentials up to 6000 volts may be produced.

PRODUCTION OF ELECTRIC CHARGE BY FRICTION OF TWO PIECES OF RUBBER

Dawson, T.R. and B.D.Porritt, "Rubber-Physical and Chemical Properties", R.A.B.R.M., England, c.1935, p. 431

Charges may be produced by rubbing together 2 pieces of rubber. If a small area of one piece (A) is rubbed over a relatively large area of another (B), A becomes negative and B positive, provided the two surfaces are initially in identical condition. Dirt, adsorbed films, temperature, and strain considerably influence the results.

"Strain" is produced by continued rubbing, and causes the charge on A to become zero and eventually positive. "Strain" is removed by boiling in water.

Warming A gives it a positive tendency.

PRODUCTION OF ELECTRIC CHARGES ON RUBBER BY PRESSURE

Dawson, T.R. and B.D.Porritt, "Rubber-Physical and Chemical Properties", R.A.B.R.M., England, c.1935, p. 430

Tests on (i) "Para rubber" containing "very little if any" crystalline sulfur, dielectric constant 2.94; (ii) pure (vulcanized) sheet, dielectric constant 3.96.

The rubber (sheet 1.6 mm. thick) was mounted on a steel disc and sheets of various materials pressed on to it. As pressure increased from 0.5 to 2 kg./cm^2 the piezoelectric charge increased, but then remained constant up to a pressure of 5 kg./cm.^{2}; the table gives these constant values.

TRIBOELECTRIFICATION

Davis & Blake, "Chemistry & Technology of Rubber", Reinhold, N.Y., c.1937, pp. 588-590

This section contains a literature survey of the work dome on triboelectrification between the periods 1898-1932.

FIRE HAZARDS

Power Transm. 8, 665 (1940); Ann. Rept. Prog. Rubber Technol. 4, 89 (1940)

The risk of fire or explosion is due to accumulation of static charges to such an extent that spark discharge takes place. Static electrical charges are generated on power transmission belts in three ways, first, by the friction of the belt on the pulley, secondly, through the separation of the belt from the pulley, and thirdly, to a less extent by the friction of the atmosphere on the belt.

Notes with illustrations, extracted from a report presented to an American Fire Protection Association are given.

*STATIC ELECTRICITY AND ITS EFFECT ON CAR RADIO PERFORMANCE
S.M.Cadwell, N.E.Handel, and G.L.Benson

Ind. Eng. Chem. (News Ed.) 19, 1139-1141 (1941)

In general, changes in the electrostatic field are caused by variations in electrical resistance between the wheel and the axle, variations in electrical resistivity about the circumference of the tire, variation in road materials and corona discharges from the car. All of these factors cause tire radio static and their relative importance is approximately in the order given.

It was demonstrated that it is not necessary to eliminate the generation of electrostatic charges but only to limit the potential on the tread surface to a low value in order to eliminate all of the undesirable static shock and tire static. This can be done by inserting about 2 grams of a special electrically conductive powder through the valve stem of the inner tube. The powder readily distributes itself and adheres to the walls of the inner tube, forming a continuous and uniform conductive layer.

*STATIC ELECTRICITY AS RELATED TO AUTOMOBILES AND TIRES
Rubber Manufacturers Association, Inc.

India Rubber World 103, #5, 49-50 (1941)

There are two types of difficulties resulting from static electricity in automobiles: radio interference and electrostatic shock.

Factors influencing static electricity in automobiles are road surfaces, atmospheric conditions, clothing and car upholstery and moving parts of the car.

A procedure is given which is said to eliminate either shock or radio interference static when the cause is due to generation of static electricity from friction of the moving parts of the car.

*STATIC ELECTRIC PROBLEMS IN TIRES
J.W.Liska and E.E.Hanson Ind. Eng. Chem. 34, 618-24 (1942)

The major problems are discussed, and the relation between voltage and conductivity is derived mathematically. This equation is in accord with experimental data. A laboratory testing machine for evaluating the static-generating properties of rubber mixtures is described, and data on the effects of compounding ingredients are included. Methods and techniques for measuring the resistivity of rubber mixtures are described, and it is shown that static generation and resistivity are interrelated. The relation between "dispersion" and resistivity is then discussed. The importance of semi-conductive tires in aviation and trucking, especially in munition plants, is pointed out.

*ELECTROSTATIC PROPERTIES OF RUBBER AND GR*S
R.S.Havenhill, H.C.O'Brien and J.J.Rankin
J. Applied Phys. 15, 731-40 (1944)

A new "electrostatic modulator" for measuring the electrostatic charges on various materials is described in this paper. This device in conjunction with a mirror surfaced metal plunger sustem for contracting the sample, has been used to measure the contact potential of various rubber and GR-S compounds.

Data are shown on both rubber and GR-S compounds, and they bear out the formulation of an "electrostatic contact potential theory of reinforcement" in which reinforcement is explained on the basis of contact potentials and resultant electrostatic forces set up between the rubber and reinforcing agents.

By the application of this theory,organic materials, which have a highly positive charge, such as polymerized trimethyldihydroquinoline and Flectol H, have been found to increase the tensile of GR-S pure gum type compound as much as five fold and to nearly double the tensile of high zinc oxide GR-S compounds.

*FIRE HAZARDS IN THE RUBBER INDUSTRY
H.E.Davis Trans. I.R.I. 20, 128-134 (1944)

Static electricity is produced on the mastication and mixing mills, calendering and topping operations, on ply cutting and cover building machines and during spreading operations. It is developed by the flow of solvent through pipes when transferring from one container to another, and by the discharge of dry powder from bags to storage bins.

Static electricity sparks twelve inches long have been observed when masticating rubber. Sparks, 1 inch long and although of low amperage, are sufficient to ignite solvent vapors; an operator on many processes in a rubber factory if wearing rubber shoes can generate a potential of 6,000 to 10,000 volts which is discharged on approached to earthed plant.

STATIC ELECTRICITY
H.C.Bryson Paint Technology 10, 280 (1945); Ann. Rept. Prog. Rubber Technol. 10, 73 (1946)

It is claimed that tubes wear out through static sparks passing between them and the inside of their casings, and a conducting lining is suggested.

*ELECTROSTATIC AND TENSILE PROPERTIES OF RUBBER AND GR-S AT ELEVATED TEMPERATURES

R.S.Havenhill, H.C. O'Brien and J.J.Rankin

J. Appl. Physics 17, 338-346 (1946)

With this new instrument the contact potentials of both rubber and GR-S was found to become highly negative at elevated temperatures. This apparent "boiling off" of electrons and resultant disruption of electrostatic attractive forces within the material is much greater for GR-S than for rubber and probably accounts for the much greater decrease in tensile of GR-S over rubber at elevated temperatures.

*ELECTROSTATICS IN THE RUBBER INDUSTRY

R. Beach Rubber Age 58, 453-60 (1946)

The author has investigated a number of spreader rooms in various companies where it was a common experience for several fires to occur daily during the winter months. One rubber-proofing company estimated that the cost of each fire ranged from $100 to $400, an average cost being about $175 per fire, counting the loss of stock, of carbon dioxide, and of labor outage.

The vapors liberated from the rubber cement on spreaders accumulate near the windup, on the floor, because the volatile components are from two to four times heavier than air, Also, vapors are shown to collect above the stock, after the doctor knife, where they volatilize from the cement by virtue of the high temperatures created by the steam driers.

In operations where stock is run through the various types of processing machines, the electrification of the stock occurs from its contact with the moving elements. The fire hazards appear as a result of the high energy sparks occurring concurrently with the presence of flammable fuel-air mixtures, which latter may either be entrained in the rubber-coated stock or liberated in tackifying operations.

Since the solvents are essential to the processing of the rubber stock, the mitigating efforts must then be directed essentially toward the control of the electrification. In all cases of mitigation, the devices which are employed for accomplishing this utilize the principle of ionization of the ambient atmosphere.

As air molecules are ionized by these mitigating devices, near the surfaces of the stock, the positive ions are strongly attracted to the negative charges residing on the stock, and the negative ions are repelled to remote distances from the stock. Whether or not complete neutralization of the charged stock occurs depends upon the supply of ions which is created in the closely surrounding atmosphere.

Many means are known for producing ionization of the air molecules, among which are:

1.-bombardment by x-rays;
2.-radiation of ultra-violet energy;
3.-emanation from radioactive substances;
4.-heat of combustion; and
5.-energy from high voltage electric fields.

However, the high expense, or the inconvenience of cumbersome equipment, associated with the use of x-rays, ultra-violet radiation, or radio-active materials, prohibit their use in industrial services.

In order to meet the exacting requirements of the rubber industry, the author has devised and patented certain simple, inexpensive means for the ionization air molecules to neutralize charged stock. He has utilized a relatively low and safe voltage from the stock itself, directly after the processing roll. The units are light in weight, and low in cost, and they have the advantage of utilizing no transformers or rectifying devices; also, they are not attached to the electric power or lighting system of the plant.

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RESTING OF RUBBER MIXINGS

Rev. gen. caoutchouc 24, 132 (1947)

An explanation has been given that substantiates the common works practice of resting rubber mixings for 24 hours after preparation. During mixing the rubber and sulfur become charged with static electricity of the same sign. A tension thus exists between rubber and sulfur and if vulcanization is carried out at this stage, chemical combination of rubber and sulfur is prevented. By resting, however, much of the electricity is discharged and not enough is left to interfere with vulcanization.

*FRICTIONAL ELECTRICITY. HAZARDS IN HANDLING INFLAMMABLE LIQUIDS

W. Fordham Cooper Trans. I.R.I. 23, 26-8 (1947)

A discussion of the causes of electrification when liquids are handled and precautions which should be taken to minimize the danger.

The most important precautions recommended are: (1) increase the conductivity of solvents if possible; (2) use high flash point solvents wherever possible; (3) earth all metal work and in particular bond discharging to receiving vessels, together with all intermediate nozzles, funnels, and the armouring of hosepipes; (4) keep up the humidity of the air and remember that warm surfaces tend to be dry and insulating while cold surfaces tend to be damp and conducting; and (5) do not introduce earthed or even unearthed conductors to points near the free surface of a liquid or paste which may be charged - even though it is in an earthed container.

*ELECTROSTATIC PROBLEMS ASSOCIATED WITH RUBBER

D. Bulgin Trans. I.R.I. 23, #1, 35-40 (1947)

A review and discussion, with special attention to problems in the manufacture of rubber goods, sparks from insulating surfaces, sparks from induced charges or leakage charges on conducting objects, charges on rubber dough, static electricity on rubber goods in service, and its removal.

FIRE AND EXPLOSION HAZARDS OF THE MANUFACTURE OF SYNTHETIC RUBBER
Natl. Board Fire Underwriters Research Rept. #4, 31 pp. (1947); C.A. 41, 3658 (1947)

The report is concerned chiefly with GR-S and pertains to butadiene and styrene plants, and the fire and explosion hazards both from raw materials and processing.

*A STUDY OF ELECTROSTATIC CHARGES PRODUCED DURING MASTICATION OF RUBBER AND OF GR-S
R.S.Havenhill, L.E.Carlson, and J.J.Rankin
Rubber Chem. & Tech. 22, 476-93 (1949)

A new electrostatic field strength meter has been described which measures and records, not only the magnitude of electrostatic fields, but also their polarity.

This device has been used in a study of the mastication of rubber, and has furnished data which indicate that rubber becomes less negative, and may actually become positive, as mastication proceeds; this indicates in turn an oxidation of the molecules as well as an electronic rearrangement and orientation of the rubber molecular chains.

Data on GR-S polymerized at different temperatures show entirely different electrostatic breakdown curves, which, with other physical characteristics, indicate unusual properties of the crude low-temperature polymers, e.g., high molar weight, long-chain molecules, already or easily oriented, which do not oxidize or break up appreciably on mastication.

A partial correlation of Mooney viscosity and electrostatic contact-potential and field strength has been shown for rubber and GR-S which have been masticated on a rubber mill.

*ELECTRICAL RESISTIVITY OF VARIOUS CARBON BLACKS IN NATURAL, GR-S, COLD AND BUTYL RUBBERS
L.R.Sperberg, G.E.Popp, and C.C.Biard
Rubber Age 67, 561-4 (1950)

The experiments had as their aim the effects of the type of C black, type of rubber, state of dispersion of the C black, and flexing on the electrical resistivity of vulcanizates containing various C blacks. In addition, the relation between surface and volume resistivity was studied.

The experimental technique is described in detail. The results show that the degree of milling of rubber-C black mixtures has a major influence on the electrical resistivity of the mixtures when the blacks are of intermediate or large particle size, whereas this invluence is insignificant with C blacks of relatively fine particle size.

With increase in the proportion of C black, the conductivity increases, and the relative influence of the degree of dispersion becomes less. The type of rubber governs the electrical resistivity for a given proportion of C black, probably because of the relative degrees of dispersion in the various types of rubber; the degree of dispersion is governed by thermoplasticity of the rubber at the temperature of mixing.

Butyl rubber-MAf black vulcanizates are relatively highly conductive and this feature results in lower accumulation of static charge on vehicles equipped with Butyl inner tubes. The common assumption that flexing lowers notably the conductivity of a vulcanizate containing C black by rupturing the C black chains was not confirmed. Although flexing may increase the electrical resistivity slightly, the magnitude of this increase is much less than would be expected on the basis of a rupture of C black chains, and is similar with all types of C blacks, whether good or poor conductors.

An experimental comparison of the surface and volume resistivity showed that they are of the same order of magnitude; hence it is probable that electrostatic charges built up by movement of an inner tube in a tire casing are discharged at the contact surface of the tube and casing. Such a discharge could cause surface crazing of inner tubes, since traces of O_3 might be formed as a consequence of the electrical discharge.

I. ELECTROSTATIC INVESTIGATIONS
B. In the textile industry

*SUN SPOTS, IONIZATION OF AIR AND TEXTILES

P.M.Strang — Textile Research 11, 447-58 (1941)

In addition to temperature and humidity, static has a noticeable effect on textile manufacture. Cotton fibers during processing acquire a negative electrical charge, which, although reduced in quantity by temperature and humidity, may be dispersed throughout the fibers to a greater degree when the humidity is increased.

The static charge is rather difficult to remove, so that with fiber twisted into yarn the like-charged fibers tend to repel each other. The strength of the yarn will be the net difference between these two sets of forces.

There is a daily cycle in the amount of ionization of the air, as well as an annual cycle, and the amounts of ionization vary with the altitude. Altitude, and the amount of foreign matter such as smoke, moisture, cloudiness, etc., in the atmosphere also have their effects.

It has been found impossible to prove scientifically the effects of ionization on textiles in absolute units of comparison. At present the quality spinning cottons are produced on lands of low earth resistivity in the South while the Pima cotton from Arizona, with wide variations in qualities, is grown on lands of high earth resistivity.

THE ELECTRICAL CONDUCTIVITY OF SPINNING MATERIALS

B. Axhausen — Melliand Textilber. 21, 441-3 (1940); C.A. 35, 2332 (1941)

Electrical conductivity is an important factor in the formation of static charge on the fibers during spinning.

An apparatus is described consisting essentially of a parallel plate condenser across which the fibers whose conductivity is to be measured can be inserted. The condenser is charged to 340 v., the fibers put in place, and the time required for the voltage to drop to 170 v. is recorded.

From these data, and the weight and length of the sample, the specific conductivity is calculated. This varies greatly with moisture content, salt content, and degree of lubrication or sizing.

*ELECTRIFICATION DURING THE PROCESSING OF FIBERS

J. Textile Inst. 40, T702 (1949)

The introduction of many fibers at low moisture-regain together with the general tendency to increase processing speeds has aggravated the troubles due to static electricity. The variation of static charge with moisture-regain during carding has recently been investigated. It was found that for wool, Ardil, casein, cellulose acetate and nylon, the charge increases at first with decreasing regain, but for the lower regains the curve flattens and the charge tends to assume steady value. The conclusion was reached that the amount and nature of the absorption of moisture by fibers is possibly of more importance as regards static electrification than the chemical constitution.

I. ELECTROSTATIC INVESTIGATIONS
C. In the paper industry

STATIC ELECTRICITY IN NATURE AND INDUSTRY

P.G.Guest — Bur. Mines, Bull, 368, 98 pp. (1933); C.A. 28, 417 (1934)

The literature on static electricity and its hazards is reviewed. Over 260 references are given. The industries concerned include Al, aviation, building, chemical, cleaning and dyeing, cotton, grain, mining and handling, paper and printing, petroleum, S and sugar.

STATIC ELECTRICITY IN PAPER MANUFACTURE

J. Strachan — Paper Maker & Brit. Paper Trade J. 93 TS81-2 (1937); C.A. 31, 6875 (1937)

Static electricity is not generated when 2 dry paper surfaces are rubbed together. When 2 sheets of paper are pressed into intimate contact under a pressure of 100-120 lb. per sq. in. and then separated, the 2 surfades that have been in contact are charged electrically, one positively and the other negatively.

When dry paper is rubbed or pressed into contact with another material such as metal, the paper surface acquires a single charge, generally negative. On the dry end of the paper machine, static electricity is produced not so much by friction of the dry paper surface on metal as by close contact of paper and metal under pressure. When several layers of dry paper are pressed together, opposing positive and negative charges appear when the sheets are separated.

ELECTRICAL CHARGE PHENOMENA IN PAPERS
W. Brecht, F. Schmid and R. Vieweg
Papier-Fabr. 35, Tech. Tl., 133-40, 142-59 (1937); C.A. 31, 5574 (1937)

Esperiments are described on the electrification of paper by means of a special static electrifier, paper machines, in rolls, and in rotary intaglio printing presses.

Water vapor, escaping from the inner portions of the paper disk does not cause surface charges. Primarily, electrification depends on the relative humidity of the surrounding air. When the humidity of the air is caused by atomized water particles, the electrical conductivity of air increases. Humidifying by atomization thus supplies a method of deelectrification. The type of fiber, loading, sizing, hardness, thickness, and gloss appear to be relatively unimportant factors in electrification, except insofar as they affect moisture content. The addition of small amounts of NaCl prevents electrification.

Unelectrified paper may become statically charged in the printing press. When paper rolls carry charges prior to printing, the humidity of the store room has bery little effect on the rate of discharge, and here the moisture content of the paper is important. The length of time during which the surface charge is retained is greater the drier the paper, the tighter the winding of the roll, and finally the drier the surrounding air.

ELECTRIC CHARGES ON RAPER
M.O.Lerner
Bumazhnaya Prom. 19, #5, 26-9 (1941); C.A. 37, 4245 (1943)

The formation of static electricity depends on the nature of the paper, as well as the material with which the paper comes into contact. The water-absorptive power, electrical conductivity and nature of fibers are additional factors, as well as fillers, glues and chemical salts.

*A METHOD FOR STUDYING THE DISTRIBUTION AND SIGN OF STATIC CHARGES ON SOLID MATERIALS
H.H.Hull
J. Appl. Physics 20, #12, 1157 (1949)

A special powder is used to show how static electricity is distributed on materials such as paper. Red particles of this powder are attracted to positively charged areas and blue particles are attracted to negatively charged areas. Paper from heat-set printing presses shows streaks of static electricity generated by idling rollers and shifting patterns of static electricity generated in the folder, often with opposite charges on the same sheet of paper.

I. ELECTROSTATIC INVESTIGATIONS
D. Theory

THE ELECTRIFICATION ASSOCIATED WITH DUST CLOUDS
W.A.D. Rudge   Phil. Mag. 25, 481 and Proc. Roy. Soc. A90 256 (1914); C.A. 7, 2349 (1913)

Nearly all kinds of finely divided particles when blown into a cloud of dust by a current of air give rise to electrical charges.

THE ELECTRO-OSMOTIC POTENTIAL DIFFERENCE PRODUCED BY THE MOVEMENT OF SOLID BODIES IN LIQUIDS
J. Stock   Anzliger. Akad. Wiss. Krakan 1913 131; C.A. 8, 1369 (1914)

A quantitative study of Darn's discovery (Am. Physik 10, 70) that a solid body falling through a liquid produces an electrical field.

*ELECTRICAL EXCITABILITY AND CONDUCTIVITY OF LIQUID INSULATORS
D. Holde   Ber. 47, 3239 (1915); C.A. 9, 879 (1915)

Specific conductance of various samples of benzene plus petroleum ether were found to be 10^{-14} to 10^{-15}. The extent of electrical excitations when a practically non-conducting liquid flows through a narrow tube depends primarily upon its conductance and upon the influence of temperature and moisture.

CONTACT ELECTRICITY IN HIGH VACUUM
A. Coehn and A. Lotz   Z. Phys. 5, 242 (1921); C.A. 15, 3585 (1921)

In the highest vacuum obtainable by modern methods a production of charge still takes place on the contact of two dielectrics. Subject with higher dielectric constant is always plus.

*FRICTIONAL ELECTRICITY
H.F. Vieweg   J. Phys. Chem. 30, 865-889 (1926)

A literature survey of previous work in this field is presented. In this study of the effect of moisture, certain anomalies observed by previous workers have been explained.

A frictional electric series has been established and shows the effect of using different crystal faces. An explanation of frictional electricity has been proposed, using the electronic structure of matter as a basis. A suggestion as to the physical significance of "Coehn's rule" has been offered. The effect of moisture films on frictional electric charges has been shown to be related to Lenard's "Wasserfallelektrizitat". The charges produced when air is bubbled through various solutions have been measured. An explanation of these effects, has been presented on the basis of the selective adsorption of ions by a gas.

TRIBO-ELECTRICITY AND FRICTION II - GLASS AND SOLID ELEMENTS
P.E.Shaw and C.S. Jex Proc. Roy. Soc. (London) A 118, 97, 108 (1928); C.A. 22, 4043 (1928)

Measurements have been made of the sign and charge acquired when glass rods are rubbed by various elements. Elements are listed which gave positive and those which gave negative charge. Vacuum did not affect the results. Various theories of frictional electricity are discussed.

FRICTIONAL ELECTRICITY
P.E. Shaw Phil. Mag. (7), 9, 577-83 (1930); C.A. 25, 445-6 (1931)

Charges obtained on rubbing like bodies are due to difference in surface strains. The theory of polar structure of atoms and molecules with the resultant orientation in surface films should prove important in explanations of phenomena in triboelectricity.

THE NATURE OF FRICTION
P.E. Shaw Phil. Mag. (7), 9, 628-39 (1930); C.A. 25, 445-6 (1931)

Triboelectricity and friction are two aspects of the same phenomenon. In all cases of solid contact, solid combination takes place on contact. Charging of both surfaces occurs when they separate In friction, the work is the work performed in total electrical separation plus the work in deformation of the surface structure. The law of friction is limited in application and becomes invalid for extreme surface curvatures as well as for the extreme loading.

*QUANTITATIVE INVESTIGATIONS OF FRICTIONAL ELECTRICITY
E. Hess Z. Physik 78, 430 (1932)

Experimental data are recorded with respect to the electrical charges between solid dielectric materials in which the indefiniteness of the mutual contact surfaces is avoided by substitution of the friction with a slip-free mutual pressure device having accurately defined pressure.

*EFFECT OF SURFACE CHARGES ON MEASUREMENTS OF THE CONDUCTIVITY OF POOR CONDUCTORS
A. D. Goldhammer Z. Physik 84, 212 (1933); C.A. 28, 389 (1934)

The conditions under which surface charges seriously affect such measurements were studied. In the experiments of Seidl (Z. Physik 76, 565 (1932) insufficient care was taken to avoid errors. In order to avoid these errors the objects should be shielded.

*ELECTRICAL STREAMING POTENTIALS WITH TURBULENT FLOW
H. Reichardt Z. Physik Chem. A 174, 15 (1935); C.A. 30, 11 (1936)
Helmholtz equation holds for turbulent flow through a tube.

ANISOTROPY PHENOMENA IN POLYSTYRENE WITH AN ORIENTED DISTRIBUTION OF PARTICLES
G.F. Daletckii Compt. rend. acad. sci. U.R.S.S. 54, 311-13 (1946) (in English); C.A. 41, 5355 (1947)

Oriented layers of polystyrene were obtained up to 3 mm. thick from solution, and up to 12 mm. thick by polymerization of monostyrene. Gentle polishing of these oriented films caused them to acquire a positive charge, whereas strong polishing restored the negative charge customarily present in bulk polystyrene. These oriented films probably consist of layers with identical groups toward each other (phenyl to phenyl and methylene to methylene). Mechanical treatment causes removal of material at the methylene layers, which have a smaller bond energy than the phenyl groups.

*INCENDIARY ACTION OF ELECTRIC SPARKS IN RELATION TO THEIR PHYSICAL PROPERTIES
F.J. Llewellyn Trans. I.R.I. 23, 29-34 (1947)

A discussion, with data on electrical charges of powders, diagrams of apparatus used for determining the minimum condenser energy for ignition of dust clouds and of vapors, the incendivity of metallic and organic dust clouds, and the minimum energy necessary for the ignition of vapor-air mixtures.

*ELECTROKINETIC POTENTIALS AND ELECTRICAL CONDUCTANCE IN SOLUTIONS OF LOW DIELECTRIC CONSTANT
A. J. Rutgers and M. deSmet Trans. Faraday Soc. 48, 635 (1952)

Measurements on $(iso\text{-}C_5H_{11})_4N$ picrate in pure dioxane, dioxane-water mixtures, benzene, benzene-acetone mixtures. Found potentials of up to 80V. Also found that the streaming current was dependent on applied voltage.

*COLLOID SCIENCE Vol. I - Chapter IV
ELECTROCHEMISTRY OF THE DOUBLE LAYER p. 115 - 193 Chapter V
ELECTROKINETIC PHENOMENA p. 194-244

These two chapters discuss various properties of the double layer including potentials, structure and theories. It includes various basic experimental techniques. The most pertinent sections are on streaming potentials and relaxation time. They state that the streaming potential is proportional to the pressure of flow for non-turbulent flows, provided the surface conductance of the liquid does not play a large part.

*THEORY OF CONTACT ELECTRIFICATION
F.A. Vick — British Journal of Applied Physics Supplement No. 2 S1-S6 (1953)

A discussion of the Helmholtz theory of static electrification is given. It is possible in principle to predict the magnitude and direction of the flow of electrons between two such solids in contact. In many cases in practice, however, the presence of surface states complicates the picture. The states, acting as traps for electrons, may originate in various ways, including imperfections of the lattice structure at the surface, the presence of adsorbed atoms etc., and the precise condition of the surface may depend on its immediate past history. The surface density of charge due to such states may be high enough to cause a brush discharge from the surface when the two solids originally in contact are separated, and the bombardment of the surfaces by the resulting high speed electrons and ions may again alter the surface structure. The density of surface states on an insulator may vary from place to place on the surface. In addition to electron transfer, there may be movements of ions, especially when the local surface temperatures are high or contact with liquid is involved.

*SURVEY OF GENERATION AND DISSIPATION OF STATIC ELECTRICITY
P.S.H. Henry — British Journal of Applied Physics Supplement No. 2 S6-S11 (1953)

A simple statement of the author's problem is, that if two surfaces are brought together and separated, either with or without rubbing, charged particles are found to have crossed the boundary, with the usual result that the two surfaces have gained equal opposite charges. The author attempts to explain the five following questions with regard to this phenomena.

1. What are the charged particles which cross the boundary?
2. How do they get there and when?
3. How many are present?
4. Up to what distances can they cross the gap?
5. What conditions decide how many cross which way?

A discussion is made on each of the questions. No direct adequate answer is given to any of the questions.

A REVIEW OF STATIC ELECTRIFICATION
D.F. Arthur — J. Tex. Inst. 46, T721 (1955)

The mechanism of charge separation between solids is discussed in detail including the short-range dissipation during separation. Charges on an insulator may be removed by contact with a conducting liquid including a conducting film formed on surface or by ionization of the air near the surface. Ionization may be accomplished by ultraviolet light, x-rays or a corona discharge brought about by a point or wire of high potential. A discussion of experimental methods used is also given.

*EFFECT OF TURBULENCE ON THE STREAMING POTENTIAL
P. E. Bocquet, C. M. Sliepcevich and David F Bohr
Ind. Eng. Chem. 48, 197 (1956)

A review of Helmholtz and Smoluchowski basic work on streaming potentials and experimental work in which they combine their equations. Give description of electronic equipment and experimental conditions. Conclude that the Helmoltz-Smoluchowski equation is valid for both laminar and turbulent flow, provided the flow is fully established. The existance of a laminar film at the wall in turbulent flow is further substantiated; streaming potential can be utilized as a technique for studying fluid flow phenomena near the wall.

*LOCATION OF ELECTROSTATIC CHARGES IN KIRKWOOD'S MODEL OF ORGANIC IONS
Charles Tanford Journal of the American Chem. Soc. 79, 5348-52 (1957)

The interaction between electrostatic charges on organic ions was treated earlier by Kirkwood in 1934. This paper is a further study on the same problem. It is highly theoretical and judged to be of little practical value.

*INFLUENCE OF TURBULENCE ON ELECTROKINETIC PHENOMENA
A.J. Rutgers, M. deSmet and G. deMoyer Trans. Faraday Soc. 53, 393 (1957)

The electric charges in the liquids are in a diffuse layer close to the wall; in laminar flow, the speed of the liquid near the wall is proportional to the distance from the wall. In turbulent flow, however, parts of the liquid near the wall may be carried to the central part of the capillary. By measurement of the streaming potentials in laminar and turbulent flow an equation was obtained from which the thickness of the double layer could be calculated.

*THERMODYNAMICS FOR ELASTIC SOLIDS IN THE ELECTROSTATIC FIELD I. GENERAL FORMULATION
C.M. James Li & Tsuan-Wu Ting (Carnegie Inst. of Technol) J. Chem. Phys 27, 693-700 (1957)

Condensed collection of all thermodynamic relations among 1st derivs under variation of temperature, stress, and electrostatic field.

*ELECTROSTATICS IN THE PETROLEUM INDUSTRY
A. Klinkenberg and J.L. van der Minne
A Royal Dutch (Shell Research & Development Report 178 pages) Elsevier Pub. Co. (1958)

A comprehensive report on theoretical and practical work from Lab to tank scale. Most practical results of their work is the development of an additive for petroleum which increases the conductance to a level that will allow charges to bleed off before they reach dangerous levels. They had concluded that three things are necessary to have an explosion caused by static electricity (1) an explosive gas mixture must be present (2) an electric charge must have been generated and must have accumulated on a solid or in a liquid (3) the electric field must cause a spark of sufficient intensity to ignite the gas. Charging of a liquid can occur by flowing through pipes, flowing through a filter and by small particles settling through a liquid. Increasing conductance of liquid reduces charge that will build up.

II. ELECTROSTATIC CONTROL

A. In the rubber industry

BELT ELECTRICITY AS INCENDIARY
M.M. Richter — Chem. Ztg. 31, 1255; C.A. 2, 1038 (1908)
Discussion of generation of electricity on belts. Recommends treatment of belts with glycerol and water to prevent build up of charge.

FRICTIONAL ELECTRICITY ON INSULATORS AND METALS
W.M. Jones — Phil. Mag. 29, 261 (1915); C.A. 9, 2482 (1915)
Experiments prove that rubbing friction has the effect of removing electrons from either rubber or the specimen rubbed at a rate proportional to the rate of rubbing. It is shown that frictional electricity reaches a constant maximum value when the generation of the charge is compensated by leakage.

* Pearson, Henry C., Rubber Machinery, India Rubber World Pub., c. 1920, pg. 197
In early days of proofing fires were of frequent occurrence. A simple device for discharging the frictional electricity consists of copper strips to which are soldered needles that are set just below the guide rollers, but not close enough to tear or mark the fabric. A conductor wire is attached to this device and grounded, usually in water or on a pipe running into the earth. A perforated pipe near the rubber covered roll, through which live steam is forced, is also employed to guard against such fires.

FIVE HAZARDS AND STATIC ELECTRICITY IN RUBBER FACTORIES
Wolfgang Ostwald — Kolloid Z. 29, 100 (1921); C.A. 16, 174 (1922)
It is shown that the fire hazard is greatest at the time of least humidity and that 3/4 of the fires in rubber factories are caused by deficiency in atmospheric humidity.

*CHAPMAN ELECTRIC NEUTRALIZER

Pearson, Henry C. — Pneumatic Tires, India Rubber Pub. Co., New York, c. 1922, p. 154-6

Rubberized fabric is easily electrified by friction and pressure and it is thought that this phenomenon is also caused by the evaporation of the solvent naphtha from the cement, or by some unknown chemical action, such as oxidation or change in hydration of the rubber or fabric.

To minimize the fire hazard of the spreading operation, spreaders are equipped with devices for removing these static charges. The Chapman electric neutralizer distributes alternating charges at high voltages in minute quantities to the places where the static charges collect. The principle on which it works is the simple law of attraction and repulsion, that the static charge in any insulating material selects for itself the kind and quantity to exactly neutralize itself.

In the application of the Chapman neutralizer the transformer is located on some convenient wall and a single heavily insulated wire leads to the several machines to be treated. Each spreading machine is fitted with two "inductors" extending across the machine over the fabric. One is placed just back of the spreading knife and the other near where the fabric is rolled up. These inductors are placed so that the fabric passes them at a distance of two to four inches. The influence of the inductors extends through the air for several inches around them, and every portion of the fabric as fast as it comes within this region of influence is imperceptibly but instantly deprived of any electric charge existing upon it. The result of this action is that the inductor at the head end of the spreader instantly and completely neutralizes every part of the fabric as fast as it leaves the spreading knife, before any charge imparted to the fabric can accumulate sufficiently to discharge to the roll, knife, frame or pipes in the form of a spark.

The object of the other inductor, treating the fabric just before it is rolled up, is to remove any slight charge redeveloped by the other rolls over which the fabric passes before winding up.

HOW TO AVOID STATIC FIRE HAZARDS IN RUBBER MILLS

Wm. D. Milne — Chem. Met. Eng. <u>30</u>, 20 (1924); C.A. <u>18</u>, 768 (1924)

Charges of static are built up on belts, moving surfaces of cloth, the bodies or clothing of workmen in vapor clouds and solvents flowing from nozzles or jets. Safeguarding is effected by grounding everything - material, machinery, men and by humidification.

DIELECTRIC CONSTANT, POWER FACTOR AND RESISTIVITY OF RUBBER AND GUTTA PERCHA
H.L. Curtiss and A.T.McPherson   Bur. Standards Tech. Paper. No. 299, 669 (1925); C.A. 20, 842 (1926)

Discusses experiments involving raw and vulcanized rubber and gutta percha with various sulfur levels and various fillers. These materials were tested for suitability for insulation of submarine cables. All fillers increased the dielectric constant. Carbon black increased the dielectric constant and power factor and lower the resistivity.

*FIRE HAZARDS OF STATIC ELECTRICITY
R.M. Clark   Ind. Eng. Chem. 17, 1127-9 (1925)

To prevent dust explosions caused by static, it is essential that all moving parts of machinery be connected metallically and the machines themselves grounded. The frictional electricity will be neutralized through the connections between the moving parts, and if there is any excess charge it will be dissipated through the ground wire. Rotating parts of machinery may become insulated because of the film of oil surrounding the bearings, for lubricating oil is a non-conductor. Thus it is possible for rotating parts to be charged even though the stationary parts are well grounded. A solution is to affix a small metal brush, such as a piece of piano wire, so that it will rub against a portion of the moving machinery. Such a brush should be well grounded.

Belts can be connected to the earth by installing metal combs in contact with their inner surfaces or by providing a network of grounded wires close to the belts and parallel to them. Various belt dressings have been used with the idea of making the inner belt surface conducting. Equal parts of glycerol and water are probably effective in some instances, the glycerol tending to retard evaporation of the water which acts as a conductor between the belt and the grounded pulley. If such a dressing is used, it should be applied every few days. Another method which may be more adaptable to dusty locations is the use of an idle metal roller which presses against the inside surface of the belt. In addition to being grounded, the roller should be connected to the pulley by means of an electrical conductor.

*SOME ELECTRICAL PROPERTIES OF RUBBER
P. Dansheath   Trans. Inst. Rubber Industry 2, 460 (1927); C.A. 21, 2399 (1927)

Following a review of past research on the electrical properties of rubber, experiments are described which deal with the power factor of soft cured rubber-sulfur mixtures, under different conditions. The results show that with all other conditions invariable, the power factor increases with relative humidity, and with the cure above a certain optimum cure at which the power factor is minimum. The addition of mineral rubber, of china clay or of lamp black likewise results in increased power factor. The latter is practically independent of the frequency.

*TAKING STATIC OUT OF INDUSTRY
J.A. Davis Textile World 71, #19, 77, 79, 93 (1927)

William H. Chapman made the discovery that led to the invention which has freed industry from the costly interference of "static". Rubber manufacturers formerly feared frictional electricity as something more than a deterrent to quality and output- it was a constant fire menace. Many disastrous fires had been caused by sparks of this form of electricity igniting naphtha.

In 1904, while working on some electric motors which the Continental Paper Bag Company had sent him for repairs, Chapman received a letter from that concern bearing the information that the production of their automatic bag machines was greatly curtailed by frictional electricity which caused the bags to stick together. It was so bad that a machine designed and built to produce 300 bags a minute could not be made to deliver at a rate of more than 100.

He then brought forth his invention and demonstrated its value, completely neutralizing some electrified paper. This was accomplished by bringing the paper within radiating range of a high tension, high frequency coil of wire. He constructed a similar coil of smaller size and took it to the bag mill. Placing it by the side of one of the bag machines, he inserted an extension plug into a nearby lamp socket and the finished bags slid out of the machine and into a smooth pile even at the slow speed at which the machine was running. The terminal was then strapped to the machine and the speed was increased three-fold.

The Chapman electric neutralizer had conquered a menace to production and quality in the bag industry as it has continued to do in many other trades ever since.

*BELT DRESSING FOR ELIMINATING STATIC
P.W. Edwards and J.O. Reed India Rubber World 80, #2, 60 (1929)

Static electricity can be removed from belts and other surfaces by grounding systems, humidifying the air sufficiently, ionizing the air in contact with the belt, or other surface by means of a gas flame or by silent discharge of high frequency and high voltage current. Static electricity can be eliminated by special belt dressings.

A good rubber belt dressing can be prepared by mixing 18 parts of lamp black with 82 parts of good spar varnish. A smaller quantity of lamp black may prevent most of the cracking which develops after the above dressing is used for several months. The dressing must dry on the belt before running. A non-flammable thinner for the varnish can be prepared by mixing equal volumes of carbon tetrachloride and varnish makers' and painters' naphtha.

This paper is a summary of the work done by the Bureau of Chemistry and Soils, U.S. Dept. of Agriculture.

*ELIMINATION OF STATIC FROM BELTS

Rubber Age 25, 493 (1929)

P.W. Edwards and J.O. Reed of the Bureau of Chemistry and Soils of the U.S. Department of Agriculture found that the most satisfactory results for a non-static rubber belt dressing was obtained by using 18% lamp black with 82 parts of good spar varnish. For a good non-flammable thinner they recommend equal volumes of carbon tetrachloride and varnish makers and painters naphtha. This was carefully tested on belts in actual installations on an air compressor and on a rubber conveyor belt. It was also tried on rubber belts in flour mills and on threshing machines. When applied to the entire surface and allowed to dry, static did not develop.

*EFFECT OF TEMPERATURE, PRESSURE AND FREQUENCY ON THE ELECTRICAL PROPERTIES OF RUBBER

H.L. Curtis, A T McPherson and A. H. Scott

Phys. Rev. 2 , 33, 1080 (1929); C.A. 25, 3517 (1931)

The dielectric constant, power factor and resistivity of rubber depend on the percentage of sulfur used in its vulcanization, on the temperature and pressure and for the first two properties, on the frequency at which measurements are made.

*CARBON BLACK IN RUBBER INSULATING COMPOUNDS

W.B. Wiegand and C.R. Boggs Ind. Eng. Chem. 22, 822 (1930); C.A. 24, 4958 (1930)

Contrary to popular belief and statements in the literature carbon black not only has no deleterious effects but improves insulating properties in many cases - used 3 1/4% carbon by volume. Resistivity increased 68%; breakdown voltage increased 40% and dielectric constant increased accordingly. With 30% or 35% carbon similar improvements were observed but of less magnitude.

*A METHOD OF MAKING ELECTRICAL CONTACT WITH EBONITE AND SOFT RUBBER FOR INSULATION TESTS

H.F. Church and H.A. Daynes Trans. Inst. Rubber Ind. 6, 82 (1930); C.A. 25, 3872 (1931)

An Aquadag coating was put on the ebonite or rubber for use as an electrode in measuring the resistivity, power factor and dielectric constant. The solution was dry for testing to eliminate effect of H_2O. The volume resistivity is less using Aquadag than when using Hg as an electrode.

*EFFECT OF ACCELERATORS AND ANTIOXIDANTS ON THE ELECTRICAL CHARACTERISTICS AND WATER ABSORPTION OF VULCANIZED RUBBER INSULATION
J. H. Ingmanson, C.W. Scharf and R.L. Taylor
Ind. Eng. Chem. 25, 83 (1933); C.A. 27, 629 (1933)

The influence of 10 commercial organic accelerators and of 12 commercial antioxidants on the moisture absorption, specific resistivity, specific conductance, dielectric constant and power factor of typical "30% rubber" insulating mixtures, both in dry condition and after immersion for 5 days in distilled water at 70°, was studied. The results indicate that accelerator and antioxidant do not have a determinant effect on the moisture absorption, but may influence greatly the electrical properties. The quantity of moisture absorbed is not a satisfactory criteria for judging electrical stability.

*HIGH TENSION RUBBER CABLES
H. Heering
Proc. Rubber Tech. Conf. London, 1938 p. 1086

Although rubber has excellent breakdown strength, its lack of ozone resistance is a serious disadvantage. The formation of ozone can be eliminated by use of semi-conducting or conducting rubber sheaths. These rubbers are made by incorporating large amounts of black; figures are shown of the wide differences in resistivity obtained with different blacks and the superiority of acetylene black. Rubbers with resistivities of 1/10 ohm. cm. are made with this black and used instead of metal as conductors.

CONTINENTAL GUMMI-WERKE A. -G.
Brit. 467,141 (1938); Ann. Rept. Prog. Rubber Technol. 1, 110 (1938)

Difficulties due to charges of static electricity accumulating during service are avoided by using an electrically conducting rubber consisting of rubber 100, graphitic carbon (acetylene black) 100, sulphur 3, zinc oxide 15, colophony 5, stearic acid 2, and mercaptobenzthiazole 1.

ELECTRIFICATION OF CLOTH DURING RUBBERIZATION AND A REMEDY FOR IT
N. Drozdov and V. Smirnov
Caoutchouc and Rubber (U.S.S.R.) 1938, #2, 44-8; Chem. Abs. 32, 5251 (1938)

A simple device to remove and neutralize electrostatic shocks consists of a steam pipe situated under the cloth near the knife. The pipe is perforated to let out steam and is grounded.

ELECTRICALLY CONDUCTIVE RUBBER

Electrical Review 122, 796, 800 (1938); Ann. Rept. Prog. Rubber Technol. 2, 55 (1938)

Electrically conductive rubber with good mechanical properties and a specific resistance as low as 1 ohm is useful where static charges are undesirable.

ELECTRICALLY CONDUCTING NEOPRENE & RUBBER

J. Inst. Auto Eng. 7, 57 (1938); Trans. I.R.I. 17, 50-64 (1941)

In a paper by C.D. Law mention is made of a conducting rubber tyre having a specific resistance of 50 ohms compared with 5×10^7 ohms for standard rubber tread but no details are given with regard to processing or testing. The use of such highly conducting tyres is claimed largely for combating current discharge on electrically operated trolley buses.

*DIELECTRIC MEASUREMENTS IN THE STUDY OF CARBON BLACK AND ZINC OXIDE DISPERSION IN RUBBER

A.R. Kemp and D.B. Herrmann — Proc. Rubber Tech. Conf. 1938, p. 893; Rubber Chem. and Tech. 12, 317 (1939)

Specific conductance, specific resistance and dielectric constant of various ZnO and carbon blacks at various loadings were tested. Particle size and dispersion determined change in electrical properties. Smaller size and better dispersion improved properties while H_2O soluble impurities had a deleterious effect.

*STATIC ELECTRICITY, WITH PARTICULAR REFERENCE TO THE RUBBER INDUSTRY

C.R.A. Chadfield — Trans. Inst. Rubber Ind. 14, 372 (1939) C.A. 33, 9041 (1939)

An illustrated discussion, with particular attention to the causes and results of static electricity in industry, the static detector and methods for minimizing or reducing static effect.

*REMOVING STATIC ELECTRICITY

W.C. Glass — Rubber Age 45, 89-90 (1939)

The use of the Chapman Electric Neutralizer Device on rubber spreaders and coating machines is recommended to eliminate fire hazards.

This neutralizer consists of two essential elements - a power unit to produce the corrective charge of alternating current of suitable intensity and in a safe form, and a so-called "Inductor Bar" for attachment to the machine requiring treatment in order to deliver the opposing charges, or to express it another way, to provide an alternating electrostatic field for charged materials to pass through.

*BELTS AND PULLEYS

Ann. Rept. Prog. Rubber Technol. 4, 89 (1940)

Probably the most common method of preventing the accumulation of static electricity on belts and pulleys is to provide an earthed comb placed near the surface of the belt and designed to remove the charge as it is formed. Another effective method of preventing the accumulation of static electricity is to apply to the belt, at frequent intervals, a material which will make the surface of the belt a conductor of electricity. If either combs or belt dressing are used the pulley and the line shaft must be properly earthed. Bearings in line shafts, due to the oil film, are often not of low enough electrical resistance properly to earth the shaft. In such cases, use must be made of earthed brushes on the shaft itself. Where belt drives are used, the static charge hazard can be lessened by decreasing the speed of the belt and increasing the size of the pulley.

RUBBER HOSE

J.H. Van Straelen — Belg. 435,867 (1940); Ann. Rept. Prog. Rubber Technol. 4, 93 (1940)

The danger which arises from a static electrical charge especially on hoses used for the passage of inflammable fluids is overcome by the use of a flexible rubber hose in which undulating metallic wires, which are connected to earth are incorporated and embedded in the body of the hose.

RUBBER HOSE

Soc. Industrielle du caoutchouc Soc. An.

Belg. 432,728 (1940); Ann. Rept. Prog. Rubber Technol. 4, 93 (1940)

This patent covers the manufacture of a hose which is made up with a lining consisting of a continuous layer of rubber in which is incorporated particles of electrically conducting material such as carbon or copper. Around this, metallic wires are wound helically, and a layer of nonconducting rubber surrounds the wire, being in turn protected by a layer of tough rubber.

COATING ON AEROPLANE DE-ICERS

Science & Appliance 4, 3 (1940); Ann. Rept. Prog. Rubber Technol. 5, 47 (1941)

An application of semi-conducting rubber is the coating on aeroplane de-icers to prevent punctures due to static electricity.

*ELECTRICALLY SEMI-CONDUCTING RUBBER AND SYNTHETIC RUBBER COMPOUNDS
A.E. Juve India Rubber World 103, #5, 47, 50 (1941)

The generation and dissipation of static elec. charges has become increasingly important, particularly in factories using rubber belts, in the oil and aviation industries, in hospital operating rooms and in filling stations. In view of this, rubber products which are relatively highly conductive have already been developed for special service conditions, such as for washing-machine V-belts, airplane-tire treads, airplane-wing de-icers, gasoline-hose nozzles, and hospital operating-room equipment.

The specific resistivity of rubber and synthetic compounds can be varied within wide limits of compounding.

*ELECTRICALLY CONDUCTING NEOPRENE AND RUBBER
B.J. Habgood and J.R.S. Waring Trans. I.R.I. 17, 50-64 (1941)

In applications such as aeroplane and trolley bus tyres, conveyor belts and flooring, electrically conducting rubber helps to eliminate the effect of static electricity.

HOSE
F. B. Williamson Jr. (Whitehead Bros. Rubber Co.)
U.S. 2,244,635 (1941); Ann. Rept. Prog. Rubber Technol. 5, 78 (1941)

A hose has been designed to overcome the dangers of static charges. It is made by attaching the apices of the alternate loops of a sinuous static conductor at spaced points and in a substantially straight line to the face of a fabric wide enough when wrapped on an inner tube, and on itself to provide all the plies of the hose. The apices of the intermediate loops are attached to spaced points in another line substantially parallel to the first and spaced from it at a distance equal to the circumference of the hose. The conduction should be placed inward from the side edges of the fabric far enough to provide materials for plies on each side of it.

*INVESTIGATIONS OF CARBON BLACK WITH THE ELECTRON MICROSCOPE
H. Heering, I. Gizycki and A. Kirceck Kautschuk 17, 55 (1941); C.A. 35, 8360

The particle sizes of various carbon blacks were determined and correlated with the tensile strengths and specific insulation resistance of vulcanizates containing these blacks.

*ELECTRICAL PROPERTIES OF CONDUCTIVE RUBBER INCLUDING A RECOMMENDED METHOD OF TEST FOR DETERMINING THE ELECTRICAL CONDUCTIVITY OF RUBBER - COMMITTEE ON GASES - NATIONAL FIRE PROTECTION ASSOC. OF CANADA

Rubber Age (N Y) 50, 203, 1941);
C.A. 36, 2443 (1942)

A lab technique based on fundamental principles is described.

TRIBOLUMINESCENCE OF RUBBER
Kuti Kosiyamco

J. Chem. Soc. Japan 62, 597 (1941);
C.A. 36, 293 (1942)

Linen was soaked with benzene solution of rubber and dryed. After pressing two sheets together for 2 - 3 days a bluish green light was observed on tearing them apart in the dark.

*NULLIFYING STATIC ELECTRICITY IN RUGS AND CARPETS

Rubber Age 52, 228 (1942)

This development provides for the interweaving of a conductive yarn throughout the pile and backing of the carpet which runs into a rubber composition treated backing that absorbs the static electricity generated through friction.

STATIC ELECTRICITY FROM LEATHER BELTS
S.F. Wilson

Southern Power and Ind. 60, #3, 73 (1942); Chem. Abs. 36, 2796 (1942)

Static electricity discharges from belts can be prevented by rendering them conductive. One powder manufacturing company finds that graphite is very effective as a static preventive. Another company uses a 50% glycerol-50% water solution, sufficient of which is automatically applied at intervals to keep the belt in moist condition.

Static electricity is generated by belt slippage and by the continuous making and breaking of contact between belt and pulleys, as well as by friction with the surrounding air. Potential is always highest halfway between pulleys, and discharge combs should be placed at this point. A good, pliable, high-friction belt, with good conductivity, and smooth on both sides, will never cause serious static troubles.

ELECTRICAL RESISTIVITY OF RUBBER COMPOUNDS
J. G. Robinson

Rubber Chem. & Tech. 15, 128 (1942) and Trans. Inst. Rubber Ind. 17, 33 (1941) C.A. 36, 927 (1942)

By means of a new technique for determining vol. resistivity the effect of compound variations were investigated on mixtures containing 80% rubber. Substitution of French chalk for ZnO give increased resistivity. Increased stearic acid did the same. One antioxidant decreased resistivity, two were ineffectual. Accelerators gave diverse variations. Increased concentration decreased resistivity. Variation with time of cure depended on compound being investigated.

PNEUMATIC TIRES
U S Rubber Co. Brit. 544,757 - April 27, 1942; C.A. 36 7363 (1942)

A tire with a coating of rubber cement between the carcass and sidewall and tread portions - the cement containing at least 15% by weight of the cement solids of acetylene black.

STATIC-DISCHARGING FLOOR COVERING
E.N. Cadwell and L.Marick (U.S.Rubber)
U.S. 2,302,003 (1942); Chem. Abs. 37, 2158 (1943)

A coating of a flexible electrically conducting material, such as a rubber composition containing carbon black, is affixed to the under side of a rug, and a plurality of electrically conducting elements comprising textile materials, such as cotton cords, and an electrically conductive rubber composition are used which come into contact with the coating and extend to substantially the top of the rug.

NON-STATIC BELTING
J.C. Walton and G.E. Hall (Boston Woven Hose & Rubber Co.)
U.S. 2,318,441 (1943); Chem. Abs. 37, 6158 (1943)

Use is made of a body including a plurality of fabric plies, covers of electroconductive rubber bonded to and covering the entire areas of both faces of the body, an electroconductive means such as rubber plugs containing electroconductive carbon connecting the covers at spaced locations along the belting, such means including at each location a strip of electroconductive rubber extending through the respective plies at relatively spaced points and located between adjacent plies between adjacent points.

*CONDUCTIVE RUBBER FLOORING
C.S. McChesney and J.W. Short (Dunlop Tire & Rubber Corp.)
U.S. 2,325,414 (1943)

This patent provides a flooring with a highly conductive material such as metallic wire, distributed throughout. This system of wire or wire mesh is connected to a ground so that a charge of electricity, static or otherwise, need pass only a short distance through the conductive rubber to the highly conductive wire and thence to ground.

STATIC REDUCING PNEUMATIC TIRES
G.L. Benson (U S Rubber Co) U.S. 2,316,549 April 13, 1943; C.A. 37, 5888 (1943)

The inner surface only of the inner tube wall is provided with an acetylene carbon black powder around the circumferential crown region.

PNEUMATIC TIRE
Arthur W. Bull, Glenn G. Havens and John F. Williams (U.S. Rubber Co.) U.S. 2,329,332 September 14, 1943; C.A. 38, 1145 (1944)

A tire with a ribbon of electrically conductive rubber extending from one bead under sidewall tread and to other bead to provide path for electrical charge.

CONDUCTIVITY OF RUBBER TREAD STOCKS - EFFECT OF PROPERTIES OF CARBON BLACK
Leonard H Cohan and James F Mackey
Ind. Eng. Chem. 35, 806 (1943) C.A. 37, 5274 (1943)

In a smoked sheet formulation it was found that as carbon black particle size decreased electrical conductivity increased. As the crystal structure approached graphite type conductivity increased and as volatiles were removed from black conductivity increased.

When blacks are heated at high temperatures the product becomes more graphitic and more conductive.

GENERATION OF STATIC ELECTRICITY IN RUBBER FACTORIES AND ITS PREVENTION
A.G. Tseilikman - Legkaya Prom. 1943 N. 3-4, 6-8; C.A. 38 891 (1944)

Static electricity generated particularly on spreading machines is a source of danger. It can be overcome by a Chapman ionizer as modified by author.

*ELECTRICALLY CONDUCTIVE RUBBER
H.E. Elden Rubber Age (N Y) 47, 308 (1944)

A short discussion including extreme values that can be obtained. Specific resistances between one and 10^{15} ohms; tire tread with min. resistance of 30 ohms/cm^3; cable covering minimum resistance of 10 ohm. Stretching 10% halves the conductivity.

NON-STATIC TIRE
Elmo E Hanson U.S. 2,339,546 January 18, 1944; C.A. 38, 4149 (1944)

Uses a conductive rubber compound extending over bead and under tread.

*CONDUCTIVITY OF TREAD STOCKS - NATURAL AND SYNTHETIC RUBBERS
Leonard H Cohan and Martin Steinberg
Ind. Eng. Chem. 36, 7 (1944); C.A. 38, 1908 (1944)

Electrical conductivity of natural, reclaim, Buna S, Neoprene-GN, Thiokol-N and Butyl-1.5 with various blacks and various loading. Found conductivity depends mainly on particle size of blacks.
Particle size determines conductivity in a series of the same type of black.

INSULATION RESISTANCE OF HARD AND SOFT RUBBER II NOTE ON THE MEASUREMENT OF SURFACE RESISTIVITY
H.A. Daynes
J. Rub. Res. 13, 51 (1944); C.A. 38, 5432 (1944)

Precision of volume leakage correction is confirmed in most cases but a small end correction is given for use when necessary.

*THE CARBON SPECTRUM FOR THE RUBBER COMPOUNDER
C.W. Sweitzer and W.C. Goodrich
Rubber Age (N Y) 55, 469 (1944)

Covers effect of various carbons on many properties of rubber including electrical conductance of rubbers.

STATIC RESISTANT VEHICLE TIRES
John Fielding (Wingfoot Corp)
U.S. 2,342,576, February 22, 1944; C.A. 38, 4834 (1944)

A layer of rubber having a high electrical conductivity underlying the tread but terminating short of the bead or rim contacting portions of the tire.

*METHOD FOR TESTING STATIC CONDUCTIVE RUBBER BELTS
Anon.
Rubber Age 57, 577 (1945)

A simple test equipment for estimating the power of a belt to conduct static electricity is described and consists of a low wattage neon bulb connected to two metal prongs which are placed on moistened spots on the belt surface a short distance apart. The bulb, when connected to an A.C. supply, glows if the belt possesses proper conductivity.

*ELECTRICALLY CONDUCTIVE RUBBER
D. Bulgin
Trans. Inst. Rubber Ind. 21, 188 (1945) C.A. 40, 2673 (1946)

A discussion of natural rubber, GR-S and Butyl containing different carbon black and various uses to which electrical conductive blacks have been put.

A rather long article which gives some history of conductive rubber and discusses many factors which control conductivity - black and their particle size, milling, history of sample, temperature effects and methods of testing. Of the polymer types, butyl was better than natural or GR-S.

STATIC ELECTRICITY
H.C. Bryson — Paint Technology 10, 280 (1945) Ann. Rept. Prog., Rubber Technol. 10, 73 (1946)

It is claimed that tubes wear out through static sparks passing between them and the inside of their casings. A conducting lining is suggested.

ELECTRICALLY CONDUCTIVE RUBBER - METHODS OF MEASURING CONDUCTIVITY
R. G. Newton — J. Rubber Research 15, 35 (1946); C.A. 40, 5282

General discussion of precaution in measuring conductivity includes a general discussion of electrodes and contact resistance. The conductivity of a rubber depends on history and testing conditions; e.g., 10% elongation doubles the resistivity, cutting or compressing increases the resistivity. The mixing technique, degree of vulcanization and temperature of testing influence the conductance.

*CONDUCTIVE RUBBER
A.S.T.M. & Soc. Automotive Eng.
A.S.T.M. Bull. #142, 59 (1946)

It has been found that when a rubber compound has sufficient conductivity to cause a 2 w. neon bulb to flow when a 110 volt current is passed through it, the rubber is sufficiently conductive to eliminate or dissipate static electricity.

TIRES AND EXPLOSIONS
Sehrbundt and others — P.B. 4690; Bibl. Sci. Ind. Repts. 5, 760 (1947)

This report includes the prevention of fires and explosions caused by static electricity.

*FIRE HAZARDS AND PROTECTION OF RUBBER CEMENT
E.E. Turkington — Rubber Age 62, 61-3 (1947)

In every instance of a rubber-cement coating and drying process fire caused by static - whether it was quickly brought under control or not, whether damage was severe or negligible - the fire can be traced back to inadequate grounding and humidification.

Protection engineers recommedn that practical tests be made with a static indicator by running the material through machines with the humidification system operation, but without cement in the tank. Well-grounded static-collecting brushes should be installed at all points where static is found to collect. Careful and frequent tests throughout the area always pay.

MEASURING STATIC CHARGES
Dunlop Rubber Co. and D. Blugin
Brit. 588,420 (1947); Ann. Rept. Prog. Rubber Technol. 11, 133 (1947)

A portable device consisting of an electrometer valve, with batteries and instruements, has been produced for determining the magnitude of static charges within a range of 20 to 1,000,000 volts. In use this device need not be brought closer than 12 in. to the sheet or conditions causing the static charge.

TYRES ON AIRCRAFT TAILWHEELS
W. Becker
P.B. Report #37719; Bibl. Sci. Ind. Repts. 4, 133 (1947)

This paper describes the particular problems of discharging electric charges through the conductive tyres on aircraft tailwheels.

*ELECTRICAL CONDUCTIVITY OF GR-S AND NATURAL RUBBER STOCK LOADED WITH SHAWINIGAN AND R-40 BLACKS
P.E. Wack, R.L. Anthony and E. Guth
J. App. Phys. 18, 456 (1947)
C. A. 41, 4948 (1947)

Resistance measurements and temperature coefficients were made on stocks with varying black loadings. 40-140 pts black per hundred parts of rubber were used. Results are interpreted on the assumption that carbon black tends to form chains in the rubber matrix.

FIRE AND EXPLOSION HAZARDS OF THE MANUFACTURE OF SYNTHETIC RUBBER
National Board Fire Underwriters Research Rept. #4, 31 pgs (1947) C.A. 41, 3658 (1947)

The report is concerned chiefly with GR-S and pertains to butadiene and styrene plants, and the fire and explosion hazards both from raw materials and processing.

*ELECTRICALLY CONDUCTING RUBBER
K.A.Lane and E.R. Gardner
Trans. I.R.I. 24, 70-91 (1948)

The work deals with a new method for measuring the resistivity of rubber, the development of highly conductive vulcanized rubber, and methods of testing antistatic tires.

The generation of static electricity by vehicles with rubber tires is discussed, and theory is evolved whereby the effects to be expected can be predicted from lab. tests to within about 50% of the true value.

*COPOLYMER COMPOSITIONS CONTAINING FINELY DIVIDED METAL PARTICLES
P. K. Frolich and I.E. Lightboun (Jasco Inc.)
U.S. 2,441,945 (1948)

An interpolymer of an isoolefin and diolefin (I) such as isobutylene and butadiene in liquid ethylene can be compounded with metal salts, pulverized metal or metal powder. This compound prevents the accumulation of static charges.

*STATIC-CONTROL V-BELTS

Burton, W.E., ed., Engineering with Rubber, McGraw-Hill Book Co., N.Y., c. 1949, pg. 75

Friction between ordinary V-belts and their sheaves often generates static electricity, which, by creating high potential differences, may cause shock to operators or become a hazard in plants where explosive materials are handled. Static control-V-belts were developed to drain off such electrical charges before they reach dangerous proportions. The rubber used in the covers is compounded in such a way that the belts actually are conductors of static charges but will not contuct ordinary electric currents such as those used to operate motors and lights. Some static-control belts are made by merely coating the surface with conducting materials.

To insure proper operation of a static conducting belt, the machine on which it is used should be grounded properly, as by running a stranded copper wire or strip from the machine to a water pipe. The ground conductor need not be insulated.

STATIC CHARGE ELIMINATOR
G.R.S. Charles, W.I. Sanderson and M.H. Easy
Brit. 627,241; Ann. Repts. Prog. Rubber Technol. 13, 64 (1949)

A device for dissipating static charge in aircraft consists of a flexible earthing rod of rubber, polyvinyl chloride or similar material, which contains sufficient metallic particles to give it an end-to-end resistance of 1/2 megohm.

STRUCTURE AND PROPERTIES OF FILLED RUBBER MIXTURES III, MIXTURES OF NA BUTADIENE RUBBER WITH CHANNEL BLACK
B. Dogalkin, K. Pechkouskaya and M. Dashevskii
Kolloid Zhov. 10, 357 (1948); C.A. 43 8188 (1949)

Measurements of resistivity of rubber with various carbon black sizes and mixing. Resistivity decreased by mixing and increase in amount of carbon black.

LIGHT PHENOMENA ON ELONGATING VULCANIZED RUBBERS
A. Van Rossem Rub. Chem. and Tech. 23, 332 (1950)
A discussion of luminescence of rubber when torn in darkness. Found only with non-reinforcing fillers. Possibly due to electric discharges.

*ELECTROSTATIC POTENTIAL "BLEED-OFF" IN RUBBER COMPOUNDS
J.A. Hurry, T.D. Bold, and W.E. French
India Rubber World 124, 689-95 (1951)
Methods are described which measure the capacity of a rubber product or experimental sample to "bleed off" self generated or imposed electrostatic voltage. Although the ohmic resistance can be established, there is no method based on resistance values alone for predicting whether static voltage will be generated during the life of a product. However, the potential bleed-off test is a direct measure of this condition, and a product which is satisfactory on the basis of this test can be relied upon to be statically safe and free of spark discharge hazard.

*RECENT DEVELOPMENTS IN ELECTROSTATIC TEST EQUIPMENT FOR EVALUATING RUBBER AND ASSOCIATED MATERIALS
R.S. Havenhill, L.E. Carlson, H.F. Emery and J.J. Rankin
Trans. Inst. Rubber Ind. 27, 339 (1951)
A new electrostatic probe and associated equipment for detecting and recording polarity and magnitude of the electrical potential when rubber is mixed in Banbury. Discusses effects of various compounding ingredients on the electric charge and how mixing can be followed by this method. Sample charts for several ingredients are given.

*CONTACT RESISTANCE OF VARIOUS ELECTRODES FOR TESTING ELECTRICALLY CONDUCTIVE RUBBER
R.H. Norman Trans. Inst. Rubber Ind. 27, 276 (1951)
A number of types of electrodes were tested on rubbers in the resistivity range of 10 to 10^5 ohm cm. Brass electrodes vulcanized to the rubber were found to be the best. For already vulcanized samples, tin foil attached by colloidal graphite were best. Samples of high resistance give most trouble in measurement because of high value of contact resistance and surface leakage.

*STRUCTURE AND PROPERTIES OF LOADED RUBBER MIXTURES IX
K. Pechkovskaya, T.S. Mil'man and B. Dogadkin
Koll. Zhurnal 14, 250-2 (1952) - Rub. Chem. Tech. 26, 810 (1953); C.A. 46, 987 (1952)
Conductance of rubbers on milling of carbon blacks is measured. The most highly developed carbon black structures were obtained with butyl and natural rubber - highly crystalline rubbers. Sodium butadiene rubber and butadiene styrene copolymers gave less highly developed carbon black structures.

*THE ELECTROSTATIC PROPERTIES OF RUBBER AND PLASTICS
H.A. Endres and W.T. Van Orman
Rubber World 129, 359 (1953)

A review of the accumulation of electrostatic charges in rubber and plasticis and its dissipation. Discuss use of self charging electrostatic polyethylene air filters and show the difference in the dust collecting ability of this type compared with conventional types.

*STATIC ELECTRICITY ON RUBBER TIRED VEHICLES
D. Bulgin
Brit. J. of Appl. Physics 4, Supplement 2, S83 (1953)

The electrostatic charge which originates at the separation of the tire tread from the road raises the potential of road vehicles to a maximum of 100,000 V., the value depending on roughness of the road surface, vehicle speed and tire tread resistance. The inter-connection of these factors is given in the paper with both experimental and theoretically derived values of voltage. Harmful effects include shock from the vehicle, radio interference and puncture of the inner tube due to ozone originating between the tube and the inner wall of the tyre. Elimination of these effects is obtained using tyres of electrical resistance of less than 10^9 ohms.

*ELECTRICAL PROPERTIES OF RUBBER
Jean Granier
Compt. rend. 236, 786 (1953); C.A. 47, 6689 (1953)

If rubber is compressed between 2 parallel plates serving as electrodes, its d.c. conductance, dielectric constant at frequency 1,000, and loss angle at the same frequency decrease with increasing pressure. This is true only if the rubber is free to decrease in thickness, otherwise pressure has no effect. If the rubber is sheared between a median electrode and 2 external electrodes coupled together, and equal and opposite forces, parallel to the plates one applied to the median and external electrodes, the loss angle decreases with the force applied. If the rubber is stretched while immersed in mercury acting as the condenser, the loss angle decreases with extension. An explanation assuming a decreased mobility of the ions when the chain molecules have begun to flow is advanced.

*AN INTERESTING PROPERTY OF CERTAIN CONDUCTIVE RUBBERS
L.G. Kersta
J. Polymer Science 10 447 (1953)

Polysulfide rubbers decrease in electrical resistivity up to 20% elongation followed by a flat interval and subsequently increases to the elastic limit. When natural rubber, butyl or Neoprene containing silver particles were tested, each gave positive slopes of resistance - elongation curves.

*SURVEY OF HARMFUL STATIC ELECTRIFICATION

H.W. Swann — British Journal of Applied Physics Supplement No. 2 S68-S71 (1953)

Interesting examples of explosions are given for the cleaning industry, rubber, aircraft and others. This article is pertinent. It is recommended it be read in full.

In the example for the rubber industry it was judged that a static charge from a workman ignited a rubber cement.

ELECTRICALLY CONDUCTIVE RUBBER. TRACING AND MEASURING STATIC ELECTRICITY

P.D. Patterson — (Dunlop Rubber Co. - Eng) Kautschuk Anwendungen 3 No. 3, 55-7 (1953) C.A. 47, 9656 (1953)

A discussion of present developments, with special attention to applications of conductive rubber.

NONELECTROSTATIC SYNTHETIC RESIN MATERIAL

J.A. Bjorksten and J.B. Eisen

U.S. 2,624,725 January 6, 1953; C.A. 47 3032 (1953)

Aliphatic amine (0.03 - 1%) with at least 6 C atoms in one radical and 0.005 - 0.5% acid in a resinous material prevents accumulation of static charges. Thus 99.81 parts polystyrene, 0.15 part octadecyldimethylamine and 0.04 part H_3PO_4 were mixed and injection molded. The molded articles acquired no substantial charge during three months.

CONTROL OF STATIC ELECTRICITY IN INNER TUBES

Herbert D. Hiatt, George P. McCord and Lester C. Peterson (U.S.Rubber)

U.S. 2,656,641 (September 1, 1953); C.A. 48, P1049 (1954)

A dispersion of a conductive carbon black is blown into an inner tube before splicing to render this cured tube static free.

The liquid in the dispersion is a non-solvent for rubber of B.P. between 45-85°. For example, the dispersion may contain 10-20 parts of a conductive black and isopropyl alcohol 80-90%.

*ELECTRICAL MEASUREMENTS OF RUBBER-CARBON BLACK SYSTEMS

G. Kickstein — Kautschuk u Gummi. 7, WT 50 (1954); C.A. 48, 6728 (1954)

A general description is given of the electrical properties of rubber-carbon black mixtures, its dependence on variables such as mixing temperature, carbon black content, field strength and frequency. After effects are the most important cause of the frequency dependence of dielectric constants and loss angle. Compressive stress causes complex variations in dielectric properties connected with the shape factor (length to thickness ratio of the carbon black flocculated. These effects are interpreted to give information on the type of carbon black dispersion.

*A STUDY OF ELECTROSTATIC CONDITIONS IN AUTOMOBILE TIRES
O. Giese, H. Stein and F. J. Lauer

Kautschuk u. Gummi 6, WT 217 (1953);
Rub. Chem. and Tech. 27, 569 (1954)

Measurements were made on tires running on a steel drum. Details are given of the electrical set up. Discuss tire as cause of charge - two primary causes (1) contact (road to casing), (2) flexure (casing to tube). Measured voltage developed in many combinations of conductive and non-conductive tires and tubes. Voltage measured on tread and on tube. Best combination was standard casing and conductive tube which reduced flexure voltage to zero and reduced tread potential to such an extent that no undesirable effects could arise. Voltages of over 5,000 V were obtained. Charge distribution around the tires are given for various combinations.

Supplementary Report
F. Hommel

Comments on previous paper and gives a more theoretical treatment of the charge distribution around and inside the tire. Discusses the charging of the vehicle from the tire. They observed: a direct proportionality between the charge voltage of the vehicle and the tire resistance, especially that of the sidewall; a reduction of charge voltage by about 30%, due to placing water in the tube or provision of conductive inserts; definite dependence of these functions on the speed of the vehicle, i.e. on the charge per second.

PROCESSING OF RUBBER-CARBON BLACK MIXTURES
Kenneth W. Doak — U.S. 2,720,499, October 11, 1955; C.A. 50, 3793 (1956)

Rubber-carbon black mixtures containing 0.5-3.0 parts hexachlorocyclopentadiene per 100 parts natural or synthetic rubber are heated 10-60 min. at 275-400°F. After compounding and curing, the stock has lower torsional hysteresis and higher electrical conductance.

* ELECTRICAL CONDUCTIVITY EXPERIMENTS WITH HIGH ABRASION FURNACE BLACK LOADED NATURAL RUBBERS
N.C.H. Humphreys — Proc. Inst. Rubber Ind. 2, 163 (1955)

This includes three sections: 1- effect of time of milling - increased milling time decreases conductance and increases variance within batches. Heat treatment after vulcanization gives better within batch and batch to batch correlation. 2 - comparison of test procedures and estimation of experimental error-molded in brass electrodes and absolute method show no difference. No effect due to mold cavities or loadings. 3 - Effect of flexing on resistivity - a profound and immediate increase in resistivity on flexing and a large decrease as soon as flexing ceases followed by further slower decrease.

*ELECTRICAL CHARGES ON TYRES AND VEHICLE
F. Hommel Rubber J. 128, 689 (1955)

The following relationships exist between the measurable electric properties of tyres and vehicle. A proportional increase of voltage with tyre resistance and speed; tyres and vehicles are negatively charged on smooth asphalt, but positively on tarred, wood roads; the smoother the road, the higher the charge and the insertion of a conductive layer into the tyre reduces the vehicle potential.

ELECTRICAL RESISTANCE CHANGES IN GRAPHITED RUBBER SHEETS UPON DEFORMATION
Bela Nador Magyor Kem. Folyoirat 61, 353 (1955); C.A. 52, 9639 (1958)

Rubber sheets (60 x 100 mm. and 0.75 and 0.25 mm thick) were fitted at their shorter edges with 5 mm. thick conductor contacts and their resistance was determined by an electronic "Orivohm" meter. The surfaces of the test specimens were graphited by spraying on a suspension of ground graphite in benzene. The contacts were separated and the distances accurately measured. Resistance measurements indicated that up to an elongation of 25%, resistance increases by the square, thence the increase is becoming progressively larger. By maintaining a certain elongation resistance will considerably decrease as the time advances, the rate of the decrease following an approximate parabolical curve, becoming asymystatic and ceasing after about 25 hours. This decrease is attributed to the relaxation of the rubber molecules on the surface.

COMPARISON OF FRICTION AND ELECTRIC CONDUCTIVITY OF RUBBER RESINS
S.B. Ratner and V.V. Lavrent 'ev
Zhur. Tekh. Fiz. 26, 853 (1956); C.A. 50, 15115 (1956)

Relations between the graphite, carbon black or alumina content of SKS-30 rubber, and the friction, electric conductance and strength are shown.

*ELECTRICAL CONDUCTIVITY OF CARBON BLACK-REINFORCED ELASTOMERS
Gerald Kraus and J.F. Svetlik
J. Electrochem. Soc. 103, 337 (1956)

The experimental evidence indicates that electrical conductivity in carbon black-reinforced rubbers is due to conductive chains formed by carbon black particles. Below the critical threshold loading for conductivity these chains do not extend continuously throughout the rubber sample and do not cause conductivity, the resistivity of random dispersions being independent of particle size and shape. High surface area blacks appear to adsorb ionic impurities to produce an increase in resistivity at low loadings. High surface area blacks, which contain the longest number of particles per unit volume, produce the most highly resistant stocks at small loading and also yield the most conductive stocks at high black content. Particle aggregation habit contributes strongly in determining the conductivity of rubber stocks at intermediate and high black loadings, but the intrinsic conductivity of the carbon black exerts a noticeable influence only at high black concentrations.

*CHANGES OF ELECTRICAL RESISTANCE OF RUBBERS LOADED WITH CARBON BLACK
D.G. Marshall   Proc. 3rd Rubber Technol. Conf. London, 1954 p. 483-95

The resistance of a black-loaded rubber rises when the rubber is first stretched. If the rubber is then repeatedly stretched and released without being left in the unstretched position, then its resistance at first drops and then rises with extension. If the material is left unstretched then its resistance gradually returns toward its initial value at a rate that increases as the temperature is raised. A theory is proposed that stretching breaks contact between carbon particles and these are gradually reformed as the rubber returns to its original volume.

*THE ELECTROSTATIC CHARGE OF FLAT RUBBER DRIVE BELTS
G. Schon and G. Vieth   Kautschuk u. Gummi, 9, WT159 (1956)

A study was made of equilibrium static charges generated on flat rubber belts running on aluminum pulleys. A shielded electrode system was connected to an electrometer to measure the induced charge. The effects of velocity humidity, tension and slip were determined.

*ELECTRIC POTENTIALS IN RUBBER COMPOUNDING
R.S. Havenhill, L.E. Carlson and J.J. Rankin
Rubber Age (N Y) 79, 75(1956)

The Electrostatic Contact Potential Theory of Reinforcement, in which reinforcement is explained on the basis of the strong electrostatic attractive between the positive pigments and the negative rubbers, is discussed and data presented to prove the theory. Also shows use of electrical potentials produced while mixing in Banbury's as an aid to rubber compounding.

*MODEL EXPERIMENTS WITH ELECTRICALLY CONDUCTING RUBBER TO CLARIFY THE PROCESSES OCCURRING IN LOADED METALS
W. Spath   Gummi u. Asbest 9, 500 (1956); C.A. 51, 1638 (1957)

The properties of electrical conductive rubber with simultaneous mechanical loading are explained on the basis of the cooperative action of the destructive and recombination effects of the carbon black. A significant effect must further be ascribed to internal stress. The action of such internal stress is attributed to the doubling of the electric frequency during periodic loading. Since the recombination effects act very differently electrically and mechanically, a systematic and simultaneous investigation into these values might give a further insight into the deformation mechanism.

*MEASUREMENT OF THE ELECTRICAL CONDUCTIVITY OF RUBBER
Kautschuk u. Gummi 10, WT 1-5 (1957); C.A. 51, 4747 (1957)

A tabulation is given of standardized methods of resistance measurement including details of electrodes, voltage power and test specimens. Best electrode system gives the lowest specific resistance for conditions otherwise the same. Variables studied included electrode pressure, power, heat effects and polarization conductive silver paint electrodes and their stability. Use of silver paint electrodes eliminates contact resistance.

*CONDUCTIVE RUBBER - ITS PRODUCTION APPLICATION AND TEST METHODS
R. H. Norman - 100 pages   Pub. Rubber Journal - London

A comprehensive review of conductive rubber including methods of measuring the conductance, manufacture, effects of stress, time and other variables on resistivity and a discussion of the uses of conductive rubber. This includes antistatic vehicle, tires, industrial goods, hospital equipment, etc.

II. ELECTROSTATIC CONTROL

B. In the plastics industry

REMOVING ELECTROSTATIC CHARGES
P.J.M. Leboucher   Fr. 675,109 (1928); Chem. Abs. 24, 2815 (1930)

The accumulation of electrostatic charges in the manufacture of linoleum, celluloid, etc., is prevented by rendering the surrounding atmosphere conductive by moistening it with water to which an albumin, such as white of egg, has been added. The atmosphere may also be ionized by ultraviolet rays.

ARTIFICIAL SHEETS
I.G. Farbenind.   Fr. 757,786 (1934); Chem. Abs. 28, 3198 (1934)

The electrical charge on sheets and other colloid products of a high degree of polymerization is diminished by utilizing as constituents either in or on the products, polymeric polycarboxylic acids or their salts, or mixed polymerization or condensation products which contain polymeric polycarboxylic acids or their salts, e.g., a mixed polymerization product of acrylic acid nitrile and Na acrylate in acetone and MeOH, or a mixed polymerization product of polyvinyl chloride and polyacrylic acid in CH_2Cl_2.

FILMS, ETC.
W.H.Moss (Brit. Celanese Ltd.)
Brit. 452,122 (1936); Chem. Abs. 31, 485 (1937)

The tendency of foils, films and similar materials having a surface of a water-resistant organic compound to become electrified is reduced by applying thereto a solution that contains a hygroscopic film-forming compound or a hydroscopic liquid of low volatility and which has a viscosity not substantially exceeding that of water and a lower surface tension than water.

The solution applied to the films, etc., may contain an organic liquid, e.g., EtOH, of low surface tension and viscosity in addition to the hygroscopic film-forming compound or liquid of low volatility to facilitate spreading of the solution over the foil. The solution preferably contains water and a softening agent for the foil substance.

Suitable film-forming hygroscopic substances are cellulose esters or ethers.

*THIN, TRANSPARENT SHEETING OF CELLULOSE ACETATE OR THE LIKE SUITABLE FOR USE AS A WRAPPING AND PACKAGING MATERIAL
G.F.Nadeau and E.H.Hilborn (Eastman Kodak)
U.S. 2,331,715 (1943)

For preventing cohesion and static accumulation by the sheeting, at least one of its surfaces is provided with an adherent deposit of fine descrete particles of zein or other prolamine, free from plastic binder.

*ANTISTATIC COATINGS FOR VARIOUS FILMS, SHEETS AND PELLICLES
G.W.Brant (duPont) U.S. 2,357,380 (1944)

A coating composition suitable for use on films of various cellulose ester or ether or other compositions is formed of water together with starch about 0.5-3, a hydroscopic electrolyte such as KOAc or LiCl about 0.03-0.2, and a wetting agent such as "Duponal ME" about 0.2-1.5%.

*CONDUCTIVE PLASTIC
B.H.Maddock (Carbide & Carbon)
U.S. 2,379,976(1945)

A composition of a highly plasticized vinyl chloride resin with a C black can be prepared which is electrically conductive and of satisfactory tensile strength, resilience, flexibility, and elasticity. Acetylene black is better for the purpose than other C blacks. The plasticizer may be tritolyl phosphate, trichloroethyl phosphate, or one of the phthalate esters.

The resistivity of the complete composition at 25° is designed to be less than 500 ohm-cm. Such a composition reduces accumulation of static electricity and can be used as a coating in films, threads, sheets, etc., and for mats, heels, soles, and sheeting and anesthetic tubing in hospital operating-room equipment.

As soles or a component of soles in shoes worn by workers in a powder mill, also, it reduces the hazard of fire from sudden discharge of static electricity.

*ANTISTATIC COMPOSITIONS
C.S.Myers (Bakelite) U.S. 2,393,863 (1946)

Suppression of static charges particularly in the handling of vinyl resins is produced by application of a coating of polyethylene glycols, having an average molecular weight of over 900.

*ANTISTATIC TREATMENT OF VINYL RESIN ARTICLES
W.N.Stoops and A.L.Wilson (Carbide & Carbon) U.S. 2,403,960 (1946)

The tendency for articles made of vinyl resins containing a substantial amount of a polyvinyl halide, to develop an electrostatic charge upon their surfaces is reduced by treatment with a highly basic, water dispersible, polyalkylene polyamine or derivatives thereof.

Treatment is made by immersing the article in a 2% aqueous solution of the polyamine for a few minutes at room temperature and then drying at 60-65° for about 45 minutes.

*COMPARISON OF RECENTLY DEVELOPED PLASTICIZERS FOR NITROCELLULOSE - Part II
Chicago Club Official Digest Federation Paint & Varnish Prod. Club #262, 488-502 (1946)

Plasticizers, found to increase or decrease the static charge of films, were rated as to their electrostatic relation to nitrocellulose.

ANTISTATIC-SYNTHETIC-RESIN COMPOSITIONS
W.E.F.Gates and I.C.I. Brit. 580,250 (1946); Chem.Abs. 41, 1876 (1947)

Interpolymers of ethylenically unsatd. monomers and monomers having acid groups (2-20 wt.% of interpolymer total) give resins which may be converted to salts by alkali treatment after polymerization. The salts swell moderately, are antistatic, antimisting, and may be dyes or impregrated with ionic salts. Methyl methacrylate and methacrylic acid give the preferred interpolymer, the acid comprising about 10 wt.% of the monomers.

*SAFETY PLUS BUILT INTO PYROXYLIN COATING PLANT
H.Rosenberg Chem.Eng. 55, #5, 136-8(1948)

Safety features are described. Special features are control of humidity at 60% to prevent sparking, automatic analysis of atms., use of scored single strength glass in windows with 1 sq. ft. window area for each 25 cu. ft. of room vol., discharge into tanks insolid streams to prevent static sprays and careful grounding at all points.

*ANTISTATIC FILMS
Bun Po Kan (duPont) U.S. 2,463,282 (1949)

It is believed the mechanism of this invention may be attributed in part to the ability of the partially hydrolyzed ethylene/vinyl acetate copolymer to adsorb moisture from the surrounding atmosphere and thereby furnish the alkyl pyridinium halide with moistened paths to ionize and conduct.

*UNCHARGING PLASTICS

Machine Design 22, #4, 266-8 (April 1950)

Static electricity has for years created serious difficulties in the plastics, textile, and paper industries. It engenders many problems of the annoyance class in a wide range of fields and activities. Any place where nonmetallic materials must be handled in quantity or with speed and where electrical nonconductors are is fair game for static electricity.

One process for static elimination, known as Electrosol, consists of a two-stage dip or spray application of two successive formulations. The first material is a fluid consisting essentially of an electrical insulator, a dispersing and wetting agent, a catalyst for the complete process reaction and a vehicle to provide uniform deposit, control viscosity and permit uniform pull-out in dip usage.

After a dip or spray application and a twelve minute air dry at normal room temperature, the plastic is given an application of another fluid. The result of the second application is an unchanged original material, the surface of which cannot be electro-statically oriented and which prevents orientation of the parent material it covers. Hence, no static charge can exist. The total deposit on the parts or material processed averaged 0.00035-inch in thickness.

STATIC DUST COLLECTION ON PLASTICS
P.C. Woodland and E.E. Ziegler

Modern Plastics 28, No. 9, 95 (1951)

A standard dust was developed incorporating a fluorescent pigment to allow good photographs to be taken under "black" light. This allowed use of any color plastic. Pigments, surface or internal lubricants molding method and size, humidity had no effect on dust collection. Radioactivity and x-ray would temporarily stop dust collection on polystyrene. Concluded that it was unlikely in the near future that a static free polystyrene would be developed.

*REDUCTION OF STATIC ELECTRIFICATION BY MEANS OF INHIBITING COMPOUNDS
G.W. Graham Nature 168, 871 (1951)

The antistatic activity of liquids was investigated. Two types of behavior were noted. 1. A smooth decrease in charge accumulation with increase in amount of liquid with liquids of higher dielectric constant more effective in small amounts. 2. Surface active types which give a periodicity often with a reversal of sign up to a certain value for each liquid after which no accumulation occurs.

INVESTIGATION OF GASEOUS DISCHARGE ON TEARING OF HIGH-POLYMER FILMS FROM HARD BACKING
V.V. Karasev, N.A. Krotova and B.V. Deryagin
Doklady Akad. Nauk S.S.S.R. 89, 109 (1953)
C.A. 50, 4624 (1956)

Films of benzylcellulose, acetylcellulose, gutta-percha, caoutchouc and polyvinyl chloride exhibited a luminous discharge when torn from a backing of crown glass at gas pressures not less than 10^{-3} mm. Hg. and at rates not less than 10^{-2} cm./sec. with the exception of polyvinyl chloride which yielded bright sparks every 2-4 sec. at a tearing rate of 10^{-5} cm./sec. Observation supported the electric theory of adhesion previously published by the authors.

*THE ELECTROSTATIC CHARGING OF SOME POLYMER BY MERCURY
J. A. Medley Brit. J. Appl. Phys. Suppl. No. 2, 528 (1953)

A method is described by which very heavy charge densities may be measured after separation. Concluded that the application of an external potential gives no information about the intrinsic mechanism of electrification beyond confirming that charge may transfer freely across the interface.

COATING OF THERMOPLASTIC RESIN ARTICLES FOR ELECTROSTATIC CHARGE PREVENTION
John Browning U.S. 2,678,285, May 11, 1954

The surfaces of thin flexible thermoplastic films having a tendency to accumulate electrostatic charges are treated with a dispersion of finely divided, discrete particles of a polymeric resinous material containing a surface active agent. Thus a transparent 0.0002 in. film of polyethylene was passed through an aqueous bath containing 0.5% of a condensation product of isooctylphenol and ethylene oxide and 0.5% of an aqueous emulsion containing 6% triethanol stearate and 30% polyethylene. The excess is squeezed off and film dried.

PLASTIC COMPOSITIONS FREE OF ELECTROSTATIC CHARGES
Myron A Coler U.S. 2,758,984, August 14, 1956; C.A. 51; 1653 (1957)

Compositions for molding of plastic articles free of electrostatic charges are prepared from thermoplastic materials containing 20-3% sorptive materials e.g. pigments or fillers, and a liquid for electrostatic charge dissipation which is insoluble in and non-reactive with the resin, e.g. an amide, nitrile, nitro compound, polyhydric alcohol, or water. The liquid for charge dissipation may be developed in situ.

TEMPERATURE DEPENDENCE OF STATIC ELECTRICITY DURING PEELING OF POLYMER FILMS FROM GLASS
Yonosuke Kobatake and Yukihiko Inoue
Tokoyo Inst. Technol. Killoid-Z 154, 168-9 (1957) in English; C.A. 52, 4239 (1958)

Vinyl chloride-vinyl acetate copolymer etc. show temperature dependency of electric charge generated on peeling from a glass surface parallel to that for modulus of rigidity.

MAKING SURFACES CONDUCTIVE
Arnold S Louis U.S. 2,817,603 December 24, 1957 C.A. 52, 6841 (1958)

Surfaces of plastics, glass, etc. are made electrically conducting by repeated impact with pellets coated with a finely divided electric conductor. The pellets may be of styrene, steel, lead, etc. coated with graphite. The treated surfaces may be coated later with a protecting film.

II. ELECTROSTATIC CONTROL

C. In the textile industry

DISCHARGING ELECTRICITY FROM FILMS
H.J. Hands (Spicers, Ltd.) Brit. 301,439 (1927); Chem. Abs. 23, 3863 (1929)

The electric charge carried by films of cellulose acetate or other cellulose derivatives after evaporation of the solvent in the process of their manufacture is removed by passing them through an electrically conducting aqueous bath connected to earth. Solutions of NaOH, NaH phosphate, NaCl, $(NH_4)_2SO_4$ or Na_2SO_4 may be used.

TREATING TEXTILES
Aceta G.M.B.H. Fr. 689,984 (1930); Chem.Abs. 25, 1103 (1931)

The electrical charge on textile fibers made of cellulose esters or ethers is reduced during their preparation or manufacture by impregnating the fibers with a mixture of oils or fats to which organic bases soluble in the oil such as dibutylamine or triethanolamine are added.

TREATING TEXTILE MATERIALS
D.Finlayson and R.G.Perry Brit. 488,945 (1938); Chem.Abs. 33, 407 (1939)

Electrification of the materials, particular those of an organic derivative of cellulose, is prevented or reduced by depositing thereon soaps of organic bases or tetra-substituted NH_4 bases, e.g., soaps of mono-, di- or tri-ethanolamine, propanolamines, dihydroxypropylamines, tetra-methyl- or -ethyl-ammonium hydroxide or trimethylbenzylammonium hydroxide with oleic, stearic, palmitic, ricinoleic, resin and naphthenic acids, in conjunction with pine oils.

METHODS OF PREVENTING THE ELECTRIFICATION OF SILK
G.R.Vishnevetskii Shelk 9, #6, 19-22(1939); Chem. Abs. 35, 5709(1941)

After the checking of various methods for preventing the electrification of silk it was concluded that impregnation of the silk with electrolytes and hygroscopic materials was most satisfactory.

Electrolytes recommended are Na_2SO_4, AcONa, and NaCl.

TREATING FIBERS, ETC., OF ORGANIC ESTERS OF CELLULOSE
British Celanese Ltd. Brit. 514,134 (1939); Chem.Abs. 35, 3105 (1941)

The tendency to electrification of staple fibers of cellulose acetate, etc., is reduced and (or) their coefficient of friction is increased by a saponification treatment conducted for 6-14 hours at so slow a rate that the acyl content of the material is not reduced by more than 2% in 8 hours treatment.

PREVENTING STATIC CHARGES IN THE PROOFING INDUSTRY
C.R.A.Chadfield Brit. 516,383; 516,384 (1940); Ann.Rept.Prog.Rubber Technol. 4, 144 (1940)

In the proofing industry, spreading machines, dough mills, and vulcanising machines, are liable to fire and explosion, caused by static electrical charges. An apparatus

(cont.)

for neutralising these charges incorporates a series of conductors mounted in a rotary insulated carrier.

PREVENTING STATIC CHARGES IN THE PROOFING INDUSTRY
W.E.M.Ayres and English Electric Co. Ltd.
Brit. 517,855 (1940); Ann.Rept. Prog. Rubber Technol. 4, 144 (1940)

This device eliminates electro-static charges produced during manufacture, by providing a conductor maintained at a high potential in close proximity to the material and wholly embedded in or enveloped by insulation.

RUBBER-CORED YARN: TENDERING
C.E.Bergamini
Textile World 90, #1, 67 (1940); Ann.Rept.Prog.Rubber Technol. 4, 127 (1940)

Precautions necessary when producing covered rubber yarns, such as control of humidity and temperature, exclusion of sunlight, and efficient earthing of machines to guard against ozone from electric discharges, as well as the absence of copper and manganese are described.

*ALKYL ESTERS OF PHOSPHORIC ACID
C.A.Hochwalt, J.H.Lum, J.E.Malowan and C.P.Dyer
Ind.Eng.Chem. 34, 20-5(1942)

Concentrated aqueous solutions of several alkyl phosphates are good antistatic agents for textile fiber spinning.

STATIC ELECTRICITY IN WORKING RAYON
H.Seifart
Kunstseide 16, 307-12 (1934); Chem.Abs. 28, 7026 (1934)

Two different methods of avoiding the disturbances due to the formation of electrostatic charges in the working of rayon, particularly acetate rayon, are discussed.

The first method which involves preventing formation of the static electricity is to choose suitable surfaces with which the rayon comes into contact or incorporate materials into the filaments. The second method involves the use of devices for discharging the electrostatic charge.

USE OF AMINOCARBOXYLIC ACID DERIVATIVES IN WET TREATMENTS OF MATERIAL SUCH AS IN WETTING-OUT, SIZING, LUBRICATING, DE-ELECTRIFYING OR DISPERSING MATERIALS SUCH AS IN DYEING RAYON, ETC.
H.Dreyfus U.S. 2,063,908 (1936); Chem.Abs. 31, 784 (1937)

As an assistant, there is used a condensation product of an aliphatic aminocarboxylic acid such as 1-methyl-amino-anthraquinone with an ester-forming agent such as the Na salt of sarcosine naphthenate.

CONDITIONING YARN SUCH AS THAT OF CELLULOSE ACETATE
J.B.Dickey and J.G.McNally (Eastman Kodak)
U.S. 2,196,750 (1940); Chem.Abs. 34, 5767 (1940)

A method of eliminating the tendency of yarns, filaments or fibers to accumulate charges of static electricity comprises applying thereto a composition containing as its essential antistatic component a salt selected from the group consisting of the amine salts of furfuryloxy and tetrahydrofurfuryloxy-aliphatic acids.

TREATING STAPLE FIBERS OF CELLULOSE ACETATE
W.T.Jackson and W.G.Faw (Eastman Kodak)
U.S. 2,197,930 (1940); Chem.Abs. 34, 5675 (1940)

To prevent them from accumulating charges of static electricity, cut stapleyarns of material such as cellulose acetate are treated with a composition containing a cyclohexyl-dialkylamine salt of a sulfated aliphatic alcohol containing at least 10 C atoms, such as one of sulfated decyl, lauryl or cetyl alcohol.

CONDITIONING YARN
J.B.Dickey and J.B.Normington (Eastman Kodak)
U.S. 2,197,998 (1940); Chem.Abs. 34, 5676 (1940)

To render yarn, such as that of cellulose acetate or the like more amenable to textile operations such as knitting, weaving, spinning, manufacture of staple fibers and the like, it is treated with a composition containing, as a lubricating and antistatic component, dioxane-2,3-glycolic acid ether butylamine oleylamine salt or other salt of dioxane.

CONDITIONING YARNS SUCH AS THOSE OF ACETATE RAYON
J.B.Dickey and J.G.McNally (Eastman Kodak)
U.S. 2,199,989 (1940); Chem.Abs. 6098 (1940)

This patent relates to the treatment of yarns such as those of acetate rayon with a lubricating and antistatic composition containing diglycolic dioleyl amine salt or other selection from organic amine, mixed organic amine and metallic salts or organic acids.

CONDITIONING YARN SUCH AS THAT FORMED OF ACETATE RAYON
J.B.Dickey (Eastman Kodak) U.S. 2,233,001 (1941); Chem.Abs. 35, 3832 (1941)

A process of conditioning yarn to render it more amenable to textile operations including knitting, weaving spinning, the manufacture of staple fibers, etc., comprises applying a lubricating and antistatic composition containing as its essential lubricating and antistatic component an ester selected from phosphate or thiophosphate esters of partially esterified hydroxy tertiary alkanol amines.

CONDITIONING YARNS OF CELLULOSE ACETATE AND OTHER ORGANIC MATERIALS FOR KNITTING, WEAVING, ETC.
J.B.Dickey (Eastman Kodak) U.S. 2,256,112 (1941); Chem.Abs. 36, 280 (1942)

A method eliminating the tendency of various materials to accumulate charges of static electricity, as in twisting, winding and spinning, involves treating them with a composition containing as an essential antistatic component a phosphinic acid of a ketone.

CONDITIONING YARNS, FILAMENTS OR FIBERS
J.B.Dickey and J.G.McNally (Eastman Kodak)
U.S. 2,279,501 (1942); Chem.Abs. 36, 5360 (1942)

The tendency of the material to accumulate charges of static electricity is inhibited by applying a composition containing bis((1-phenyl-1(hydroxyphenyl)heptane)) phosphinic acid or various hydroxylalkyl aryl phosphinates.

CONDITIONING YARNS SUCH AS THOSE OF CELLULOSE ACETATE
J.B.Dickey (Eastman Kodak) U.S. 2,292,211 (1942); Chem.Abs. 37, 781 (1943)

For eliminating the tendency to accumulate charges of static electricity prior to textile operations upon it, the yarn is treated with $C_{18}H_{35}OCOCOOH.NH_2C_{18}H_{35}$ or other salt selected from mono ester derivatives of polycarboxylic esters.

TREATMENT OF THREADS

G. Loasby and D.L.C. Jackson (British Nylon Spinngers Ltd.)
Brit. 563,725 (1944); Chem.Abs. 40, 3000 (1946)

Threads which are liable to develop electrostatic charges during processing are treated with a composition which comprises an aqueous solution or emulsion containing a condensation product of CH_2CH_2O with a higher fatty alcohol and a lubricating oil.

*FIRE PREVENTION ON HOME-MADE CEMENT COATING MACHINE
Rubber Age 58, 82 (1945)

The following methods were used to reduce static which had been causing fires on a six-roll stand dryer at least once each week.

The machine hood was changed so that the fumes from the cement tank were not exhausted through the drying roll system.

With baffles, the air was made to move across the fabric, instead of from bottom to top above the fabric. This eliminated gas pockets under the fabric, and prevented the accumulation of explosive vapors.

The rolls had been heated by steam, causing the rubber to stick to them. This required frequent cleaning, as it caused the fabric to stick too tight to the roll and generate more static as it was pulled loose. A circulating hot water system was installed, and the temperature maintained at 170°F. The rolls were thus kept at an even, lower temperature, greatly reducing their coating up.

The next step was picking up and removing the static. The ends of all rolls that the fabric passed either over or under were finished to a smooth surface, and a carbon brush installed on every roll. Welding cable was used to pick up the static inside the dryer.

Copper ground stakes, driven in separated locations in the building, and a cold water pipe, were used to ground the system. Each carbon brush and each bar with wire brushes were tied together with copper wire, using approved ground clamps in such a manner that there was continuous circuit to the four grounds.

*ANTISTATIC TREATMENT OF VINYL RESIN TEXTILES

B.G. Wilkes and W.A. Denson (Carbide & Carbon)
U.S. 2,381,020 (1945)

The accumulation of an electrostatic charge on textiles containing vinyl resins can be prevented by a treatment with highly basic polyalkylene imines of a molecular weight from 300 to 1500, especially from 800 to 1000.

MANUFACTURE AND USE OF NEW AMINE SALTS
E.B.Thomas (Celanese Corp.) U.S. 2,384,382 (1945); Chem.Abs. 40, 220 (1946)

The salt of N-diethyl ethylenediamine and lauryl acid sulfate is a useful oil-soluble composition for dressing textile materials, such as silk or cellulose esters, to reduce their tendency to acquire and retain electric charges.

FIBER TREATMENT
F.J.Schliessler (Celanese Corp.)
U.S. 2,406,407 (1946); Chem.Abs. 41, 293 (1947)

Staple fibers having a basis of cellulose acetate or other org. deriv. of cellulose can be rendered more amenable to textile operations by applying to the fibers a conditioning agent. This conditioning agent is applied in the form of a 2% aq. emulsion at a temp. of 40-50°. The antistatic properties of the treated staple fibers are improved. (See following patent)

*TREATMENT OF TEXTILE MATERIALS
G.W.Seymour & W.Brooks (Celanese)
U.S. 2,406,408(1946)

The conditioning agent is formed by reacting a mineral oil, a fatty acid, a vegetable oil, and fuming H_2SO_4, and adding to the reaction product an alkali, an alkyolamine, and water. An alkylated phenol or other spreading or penetrating agent is added also.

*LUBRICANT FOR CELLULOSE ACETATE
G.W.Seymour & Walter Brooks (Celanese)
U.S. 2,407,105 (1946)

A composite lubricant, softening agent, and anti-static agent for use in making high tenacity cellulose acetate and saponified acetate filaments is described.

*LUBRICATION OF TEXTILE FIBERS
H.J.Billings(Monsanto Chem. Co.)
U.S. 2,413,428 (1946)

An aq. soln. contg. 50-60% by weight Na and (or) K salts of Et, Me, or Am phosphates, or alkylamino salts of these phosphates, as triethanolamine Et phosphate, provides a water-sol. hygroscopic lubricant and antistatic compn. that is nontoxic and noninflammable.

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*STATIC ELIMINATOR
U.S.Radium Corporation UTextile World 97, 2,154, 156 (1947)

A new type of self-contained static-eliminator, the "Ionotron," consists of a shielded bar carrying a radioactive alloy strip that ionises the air by virtue of the alpha-rays. The action is said to be permanent for all purposes where passing of material causes a static electric charge to generate.

NEUTRAL ESTERS OF PHOSPHORIC ACID
D.C.Hull and A.HAgett (Eastman Kodak)
U.S. 2,430,569 (1947); Chem.Abs. 42, 3773 (1948)

Neutral esters of phosphoric acid can be used as antistatic agents.

STATIC ELIMINATOR
Anon Text.Inds. p. 91 (Nov. 1949); Ann. Rept. Prog. Rubber Tech. 13, 40 (1949)

A static eliminator employing radioactive polonium has been developed.

TESTING DEVICE FOR ANTI-STATIC CHARACTERISTICS
Anon Text.Inds. p. 113 (Dec. 1949); Ann. Rept. Prog. Rubber Tech. 13, 40 (1949)

A new testing device has been developed by the U.S.Testing Co. for comparing the antistatic characteristics of different fabrics.

*CONDITIONING CELLULOSE ESTER FILAMENTS
John B. Eisen (Am. Viscose Corp.)
U.S. 2,461,043 (1949)

Prior to collection filaments are conditioned by use of an agent which is a nonvolatile, nonaq. soln. in mineral oil plus a higher fatty alc. sulfate as an antistatic agent.

ANTISTATIC TEXTILE MATERIALS
A.L. Fox (General Aniline & Film Co.)
U.S. 2,498,408 (1950); Chem. Abs. 44, 6654 (1950)

Dodecyl ethyl acid orthophosphates and other dialkyl acid orthophosphates such as hexyl ethyl, octadecyl ethyl in concs. of 0.3% or more prevent the accumulation of electrical charges during the processing of fibers or fabrics made of cotton or of cellulose ester derivatives such as cellulose acetate.

*STATIC PROBLEMS AND THEIR CONTROL IN THE TEXTILE INDUSTRY
J.A. Lopez and J. K. Heusen Amer. Dyest. Rept. 41, 105 (1952)

Three factors have caused static problem to be intensified (1) introduction and widespread use of synthetic fibers, (2) increasing speed of textile machinery, (3) pressure for improvement in quality. There are four major problems caused by static (1) reduction in output (2) improvement in quality (3) increase in waste (4) fire or explosion hazards. Discusses the control measure such as grounding the machine or textile, humidity control, chemical additives, radioactive salts and high voltage discharge bars. All of these measures have some drawbacks. Recommends a new development, the controlled diffuse discharge system and gives details for its use.

*THE STATIC ELECTRIFICATION OF TEXTILE YARNS. PART I
V.E. Gonsalves Text. Res. J. 23, 711 (1953)

A theoretical treatment of the generation of static electricity based on the energy levels of the electrons in the various materials.

THE FORMATION MECHANISM OF ELECTROSTATIC CHARGES OF FIBROUS MATERIALS
Heinrich Gruner Faserforsch u. Textiltech 4, 249 (1953)

The formation of electrostatic charges on fibers is caused by touching, rubbing, distortion and warming. Electrostatic charges of identical materials are caused by rubbing them between surfaces of different size. When a perlon thread is torn the ruptured ends are charged; these rupture charges are the result of an ionization at the rupture of molecular chains and indicate that some molecules must be orientated in the fiber direction. Perlon silk shows the piezo effect, and piezo-electric plates can be prepared.

THE ELECTROSTATIC CHARGE OF TEXTILE FIBERS AND ITS PREVENTION
K. Gotze, W. Brasseler and F. Hidgers

Melliand Textilbes 34, 141-2, 220-2, 349-50, 451-2, 548-50, 658, 768-9 (1953); C.A. 48, 13224 (1954)

The electrification of fibers is discussed with special reference to its occurrence in mill operations. The various fibers are compared as regards their ease of electrification which is shown to be closely related to their electrical conductance. An explanation is offered for the electric charge developed on the fibers when they are rubbed together. The means taken in practice to prevent the charging of fibers are reviewed. Tests were made on various yarns to determine the electrostatic charge developed as the result of the rubbing action against a thread guide at various speeds and humidities. Increasing the relative humidity decreased the charge, the effect being greater the higher the speed. The effect of various finishing treatments on electrostatic charge discussed. Generally, any treatment which reduces the friction between the yarn and the machine or which increases the hygroscopity of the yarn reduces the electrostatic charge.

ELECTROSTATIC ELIMINATORS IN THE TEXTILE INDUSTRY
P.S.H. Henry

Brit. J. Appl. Phys. Suppl. No. 2 S78 (1953)

The occurrence of static electricity in the textile industry and the ways in which it interfers with production are briefly described. The general principles and brief description of methods of elimination are given. Classes of eliminators on (1) electric static neutralizers (2) radioactive static eliminator: α -ray (3) radioactive static eliminator: β -ray. A detailed description of an eliminator of the latter type containing radioactive thallium.

THE STATIC ELECTRIFICATION OF TEXTILE YARNS: PART II
V.E. Gonsalves and B.J. van Dongeven

Text. Res. J. 24, 1-12 (1954)

A list is given of the many troubles caused in the textile industry by static. The testing methods for generation of static electricity are discussed and details of the method used in this paper. The voltages generated at different angles of wrap around a thread guide are given for several fibers. The effect of relative humidity on both charge for finished and unfinished fibers which generally shows the higher the humidity the lower the charge.

*STATIC ELECTRICITY IN TEXTILES
J. W. Ballou Text. Res. J. 24, 146 (1954)

A discussion concerned with the physical effects that are objectional from the wearer's standpoint. Three factors enter into these effects - electrical charge, sign of charge and rate of decay. The rate of decay plays an important part because it determines how long a charge will remain. An electrostatic series is developed for Textile fibers. Show how blends of fabrics can be at zero potential when rubbed even though the individual fibers have an electrostatic charge.

*THE DISCHARGE OF ELECTRIFIED TEXTILES
J. A. Medley J. Text. Inst. 45, T 123 (1954)

Discharge processes which may be conveniently utilized for the dissipation of static, are analysed quantitatively and shown to be of three main types.

(a) Conduction within the textile itself, which is responsible for the well-known humidity effect.

(b) Conduction by surface impurities, a different mechanism which accounts for the action of antistatic agents.

(c) Gaseous discharge: this determines maximum charge densities in accordance with geometrical considerations.

STATIC ELECTRICITY IN THE TEXTILE INDUSTRY
Jens Munksgaard Tidsskr. Testiltek 12, 49 (1954)
C.A. 48, 11068 (1954)

A review of this subject based on twenty references, enumerating the advantages and disadvantages of the different methods used in dealing with static electricity, such as use of antistatic chemicals, electrostatic discharges, radioactive radiations and relative humidity.

II. ELECTROSTATIC CONTROL

D. In the paper industry

REMOVAL OF STATIC ELECTRICAL CHARGES FROM PAPER
J. Rathier Papier 37, 83-4 (1934); Chem. Abs. 28, 2898 (1934)

Static electricity was effectively discharged from rolls of paper 750 mm. long and 600 m. in diameter by exposing the end of the roll to the action of ultra-violet light for 10 min. at a distance of 1 m. from Hg-arc lamp. Exposure for such a short period did not affect the color of the paper.

PREVENTING STATIC ELECTRICITY IN PAPER OR TEXTILE TREATING APPARATUS

J.C. Patrick (Thiokol Corp.) U.S. 2,218,176 (1940); Chem. Abs. 35, 1230 (1941)

A guide for moving objects such as cloth or paper which generate static electricity by friction with solids is formed of a solid material having an organic polymeric disulfide along the surface which is in contact with the moving objects.

SEMICONDUCTING COMPOSITION

Donald E. Edgar and D.J. Sullivan (duPont) U.S. 2,408,416 (1946); Chem. Abs. 41, 627 (1947)

Static charges in insulated high tension elec. cables and other nonconducting surfaces are eliminated by coating the flexible elec. insulation (e.g. oil impregnated paper) with a semiconducting compn. comprising finely divided C black of low elec. resistivity dispersed in a vehicle contg. an alkyd resin as the essential film forming ingredient.

*NEUTRALIZATION OF STATIC ELECTRICITY

M.S. Pennell Paper Trade Journal 130, #15, 33-7 (April 13, 1950)

It is shown that the use of capacitative coupling, rather than a high resistance between ionizing point and source of high voltage makes for great flexibility and enables inductors - ionizing bars - to be made in almost any desired form.

Proper application of these inductors requires consideration of several factors. For one thing, the inductor, or at least one of them if more than one is needed, should be located as near the final delivery as possible, since after static is removed from the material its subsequent travel may generate another charge. Sometimes it becomes necessary to use several applications, because static causes trouble at several points in the travel of material through a machine.

Ideal conditions are for the inductor to be applied over or under the web or sheet of paper at some place where nothing intervenes between, and there is an air space on the opposite side of the paper so that the charge in the paper at this point of application shall be a "free" charge rather than a "bound" charge.

II. ELECTROSTATIC CONTROL

E. In the petroleum industry

PREVENTING STATIC CHARGES OF ELECTRICITY IN BENZINE CONTAINERS
C. Lund. Lawerentz — Dan 18, 161 October 15, 1912
C.A. 9, 711 (1913)

A cartridge or a chamber is disposed in the mouth of the supply pipe and provided with a wire gauze connected by a conductor with the earth.

THE ELECTRICAL EXCITABILITY OF BENZENE
M.M. Richter — Chem. Ind. 35, 833; C.A. 7, 1096 (1913)

Experiments with benzine, petroleum, benzene, carbon tetrachloride ether and carbon disulfide. C_6H_6, $C\ Cl_4 2CS_2$ showed up to 13,000 V. There was no ignition in 600 experiments with CS_2. Benzine charged to 5,000 volts lost its charge on contact with the hand in the dark with no visible spark.

*INFLUENCE ON THE ELECTRICAL CONDUCTIVITY OF HEAVY HYDROCARBON OILS OF THE PRESENCE OF SOAPS OF THE NAPHTHENIC ACIDS AND PHENOLS
D. Holde — Ber. 48, 14 (1915); C.A. 9, 1109 (1915)

Conductance is increased markedly by the naphthenic acid soaps and phenol.

THE CONDUCTIVITY AND ELECTRIC EXCITABILITY OF LIQUID INSULATORS
D. Holde — Z. Elektrochem. 22, 1 (1916); C.A. 10, 1136 (1916)

Found that charges generated by benzine, petroleum ether and benzene were quickly transferred to walls of conducting vessel and dissipated if grounded. Addition of ethyl alcohol or acetic acid increases conductance and acts as further safeguard when transferring these liquids to the container.

DISCHARGES CAUSED BY ELECTRICALLY CHARGED BENZINE FLOWING THROUGH NARROW PIPES INTO AN EARTHED CATCH-VESSEL
D. Holde — Z. Elektrochem. 22, 195 (1916) C.A. 11, 885 (1917)

Fires have been caused by electrical discharges generated when benzine or petroleum ether flows from an insulated metal container into an earthed vessel. Gives conductance and half life of charges in benzine. Suggests acetic acid or alcohol to raise conductance.

THE CONDUCTIVITY AND ELECTRICAL EXCITABILITY OF BENZINE, BENZENE AND SIMILAR INFLAMMABLE LIQUIDS
D. Holde — Petroleum 11, 425, C.A. 11, 1291 (1917)

Calculated theoretical time of discharge for electrically excited benzine from conductivity and density. When the conductives holding the benzine are grounded the discharge occurs in a very short time.

SOME CHARACTERISTICS OF THE SPARK DISCHARGE AND ITS EFFECT IN IGNITING EXPLOSIVE MIXTURES
C.C. Paterson and Norman Campbell
Proc. Phys. Soc. 31, 168 (1919)
C.A. 1970 (1919)

The relationship between the electrical characteristics of a spark discharge and its power of exploding ignitable mixtures was investigated. A definite quantity of electricity is discharged by a spark.

Experiments were performed on petrol-air mixtures. Igniting power of spark increases with both the capacity discharging and the spark potential - more with the latter. Shape of electrode influences spark as smaller radius of curvature givesgreater igniting power. Experiments on airplane engines showed that energy required for ignition is only a small fraction of that given by an ordinary magneto or battery and coil system.

ELIMINATION OF THE DANGER OF IGINITION OF ELECTRICALLY CHARGED PETROLEUM SPIRIT, ETHER, ETC.
D. Holde — Ber. pharm. Ges. 29, 569 (1919)
C.A. 14, 1440 (1926)

Experiments with discharge of petroleum spirits. Found charge retained for considerable periods in earthed vessels. Found time of charge dissipation greatly reduced in humid atmosphere. Temperature had little effect.

ELECTRIFICATION OF BENZENE FLOWING THROUGH TUBES
D. Holde — Ber. physik. Ges. 21, 465 (1919)
C.A. 14, 3351 (1920)

When benzene is forced through a small tube the charge is produced by the frictional effect on the walls of the tube.

THE ELECTRIC EXCITATION OF BENZENE CAUSED BY CURRENTS IN TUBES
D. Holde — Arb. Pharm. Inst. Univ. Berlin 12, 49 (1921); Chem. Zent. 1923, III, 1056 - C.A. 18, 2638 (1924)

Proved electrical charge occurring in a current in benzine in an isolated vessel is due to friction on walls and not to waterfall effect.

*EXPLOSION OF AGITATOR CHARGED WITH NAPHTHA
Chem. and Met. Eng. 25, 949 and " " " " 26, 4 (1921-22)

Letters to the editor telling of an explosion of 900 barrel of naphtha in an agitated vessel. The temperature was 70°F. The naphtha had been pumped through litharge and caustic soda.

The second letter indicates a street car 100 yd away passed by at the time of the explosion.

THE DANGER OF ELECTRICALLY EXCITED IGNITION OF FLAMMABLE LIQUIDS
D. Holde — Farben-Ztg. 29, 1891 (1924); C.A. 19, 400 (1925)

The apparatus is described and voltages measured when flowing benzene through the following metal tubes, Fe-4000 V, brass-3600 V, Al 2900 V, Cu-2000 V, humidity of air has some effect but temperature does not.

ELECTRIFICATION OF GASOLINES
L. Bruninghaus — Researches Inventions 7, 735 (1926) C.A. 21, 1004 (1927)

Gasoline passed over Cu or brass filings, loses power of acquiring electrical charges. Probably due to increased conductances. Mg and Fe filing without effect. Zn powder gives temporary effect.

EXPLOSIONS AND FIRE AT PACIFIC WHARF WEST HAM (ENGLAND)
H.E. Watts and H. N. Swan — Special rept. under Petroleum Acts 1871-1926 - June 20, 1927; C.A. 21, 2986 (1927)

A report on the circumstance and probable cause of the accident at the works of Glico Petroleum Ltd. originating in a Pb tank in which 2000 gals. of Roumanian spirit, of the kind used as a solvent for rubber, was being heated with H_2SO_4 for the removal of unsaturated hydrocarbons and sulfur compounds. By means of a circulating pump a mist of the spirit and H_2SO_4 was formed and it is believed that the ignition of the explosive mixture, about the upper part of the tank was due to a static charge built up in the operation.

ELECTRIFICATION OF GASOLINES
Bruninghaus — Ann. Office Nat. Comb. Liquids 2, 507 (1927) C.A. 22, 159 (1928)

From experimental results, concludes that the electrification of gasoline in contact with metal surfaces (which increases with contact surface rather than with the velocity) is due to metal ions which are taken up by the hydrocarbon molecules.

CAUSES OF FIRE IN THE PETROLEUM INDUSTRY WITH METHODS OF PREVENTION
Christopher Dalley — J. Inst. Petroleum Tech. 14, 154 (1928); C.A. 22, 3769 (1928)

States that static or friction cause little risk of fire but that precautions are necessary. Pyrophoric FeS is dangerous in dry atmosphere. It is formed by reaction of H_2S with Fe in tank.

FRICTION ELECTRICITY IN BENZINE AS CAUSE OF FIRE
Heinz Von Falsen — Petroleum 2, 24, 656 (1928) C.A. 23, 269 (1929)

While spent bleaching earth was being removed from a filter press, an explosion occurred which apparently was caused by the discharge of friction electricity generated in an insulated apparatus.

CAUSE OF BENZINE EXPLOSIONS
Robert Burstenbinder — Chem. Tech. Rundschau 45, 40 (1930); C.A. 24, 1513 (1930)

Benzine explosions occurring during its use in cleaning results from electric sparks between the metal container and the body of the individual. They may be avoided by rendering the benzine an electrical conductor by addition of a small quantity (2%) of 96% alcohol.

THE ELECTRICAL CONDUCTANCE OF LIQUID HYDROCARBONS
L. Bruninghaus — Ann. Combustibles Liquides 4, 515 (1930); C.A. 24, 4142 (1930)

Experiments were carried out on liquid petrolatum identical results were obtained with gasoline but volatilization made experiments difficult.

ELECTRIFICATION AND ELECTRICAL CONDUCTION OF LIQUID HYDROCARBONS
L. Bruninghaus — J. phys. radium (7), 1, 11 (1930)
C.A. 24, 2354 (1930)

Liquid hydrocarbons become negatively charged on flowing along metal wall. Shows optimum conditions for generation of electricity. Measured conductance under various conditions. Showed 3 types of conductance. 1. Thick layers under a moderate electrical field show high resistivity. Any cond. is due to traces of H_2O. 2. Thin layers under an intense field produce a semi-conductor. 3. Layer 10μ thick under fields of 100,000 V/cm. have conductance same as metals.

FLUE GAS FOR REDUCING FIRE HAZARDS
A.E. Pew, Jr. — Refine. and Natural Gasoline Mfr. 9, No. 12, 122 (1930); C.A. 25, 1370 (1931)

Various methods are given for using flue gases in tank and refinery equipment. This system also eliminates the danger of discharge from static or bound charges.

*THE ELECTRICAL CONDUCTANCE OF HYDROCARBONS IN THIN FILMS
L. Bruninghaus — Compt. Rend. 192, 151 (1931)
C.A. 25, 2276 (1931)

Films of oil 1μ thick become highly conductive at 110 V d.c. and remain so until electrodes are separated by 15μ.

THE IGNITION OF GASEOUS MIXTURES BY THE CORONA DISCHARGE
R.W. Sloane — Phil. Mag. 19, No. 129, 998 (1935)
C.A. 29, 5753 (1935)

Ignition of coal-gas-air mixtures by discharges between good insulators and metal or between moderate insulators cannot be ignited by discharge between two good insulators.

PREVENTING EXPLOSIONS AND IGNITION OF PETROLEUM PRODUCTS BY STATIC ELECTRICITY
E. Myshkin — Neft 7, No. 7, 24 (1936); C.A 31, 4479 (1937)

Addition of 0.1% of naphthenic acid salts of elements of the 2nd or 3rd group of the periodic system to petroleum products increases their electrical conductance and accordingly lowers the fire hazards due to static electricity.

*ELECTRIFICATION OF INSULATING LIQUIDS BY FLOW OR FILTRATION
C. Reichart — Compt. Rend. 202, 1494 (1936)
C.A. 30, 4408 (1936)

Motor fuel flowing through an outlet pipe and into insulated vessel and on recirculating the negative gradually changed to positive. Also charged by filtering through chamois leather, silk or felt. Motor fuel treated with HCl and untreated chamois leather found potential difference of 50,000 volts and gave 6-7 sparks/min. between 2 spheres 1.65 cm. in diam. and 2 cm. apart.

POSSIBILITIES OF THE SELF-IGNITION OF MINERAL OILS
Zaps and Inglaube — Feuerschutz 17, 91 (1937); C.A. 31 6883 (1937)

Benzine fires occurring in cleaning establishments are due not to any tendency of self-ignition of the solvents, but to electrical excitation and the production of sparks. During the pouring of the benzine electrical tensions up to 9000 V. develop and sparks may be formed on removal of the funnel.

POSSIBILITIES OF THE (SPONTANEOUS) IGNITION OF MINERAL OIL
Karl Sperling — Feuerschutz 17, 142 (1937)
C.A. 32, 335 (1938)

Discusses causes and remedies among which are grounding to discharge static electricity. Catalysis hastens ignition but does not influence temperature of ignition.

ELECTRIFICATION OF GASOLINES
L. Bruninghaus — Bull. Assoc. franc. techniciens petrole 1937 No. 38, 29; C.A. 31, 8874 (1937)

A study of this phenomenon in an apparatus in which gasoline is rendered charged and conducting by passage through a tube filled with brass filings has yielded information to be applied in grounding commercial equipment.

CONDITIONS FOR THE FORMATION OF EXPLOSIVE MIXTURES IN PETROLEUM-STORAGE RESERVOIRS
Z.A.Zaitseva — Azerbaidzhanskoe Neftyanoe Khoz. 1938 No. 2 - 36 C.A. 33, 3157 (1939)

Cracked gasoline does not give explosive mixtures below -10°C. Naphtha with an initial boiling point of 70° to 135° will give an explosive mixture between 0° and 30°.

*STATIC ELECTRICITY IN DRY CLEANING PROCESSES
L. Hartshorn and W.H. Ward — J. Soc. Chem. Ind. 57, 178 (1938)

Discusses uses of water and soap emulsions to increase conductance and decrease static charge.

FIRE IN A DRIVING BELT AND TRANSPORTATION BELT FACTORY AND ITS LESSONS

H. Manskopf — Feuerschutz 18, 181 (1938); C.A. 33, 1941 (1939)

Fire described is probably caused by discharge of static electricity in benzene recovery unit.

FIRE IN A BENZENE TANK PIT

Kattenstroth — Feuerschutz 18, 166 (1938); C.A. 33, 1941 (1939)

Benzene allowed to escape through a petcock left open accidentally, was ignited on contact with a hair broom, probably owing to discharge of a static electric spark.

ELECTROSTATIC PHENOMENA ON THE FILTER PRESSES IN THE DZHAPARIDZL REFINERY

S.N. Usatyi and P.A. Baskutis — Azerbaidzhanskoe Neftyanoe khoz 1940, No. 2-3 56-62; C.A. 34 8234 (1940)

Fires occurring in the filter plants, after the naphtha washing of the bleaching clay deposited on filter cloths or gauzes, were caused by static electric charges on the clay dust.

CARELESSNESS WITH GASOLINE

William H. Gardner — Fire Eng. 93, 446 (1940); C.A. 34, 7608 (1940)

A discussion of the fire and explosion. 400-500 V can be generated in a gasoline supply hose by the friction of the flowing fluid.

FIREDAMP IGNITION BY COMPRESSED AIR DISCHARGES. EXPERIMENTAL WORK TO DETERMINE LIMITS OF RISK

I.C.F. Statham — Iron and Coal Trades Rev. 142, 315 Colliery Guardian 162, 265 (1941) C.A. 35, 5318 (1941)

Earlier work on electrostatic discharges is reviewed. Mine accidents are mentioned. Experiments with electrostatically charged compressed air nozzles are described. When relative humidity falls below 70% danger of explosion is increased.

THE ORIGIN, REMOVAL AND DANGER OF ELECTROSTATIC CHARGES

H. Nitka — Z Ver. Deut. Chem. Beiheft 42, 28 Chem. Fabrik 1941, 211 - C.A. 35, 6794 (1941)

Found high velocities in pipes increased charges. Pipes had little influence except for smoothness of inner surface. Liquids which dissolve water or were hygroscopic are not easily charged. Sprays from insulated vessels gave high charges. Good conductance of material gave best charge prevention. It was also necessary to ground all discharge pipes vessels, nozzles etc. Avoid high velocities, spattering, atomizing or local violent disturbances.

*ELECTRICAL CHARGES PRODUCED BY FLOWING GASOLINE

S.S. Mackeown and V. Wouk — Ind. and Eng. Chem. 34, 659 (1942) Cal. Tech.

Gives details of vacuum tube meter for measuring currents of order (10^{-11} to 10^{-6} amp.) Measurement made on filling of tank trucks, unloading of tank trucks into underground tanks and filling of cars. Graphs and figures given. Highest found was about 90×10^{-8} amp. Current varied with rate of filling and also from gasoline to gasoline. Sign of charge varied in some cases. Also measured resistance of tires. Varied from 12,000 megohms (12×10^{-9} ohm) to 2,000 megohm at fairly low humidity - under damp conditions as low as 10 megohms were obtained - concluded that only under very low humidity conditions in the filling of a tank truck was there any possibility of generating enough current to cause a spark and that only when all precautions had been neglected. Could not account for differences in gasolines.

STATIC AND FLOWING LIQUIDS

Loren G. Farrel — Paint Ind. Mag. 57, 370 (1942) C.A. 37, 540 (1943)

The crux of the static problem is preventing an accumulation of separated charges whose increasing voltage and final sudden discharge will lead to trouble.

REPORT OF SUBCOMMITTEE ON CHEMICAL ASPECTS OF SAFETY AND ACCIDENT PREVENTION

Wilbert J. Huff — Am. Gas. Assoc. Proc. 28, 510 (1946) C.A. 42, 3963 (1948)

A discussion of a natural gas tank explosion in Cleveland which includes recommendations about static electricity. Flash point and ignition temperatures for 217 compounds and limits of inflammability of 119.

FIREPROOF STORAGE OF LIQUIDS FUELS
H. Schulze — Manitias Die. Technik. 2, 437 (1947)
C.A. 42, 2417(1948)

Precautionary measures against spontaneous inflammation, lightning and static electricity by protective gases over the liquid and by proper storage tank arrangements and extinguishing devices are surveyed.

*FORMATION OF STATIC ELECTRIC CHARGES ON AGITATING PETROLEUM PRODUCTS WITH AIR
G.M. Kleerner — Ind. Eng. Chem. 39, 92 (1947)
C.A. 41, 1105 (1947)

There is a close relation between flash point and temperature of explosive. Potentials as low as 300 V may cause ignition whereas several thousand volts may be generated by flowing through pipes at a few ft. per sec. Voltage above those in pipe flow may be expected from air agitation in metal wall containers.

*IGNITION OF EXPLOSIVE GAS MIXTURES BY ELECTRIC SPARKS I. MINIMUM IGNITION ENERGIES AND QUENCHING DISTANCES OF MIXTURES OF METHANE, OXYGEN AND INERT GASES
M.J.Blanc, P.G.Guest, Guenther V. Elbe and B.Lewis
J. Chem. Phys. 15, 798 (1947)

Describe apparatus used for measurements. Discuss effect of inductance (no effect for moderate changes). Electrode voltage (min. ignition energy was found to be essentially independent of overvoltage), electrode distance (increased energy necessary above a certain distance). Mixture compound and pressure (changes considerably with changes in pressure and dilution gas composition).

*IGNITION OF EXPLOSIVE GAS MIXTURES BY ELECTRIC SPARKS - MINIMUM IGNITION ENERGIES
R. Viallard — J. Chem. Phys. 16, 555 (1948)

Discussion of minimum energy necessary to ignite inflammable gases (mixture CH_4, O_2 and inert gas). Comments on a previous theory and takes issue on minimum energy necessary. Indicates that it is dependent on both shape of the electrode and voltage across the spark gap.

*SAFE PRACTICES IN HANDLING FLAMMABLE LIQUIDS
Don Attaway — Petroleum Refiner 28, No. 12, 117 (1949); C.A. 4232 (1950)

A digest of safe practices to be used when handling liquids having a flash point below 200°F and a vapor pressure not exceeding 40 lb/sq. in. with emphasis on application to petroleum tank truck.

*SPARK IGNITION; EFFECT OF MOLECULAR STRUCTURE
H.F. Calcote, C.A. Gregory, C.M. Barnett and R.B. Gilmer
Ind. Eng. Chem. 44, 2656 (1952)

A description of apparatus and experimental details on measuring the minimum ignition energy for 74 compounds - mostly organic. Found values ranging from 0.0033 to 0.000285 Joules for hydrocarbons and olefins. Gives thirteen general principles in correlating structure with ignition energy.

ORIGIN OF ELECTRICAL CHARGES IN HANDLING ANHYDRIC FLAMMABLE SOLVENTS
Maurice Lecaustey — Bull. mens. inform. Iterg 7, 5(1953); C.A. 47, 4011

Dangers presented by electric charges and means to avoid them.

*LIQUIDS GIVING NO ELECTRIFICATION BY BUBBLING
W.R. Harper — Brit. J. Applied Phys. Suppl. No.2, S19 (1953)

A discussion of previous work on electrification by splashing, bubbling, spraying and the shattering of drops. Experimental work showed that if liquid is pure enough to reduce its conductivity to below 10^{-13} ohm per cm, electrification will appear.

*THE ELECTRIFICATION OF FLUIDS IN MOTION
W.F. Cooper — Brit. J. Appl. Phys. Suppl. No. 2 S11 (1953)

The electrification of electrolytes by flow in pipes can be explained in terms of the Helmholtz electrical double layer, and it is suggested that some sort of double layer is also produced in commercial grades of organic liquids such as petroleum, by impurities. The charge produced is expressed in terms of the electrokinetic potential and the Reynolds number. With an immersed discharge, electrification will not be observed unless the resistivity exceeds about 10^{-11} ohms per cm. It is pointed out that the theory is closely associated with hydrodynamics and that in experiments the requirements of dynamic similarity must be observed if important scale effects are to be avoided, and the theory is extended to charges formed on filters and in washing fabrics. Such published experimental work as is available is consistent with the theory set out.

The electrification of drops, spray and wet steam is also discussed briefly.

IGNITION OF FIRE-DAMP BY COMPRESSED-AIR BLASTS
R. Loison and M. Giltaine — Intern. Conf. Directors of Safety in Mines Research 8th Congr. - Paper No. 16, 14 pp. (1954); C.A. 49, 16436 (1955)

The production of electrostatic charges appears to be the most likely mechanism whereby a methane-air mixture is ignited by a blast of compressed air. The presence of dust in suspension in the air-stream is not absolutely necessary. By projection of metallic particles, other than ferro-cerium, ignition was obtained at temperatures much higher than room temperature. It was difficult to produce ignition by sudden bursting of a membrane.

CONCLUSIONS REACHED IN AN INVESTIGATION OF A KEROSINE STORAGE - CAUSE OF THE EXPLOSION AT BITBURG
K. Nabert and G. Schon — Erdol u. Kohle 8, 809 (1955) C.A. 50, 8207 (1956)

An underground storage tank partially filled with kerosine exploded near Bitburg in September 1954 killing 29 people. The explosion occurred after considerable amounts of CO_2 had been charged into the tank for testing of the fire extinguishing installation. Cause and possible preventive measures are considered.

IGNITION OF FIRE-DAMP BY A JET OF COMPRESSED AIR
R. Laison and M. Giltaire — Rev. Ind. Minerale 36, 21 (1955); C.A. 49, 9280 (1955)

Ignition of fire-damp by a jet of compressed air released on it by a sudden defect in the compressed-air lines is attributed to (1) electrostatic phenomena, (2) projection of solid particles carried by the air (3) sudden rupture of the diaphragm or wall separating gas and compressed air. Of metallic particles, only pyrophoric Fe or Fe-Ce can cause ignition if at a temperature of 150°; all other metallic particles and dusts require much higher temperatures and higher velocities than usually exists. A special testing apparatus is described.

* MECHANISM OF FRICTIONAL ELECTRIFICATION OF DIELECTRIC LIQUIDS
F.M. Ernsberger — J. Appl. Phys. 27, 418 (1956)

Commercial hydrocarbon fuels, when purified by absorption on silica gel, become triboelectrically inactive. Found that positive electrification can be restored by adding traces of acidic materials while if basic materials are added negative electrification results. Neutral substances have no effect. Proposed a mechanism of chemically adsorbed electrically neutral molecules at the interface which may break away as charged particles.

SPARK IGNITION OF FLOWING GASES USING LONG-DURATION DISCHARGES
Clyde C. Swett, Jr. Symposium on Combustion, 6th Yale Univ. 1956, 523 - 32

From experimental data a theory of spark ignition in nonturbulent and turbulent flowing homogeneous gases by means of long-duration discharges has been developed, based on the concept that only a portion of the discharge length is important in ignition. This theory has resulted in a relation among the variables, ignition energy, gas density and velocity, electrode spacing, spark duration, intensity of turbulence and fuel constants. The limited amount of data available substantiate the relation, except for the fuel-air ratio, which requires empirical correction.

*THE INFLUENCE OF EXTRANEOUS SUBSTANCES ON THE ELECTROSTATIC CHARGING OF FLOWING HYDROCARBONS
B. Hampel and H. Luther Chemie Ingenieur Technik. 29, 323 (1957)

The electrostatic charging of purified n-heptane was measured as a function of the type and quantity of different additives (alcohols, peroxides, esters, amines, mercaptans and silicones). The charging current was proportional to the conductivity of the system over the range 10^{-18} to 10^{11} $ohms^{-1}$ $cm.^{-1}$. The electrostatic charging of Technical hydrocarbon fractions was caused in the main by the oxidation products.

METHOD OF DISCHARGING CARBON DIOXIDE TO INHIBIT ELECTROSTATIC CHARGE GENERATION
Harry C. Grant, Jr. U.S. 2,785,124, March 12, 1957
C.A. 51, 8438 (1957)

The generation of electrostatic charge in the operation of a snow-forming CO_2 fire extinguisher is reduced 50-fold by mixing CO_2 an oily additive, such as kerosine, in an amount between 0.2% and 1.6% of the weight of CO_2.

EXPERIMENTS ON ELECTROSTATIC CHARGING OF CARBON DIOXIDE SNOW
A. Tietze Z. Naturforsch 12A, 82 (1957); CA 51, 10179 (1957)

The carbon dioxide snow, formed during rapid escape from a high pressure tank is negatively charged. Addition of methyl alcohol, ethyl alcohol, amyl alcohol, toluene, silicon oils and commercial antistatic agents had no effect. Only water caused a profound effect. One percent water causes transpolarization. Further addition caused a larger positive charge than the negative charge on dry snow.

CARBON DIOXIDE CONTAINING A MATERIAL TO SUPPRESS THE GENERATION OF ELECTROSTATIC CHARGES UPON DISCHARGE
Charles Anthony, Jr. U.S. 2,820,761, January 21, 1958
C.A. 52, 7704 (1958)

A means is described of supressing the generation of electrostatic charges upon discharge of fluid CO_2 by the addition of 0.0075-1% of readily miscible polyalkyl esters. Borates, carbonates, oxylates, phosphates phthalate etc., are claimed.

II. ELECTROSTATIC CONTROL

F. In miscellaneous industries

EXPLOSIONS IN THE ALUMINUM BRONZE INDUSTRY
M.M. Richter Chem. Ztg. 32, 136; C.A. 2, 1491 (1908)

Powdered aluminum does not conduct electricity due to coating of oxide. Voltages up to 3000 have been developed in pouring powdered aluminum. Explosions have occurred 90 secs. after the plant started operating.

ELECTRICAL EXCITATIONS IN SPLASHING OF LIQUIDS
I.C. Christiansen Ann. Physik. 40, 107 and 233; C.A. 7, 3069 (1913)

Water and a large number of aqueous solutions of various sort are splashed through a tube containing a wire connected to an electrometer and deflections are recorded. Over a hundred experiments are recorded and described but no very definite conclusions are reached.

*DUST EXPLOSIONS
David J. Price Chem. and Met. Eng. 24, 473, 737 (1921)

Discuss the problem of dust explosions in industrial plants, possible causes including static electricity and methods of prevention. The 2nd article covers a hard rubber dust explosion and gives its possible cause.

*STATIC ELECTRICAL CHARGES DETECTED BY NEON TESTER
B.E. Shackleford Chem. Met. Eng. 26, 703 (1922);
C.A. 16, 1533 (1922)

A neon filled Geissler tube is used to test for static electricity in industrial plants. The tube glows at voltages of 700 or over. It can also be used to drain off the static by grounding the tube.

CONTACT ELECTRICITY OF SOLID DIELECTRICS

H.F. Richards — Phys. Rev. 22, 122 (1923); C.A. 18, 15 (1924)

Quartz, fluorite, crown glass, flint glass and steel were wrung in pairs. The charge was found to be independent of the friction and of ionization by x-rays and proportional to the area of contact and to dielectric constant if the dielectric constant of steel is assumed to be 3.1. Compressing one amorphous dielectric on another gives a charge independent of the nature of the harder.

THE INFLUENCE OF THE SURROUNDING MEDIUM ON FRICTIONAL ELECTRICITY

J. H. Jones — Phil. Mag. 50, 1160 (1925); C.A. 20, 333 (1926)

The metal wheel gives the best results in air, ebonite the poorest; while the ebonite wheel gives the best results in oil, metal the poorest. The order of the gaseous media for the best production of Frictional Electricity is SO_2, air, N_2, coal-gas, H_2, CO_2, O_2, O_3. The static electricity is produced by the friction of rubbing silk against the wheel.

TRIBOELECTRICITY AND FRICTION. VII QUANTITATIVE RESULTS FOR METALS AND OTHER SOLID ELEMENTS WITH SILICA

P.E. Shaw and E.W.L. Leavey — Proc. Roy. Soc. A138, 502 (1932) C.A. 27, 1250 (1933)

Measurements of voltage generated on rubbing a SiO_2 rod against various metals. The voltages range from +17 for gold to - 7.7 for selenium.

*A HIGH VOLTAGE DIRECT CURRENT GENERATOR

R.E. Vollrath — Phys. Rev. 42, 298 (1932)

Used frictional electrification of diatomaceous earth by blowing with air through a metal tube. Currents of 8 x 10^{-5} amps. at 260 kilovolts were generated.

FIRES IN SULFUR MILLS AND STORAGE PLACES

Schubert — Feuerschutz 17, 80 (1937); C.A. 31, 6883 (1937)

Friction (shoveling, filling into bags, breaking and grinding in mill) produces an electrical tension which by means of a discharge spark will cause a dust explosion followed by ignition of the sulfur. Wooden scoops instead of iron eliminated the sparks.

THE RISK OF EXPLOSIONS DUE TO ELECTRIFICATION IN OPERATING THEATERS OF HOSPITALS

W.W. Thornton — J. Inst. Elec. Engrs. (London) 83, 156 (1938); C.A. 33, 1148 (1939)

Electrification of a frictional character, sufficient to produce a in a simple manner. Conductive rubber promises a valuable prevention.

INTERCHANGE OF ELECTRICITY BETWEEN SOLIDS, LIQUIDS AND GASES IN MECHANICAL ACTION
S.K. Banerji — Indian J. Phys. 12, 409 (1938)
C.A. 33, 4490 (1939)

In friction, spraying etc., the total charge in the system is zero and the amount of charge on any part thereof depends on the violence of the action. Many and widely different local distributions of positive and negative charge can be found within a given system.

NEW FIRE AND EXPLOSION HAZARDS
T. Alfred Fleming — Fire Protection 103, No. 8 - 10 (1938)
C.A. 32, 7727 (1938)

Discussion of new sources of fire hazards and actual accidents due to these hazards. Methods of avoiding similar incidents are given. Static electricity is one discussed.

HAZARDS OF STATIC ELECTRICITY DURING SURGICAL ANESTHESIA WITH O_2-ETHER MIXTURE
M.H. Remund and S. Wehrli — Schweiy. med. Wochsch. 69, 660 (1939)
C.A. 34, 1852 (1940)

Static charge of the insulated table and patient apparently caused two explosions with ether and oxygen mixtures.

CONTACT ELECTRIFICATION OF SOLID PARTICLES
R. Schnormann — Proc. Phys. Soc. 53, 547 (1941);
C.A. 36, 14

Measured electrification for many types of material on pouring from metal and glass vessels both in air and in vacuum.

STATIC DISCHARGES AS A CAUSE OF FIRES AND EXPLOSIONS
Volke Fritsch — Z. ges. Schiess u. Sprengstoffw Nitrocellulose 38, 109 (1943);
C.A. 38, 2210 (1944)

A review.

*THE EFFECT OF ADSORBED GASES ON CONTACT ELECTRIFICATION
D.E.Debeau — Phys. Rev. 66, 9 (1944)

Worked with quartz and NaCl contacting nickel in atmospheres of air, oxygen and nitrogen. Press. dependent results indicate contact electrification is a surface phenomena which depends on the surfaces involved. Two layers of absorbed gas are involved and when one is removed the other makes a major contribution to charge separation. At press. below 0.1 mm. the second layer is removed and this surface makes the major contribution to charge separation.

ANNUAL REPORT ON RESEARCH AND TECHNOLOGIC WORK ON COAL - FISCAL YEAR 1944
A.C. Fieldner, P.L. Fisher and R.E. Brewer
U.S. Bur. Mines Inform. Circ. 7322, 79 pages C.A. 46, 5897 (1945)

Mostly on coal - some results on ignition of gaseous mixtures by static electricity are given.

SENSITIVITY OF EXPLOSIVES TO INITIATION BY ELECTROSTATIC DISCHARGES
F.W. Brown, D.J. Kusler and F.D. Gibson
U.S. Bur. Mines Rept. Invest. No. 3852 8 p (1946); C.A. 41 6721 (1947)

Twenty-seven materials subjected to discharge either in confined or unconfined condition. Energies of 0.015 Joules or less required in many cases to ignite.

TOWER LIMITS OF INFLAMMABILITY IN THE PRESENCE OF DILUENTS
J.H. Burgoyne — Fuel 27, #4, 118 - 125 (1948) C.A. 43, 407 (1949)

A critical review of data.

*FRICTIONAL ELECTRIFICATION OF SAND
E.W.B. Gill — Nature 162, 568 (1948)

Found that dust from sand has a relatively fast moving positive dust and slow moving negative dust.

*EXPLOSIBILITY OF DUST DISPERSIONS
Irving Hartmann, — Ind. Eng. Chem. 40 752 (1948); C.A. 42, 4348 (1948)

The nature of the dust hazards and importance of dust explosions and various chem. and physical factors affecting dust explosibility are reviewed. Mg, Zr, Ti and some Mg-Al alloy powders can be ignited in a CO_2 atmosphere. Mg powder explodes violently in a Freon 12 atmosphere, Al powder somewhat less. Freon is generally considered inert.

*STATIC ELECTRIFICATION IN PROCESSING OF FIBERS: VARIATION WITH MOISTURE REGAIN DURING CARDING
J.F. Keggin, G. Morris and A.M. Yuill
J. Text. Inst. 40, T702 (1949)

Apparatus is used to determine charges in processing various fibers at different moisture concentration. Capacitance is independent of moisture regain with all fibers but cellulosic where it increases rapidly with regain.

*FRICTIONAL ELECTRIFICATION
E.W.B. Gill and G.F. Alfrey   Nature 163, 172 (1949)

Experiments on sand and ebonite sliding down a metal plate and measurement of charge produced. A potential between metal plate and a second plate placed above it would increase or reduce to zero or change the sign of charge developed depending on sign and amount of potential.

*ELECTRIFICATION OF LIQUID DROPS
E.W.B. Gill and G.F. Alfrey   Nature 164, 1003 (1949)

Measured potential induced by a field around falling drops into a copper vessel having an induced voltage.

*THE VOLTA EFFECT AS A CAUSE OF STATIC ELECTRIFICATION
W.R. Harper   Proc. Roy. Soc. A205, 83 (1951)

An experimental investigation of the static electrification of metal-metal surfaces shows that the erratic results normally obtained are owing to their being more than one cause, and that the complete elimination of rubbing leaves an effect that is amenable to quantitative measurement. This "separation charging" is shown to be related to the contact potential, and to have the characteristics to be expected if the Volta-Helmholtz hypothesis of its origin is correct. The supposition that the hypothesis predicts negligible charging of conductor-conductor surfaces is shown to be based on an inadequate understanding of the significance of surface topography at the points of contact. By paying proper attention to this, and revising the hypothesis to allow for the transfer of electrons by tunnel effect, a precise theory of separation charging is derived.

UNEXPECTED FIRES AND EXPLOSIONS
Rudolf Freitag   Brauwelt 1949, 559; C.A. 46, 8858 (1952)

A discussion of explosions in refrigeration plants, of explosions occurring when old, empty iron casks are opened, those occurring with compressed air equipment and vacuum equipment and spontaneous combustion of 99 - 99.5% nitric acid.

*PRODUCTION OF ELECTRIC CHARGES ON WATER DROPS
E.W.B. Gill and G.F. Alfrey   Nature 169, 203 (1952)

Charges are produced on water when it is sprayed on ice but magnitude and sign vary. The results were inconsistant. On freezing ice in contact with water a potential of about 50 V is built up with ice positive and water negative. In some cases on melting, a small reverse potential was noted.

*DETERMINATION OF ELECTRICAL CONDUCTIVITY OF CROSS-LINKED POLY-ELECTROLYTES, RESINS AND GELS
G.J. Hill, A.O. Jakubcvic and J.A. Kitchener
J. Polymer Sci. 19, 382 (1956)

A discussion of several methods of measuring conductance of this type of material with faults of each. A new method is outlined where the potential difference between two points is measured when a voltage is applied along the rod.

*CONTROLLING STATIC ELECTRICITY WITH ELECTROSTATIC NEUTRALIZER
Robin Beach
Prod. Eng. 24, Oct. p. 177 and Nov. p. 167 (1953)

Discusses harmful effects of static electricity in the processing industries. Mentions fire and explosions, accidents to personnel due to involuntary muscular responses to shock, and improper processing which will reduce efficiency of machines. States that all electrostatic neutralizers work by ionization of the air close to the charged material. The ions of opposite charge are attracted and neutralize the unwanted charge. Three general types of static neutralizers (1) High voltage pre-ionizers (2) Radioactive Pre-ionizing (3) Induction. Type 1 and 2 have advantage that they neutralize any charge found but the amount of charge they can neutralize is limited. Used on textile fibers and other applications where complete neutralization must be obtained. They do present hazards if not properly installed. Type 3 has the disadvantage that they only start working when the voltage is of the order of several hundred volts and leave this residual voltage on the material. It has the advantage of unlimited neutralization. Works well for high dielectric quality stock running at top industrial speeds. Care should be taken in choosing the proper neutralizer for each application and also in its location.

*INDUSTRIAL FIRES AND EXPLOSIONS FROM ELECTROSTATIC ORIGIN
Robin Beach
Mech. Eng. 75, 307 (1953)

A discussion which covers conditions necessary for explosions - oxygen, presence of fuel and a source of ignition; flammable mixtures. The hydrocarbon family generally has an explosive range from 1-8% by volume and requires a source of spark energy of only about 0.1 to 0.3 millijoule to ignite it. For metallic and organic dust clouds, minimum explosive concentrations occur as low as 0.02 oz. per. cu. ft. for magnesium but require 10 - 100 millijoule for ignition. Generation of static electricity - lists ten general situations found in industry where trouble from static electricity can be expected as well as the magnitude of charge - potentials varying from a few thousand to many million of volts. Development of high voltage - the increase in voltage as two charged materials are separated is discussed: Electrification by induction - a phenomena where a charge on one object, such as a thundercloud, will cause an insulated object to slowly acquire a charge from leakage through the insulator from earth; Control of electrostatic hazards - electrostatic neutralizers are recommended for some situations but are not a cure-all; Typical electrostatic problems in industry - discusses problems in petroleum, chemical, and dispersion industries as well as airport hazards. In general - each problem must be treated separately.

ELECTRIFICATION BY FREEZING
E.W.B. Gill — Brit. J. Appl. Phys. Suppl. No. 2, S16 (1953)

The high potentials of the order of 100 V developed when ice is formed from dilute solutions were investigated to discover the mechanism. Contact potentials between solids and liquids are usually of the order of 1 V and some additional fact must operate to achieve 100 V. The theory suggested is that, whereas in the usual case the charges producing the potentials are adjacent to the boundary, in the case of freezing ice the charges extend to a small distance from this boundary.

THE DISSIPATION OF ELECTRICAL CHARGES GENERATED BY ROLLERS
J.A. Medley — Brit. J. Appl. Phys. Suppl. No. 2 S23 (1953)

Shows that gaseous discharge limits the charge density and that it can be reduced further by conductors auxiliary to the rollers. Confirmed experimentally that as the bulk conductivity of a surface agent attains a calculable critical value in practice of the order of 10^{-9} mho per cm. the electrification rapidly disappears.

METHODS OF INCREASING THE ELECTRICAL CONDUCTIVITY OF SURFACES
J.S. Forrest — Brit. J. Appl. Phys. Suppl. No. 2 S37 (1953)

Difficulties due to electrostatic charges on insulating surfaces can be overcome by coating the surface with an electrically-conducting film. The paper describes conducting films of metallic oxides, metals carbon, moisture and wetting agents. Information is also given on the application of these films to ceramic and plastic insulating materials.

TWO ELECTROSTATIC FIELD-METERS
A.S. Cross — Brit. J. of Appl. Phys. 4, Suppl. 2 S47 (1953)

Two electrostatic field-meters are described, one operating from a.c. mains and the other from dry batteries.

THE PRACTICAL ESTIMATION OF ELECTROSTATIC HAZARDS
W.F. Cooper — Brit. J. Appl. Phys. Suppl. No. 2 S71 (1953)

The paper deals with experimental procedure and methods of calculation rather than with particular results. An attempt is made to provide a basis for the quantitative study of electrostatic hazards met in industry and attention is drawn to several elementary but important details which are frequently overlooked.

FACTORS IN THE DESIGN OF AN OPERATING THEATRE FREE FROM ELECTRO-STATIC RISKS

D. Bulgin — Brit. J. Appl. Phys. Suppl. No. S87 (1953)

A theoretical treatment is given of the factors governing the voltage attained by surfaces under stated conditions of separation and electrical resistance. The results are supported by observed values and indicate that the resistance of rubber articles should lie between 100,000 ohm and 10 megaohms.

SAFETY MEASURES IN OPERATING THEATRES AND THE USE OF A RADIOACTIVE THALLIUM SOURCE TO DISSIPATE STATIC ELECTRICITY

A. Quinton — Brit. J. Appl. Phys. Suppl. No. 2 S92 (1953)

Precautionary measures to minimize the risk of explosions due to the ignition of anaesthetic gas mixtures are described. Special attention is given to the elimination of charges of static electricity, including the use of an apparatus incorporating a radio thallium source.

THE ELECTROSTATIC IGNITABILITY AND ELECTRIFICATION OF FINELY POWDERED HEXAMINE

A.G. Peace — Brit. J. Appl. Phys. Suppl. No. 2 S94 (1953)

It is shown that finely divided dry Hexamine powder when dispersed in a dust cloud can be ignited by electric sparks of energy less than 0.005 Joule. and that certain previously established principles of spark ignition apply also to this substance. The powder is shown to be readily electrified in various mechanical operations similar to those used in manufacturing.

*ELIMINATION OF A STATIC HAZARD BY THE USE OF RADIOACTIVE STRONTIUM

G.G. Fowlie and G. Morris — Ind. Chemist. 29, 585 (1953); C.A. 48, 9234 (1954)

Eight 1.5 mc. Sr-90Y-90 beta-sources were mounted in the ceiling of a 22 x 14 x 7.5 ft. lead styphnate drying shed. The radiation lowered the resistance between an average man and ground to less than 6×10^{10} ohms, effectively preventing formation of small charges and subsequent sparks. The radiation health hazard was negligible.

*THE IGNITION OF EXPLOSIVES BY CONDENSER DISCHARGES EFFECT OF ADDED CIRCUIT RESISTANCE
G. Morris — Brit. J. Appl. Phys. Suppl. No. 2 S97 (1953)

To investigate the mechanism of ignition of explosives by capacitance sparks, the critical ignition energy of lead trinitroresorcinate has been examined for a wide range of capacitance and series resistance. The experimental data do not completely conform to the same energy - time relation as for ignition by hot wires. A useful empirical relation is found. The use of added resistance in earth lines is shown to decrease plant safety.

* TEN YEARS OF RESEARCH ON ELECTROSTATICS AT THE UNIV. OF GRENOBLE - 1942-52
N. J. Felici — Brit. J. Appl. Phys. Suppl. No. 2, S62 (1953)

The emphasis is on the practical development and application of electrostatic generators rather than on theoretical consideration. Description of various generators are given capable of giving up to 230 KV.

*THE ROLE OF ASYMETRIC RUBBING IN THE GENERATION OF STATIC ELECTRICITY
P.S.H. Henry — Brit. J. Appl. Phys. Suppl. No. 2, S31 (1953)

Two independent types of contact electrification are discussed. The one requiring different surfaces but not needing friction, the other requiring asymetric rubbing but not a difference in the surfaces. It is suggested that the combination of these two effects which occurs when different surfaces are rubbed together, is a contributory factor to the notorious uncertainty of such experiments.

*CONTACT CHARGING BETWEEN A BOROSILICATE GLASS AND NICKEL
J. W. Peterson — J. Appl. Phys. 25, 501 (1954)

The charging of borosilicate glass spheres rolling on clean nickel has been studied under controlled conditions of cleanliness, humidity and gas pressure. Strong evidence indicates the process of charge transfer to be a type of contact electrification akin to that operating between two metals. The amount of charge acquired increases with surface area in contact and hence with distance rolled until other factors intervene. The rate of charging depends on rolling speed and surface conductivity of the borosilicate glass, while the maximum equilibrium charge depends on the pressure of the gas. The gas pressure effect is caused by electrical discharge of the highly charged sections of the glass to the metal and causes a minimum equilibrium charge at about 1 mm. air pressure. The effect of transverse electrical fields is negligible for low surface conductivity but becomes important at higher surface conductivity.

CONTACT CHARGING BETWEEN NONCONDUCTORS AND METAL
J.W. Peterson J. Appl. Phys. 25, 907 (1954)

An investigation has been made of the charging of fused quartz and borosilicate glass spheres rolling on a clean nickel surface. The process of acquiring charge depends only upon the nature and surface condition of the materials and is independent of the pressure of an atmosphere of dry nitrogen. The total charge is limited by gaseous discharge to the metal and therefore does depend upon the pressure. The rate of acquiring charge and maximum charge in vacuum has been found to depend upon rolling speed, both reaching a maximum at intermediate speed, and to decrease with increasing surface conductivity.

THE ELECTRICAL CONDUCTIVITY OF INSULATING MATERIALS BEFORE, DURING AND AFTER RADIATION
I.M. Rozman and K.G. Tsimmes Zhor. Tekk. Fiz. 26, 1681 (1956); C.A. 51, 6247 (1957)

A new method is described for simplified measurement of electrical conductance of insulating material before, during and after the effect of ionizing radiation.

SEDIMENTATION POTENTIALS - PART I - THE MEASUREMENT OF SEDIMENTATION POTENTIALS IN SOME AQUEOUS AND NON-AQUEOUS MEDIA
G.A.H. Elton and J.B. Peace J. Chem. Soc. 1956, 22

An experimental study has been made of sedimentation potentials of glass particles in water and dilute aqueous potassium chloride, and of silica and glass particles in toluene and ether. The results for aqueous media have been used in a preliminary test of the theoretical equations of Smoluchoweski and of Hermans. The potentials obtained in non-aqueous media appear to be electrostatic in origin and cannot be interpreted on the basis of these electrokinetic equations.

COMBATING FIRE RISKS
R.W. Iwens Paint Manuf. 27, 143 (1957) C.A. 51, 9162 (1957)

The precautions necessary to minimize fire risks in the paint industry and some of the equipment to combat the menace are described.

FIRE PORTECTION IN THE CHEMICAL INDUSTRY
N.E. Strother-Smith Mfg. Chemist 28, 109 (1957); C.A. 51, 9162 (1957)

The main causes (mechanical heat, faulty electric wiring, smoking, spontaneous combustion, static electricity, chemical reactions, heating equipment, etc.) of fire are discussed, and the basic principles of fire protection are outlined.

ELECTROSTATIC CHARGING OF CdS CRYSTALS UNDER THE INFLUENCE OF STRONG FIELDS

K.W. Boer and U Kummel — Z. Naturforsch 12a, 667 (1957)
C.A. 52, 4264 (1958)

The electrostatic charging of CdS single crystals was investigated. The size of a charge depends on the position of the crystal in the contact clamp. Some crystals are charged negatively and some positively, depending on their position. The charging increases first with the voltage which reaches a maximum and then decreases. The charging effects are connected with relatively large time constants because the transport of the charges goes over crystal phases which are bad conductors.

REDUCING STATIC ELECTRICITY INSIDE STORAGE TANKS BY USE OF RADIO-ACTIVE MATERIAL

J.J. Conradi, T.R. Miller and J.J. Skelly
Oil Gas J. 55, No. 46, 197-8 (1957);
C.A. 52, 7671 (1958)

A 0.1 curie Sr-90-Y-90 beta source provides sufficient ionization in the vapor space of oil-storage tanks to provide a conducting path through which the hydrocarbon surface can be dissipated.

ELECTRICALLY CONDUCTIVE ADHESIVE TAPE

Jos. J. Coleman and S. Kurlandsky (Burgess Battery Co)
U.S. 2,808,352 October 1, 1957
C.A. 52, 1687 (1958)

The tape has a backing of thin electrically conducting sheet material and an electrically conductive coating. The adhesive composition containing about 35 parts by weight of polyisobutylene, 40 parts of finely divided silver and a plasticizer.

SUPPLEMENTARY BIBLIOGRAPHY

ELECTROSTATIC INVESTIGATION

This supplementary bibliography contains references which are not available in our library. In certain instances titles were given in the Chemical Abstracts but no information. In other cases the titles are not given. The listing is given as potential references if additional search is required.

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