

# 1956 SUPPLEMENT TO BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS-1955 AND 1956

1955

**No. 2283.** A. Keil, "Measurement of Conductivity in Metal Leafs Produced Electrolytically," *Metalloberfläche*, Vol. 9 (1955), p. 81.

**No. 2284.** A. Keil, "Soft Solders for Particular Purposes," *Metalloberfläche*, Vol. 9 (1955), p. 689.

This paper considers binary and ternary alloys of cadmium, lead, tin, and zinc and their properties as soft solders. The particular influences of additions of copper and silver are pointed out.

**No. 2285** A. Keil and G. Offner, "Method of Producing Silver Coatings on Dielectric Material," *Elektronische Rundschau*, Vol. 9 (1955), p. 432.

This paper discusses the preparation of silver surfaces on dielectric materials and means of testing the characteristics of these surfaces.

**No. 2286** H. Dzierzek, W. Winiarski, and J. Halladin, "A Series of Tests of Contacts and Driving Mechanisms of High-Voltage Circuit Breakers in a Testing Station," *Przegląd Elektrotech.*, Vol. 31, No. 6 (1955), pp. 403-406. (In Polish.)

Oil circuit breakers rated 10 kv, 400 a, 100 mva and 30 kv, 600 a, 300 mva and a small oil-volume breaker 6 kv, 600 a, 200 mva were tested. Performances of motor-driven mechanisms and deterioration of contact assembly were investigated. Limitations of available test equipment are indicated. (*Science Abstracts*)

**No. 2287** T. Lipski, J. Gatkiewicz, H. Dzierzek, and W. Winiarski, "Examination of Current Throw-Over Phenomena on Contact Systems in Low-Voltage Circuit Breakers," *Przegląd Elektrotech.*, Vol. 31, No. 6 (1955), pp. 400-403. (In Polish.)

Voltage drop measurements have been successfully used to investigate the throw-over of current and arc from main to auxiliary contacts in 500 v, 400 a, 25 ka interrupting capacity air circuit breakers. Details of APU-30 air circuit breaker contacts, measuring circuits and oscillograms obtained with currents from 22 ka<sub>max</sub> to 77 ka<sub>max</sub> are given. Possibilities of throw-back and burning of main contacts impose limitations on current interrupting capacity of air circuit breakers. (*Science Abstracts*)

**No. 2288.** R. Gert, "Investigations of the Recovery Voltage in Czechoslovakian Power Systems," *Elektrotech. Obzor.*, Vol. 44, No. 12 (1955), pp. 641-651. (In Czech.)

Three experimental methods and one theoretical method of determining recovery voltages were used on 100-kv, 22-kv, and 6-kv systems operated by one company. The r.r.v. values were found theoretically for 919 circuit breakers and then confirmed by experiment wherever possible. Agreement between experiment and theory was satisfactory. The results obtained were also evaluated graphically and statistically. (*Science Abstracts*)

**No. 2289.** J. Riddlestone, "Metal Transfer Between Palladium and Silver Contacts at Low Inductances," *Rep. Brit. Elect. Res. Assoc.*, Rep. U/T133 (1955), 10 pp.

Gives results for transfer between contacts of Pd and Ag breaking a 6-v circuit carrying currents between 3 and 15 a with inductance in the range of 0.07 to 96  $\mu$ H. Curves are given for the mean cathode gain and the growth of pip steepness for the two metals. The results are compared with those for Pt under similar conditions and it is inferred that transfer between metal contacts is generally the resultant of the superposition of four types of transfer, namely "residual transfer," reversed short arc transfer," "short arc transfer," and "long arc transfer." For Pt, with the range of currents and inductances used, it is possible to observe the effect of all four types, for Pd, "residual transfer" is not apparent and for Ag only the "short arc" and "long arc" transfers are apparent. If the circuit inductance could be reduced to very small values, Pd and Ag might show the complete range of transfer. A theoretical explanation is given of the dissimilarity between the transfer for Ag on the one hand and Pd and Pt on the other. (*Science Abstracts*)

**No. 2290.** V. M. Rusidze, "Sectional Main Switching Yards," *Elektrichestvo*, No. 11, 1955 pp. 67-69. (In Russian.)

Until the production of generators with divided windings is under way, it will be possible to obtain sectional switching yards by erecting at the generator lead-outs sectional reactors and using 1-ph. transformers with divided windings of rating up to 60 mva; these switching yards are provided with a single closed system of busbars for the connection of every generator and transformer to the neighboring group and coupling of out-

going lines by bridge-type circuit breakers. On the occurrence of faults on generators, transformers, or busbars the service is maintained by automatic closing of normally open sectional or bridge-type circuit breakers. Calculation of the short-circuit currents shows that in this type of switching yard, unit cells can be used with type MGG-10 or VMG-133 circuit breakers and without line reactors. (*Science Abstracts*)

No. 2291. D. I. Gretskov, "Phase Separation in Distribution Plant of Regional Substations," *Elekt. Stantsii*, No. 11 (1955), pp. 28-33. (In Russian.)

Isolators are not arranged between circuit breaker pole and phase busbar but on the other side of the circuit breaker, another isolator connecting directly to an auxiliary busbar. This arrangement permits routine maintenance without disconnection of consumers, although with fault interruption in only two phases. The economics of this arrangement are discussed with design sketches of outdoor (35-220 kv) and indoor plant (6-35 kv.) Operational experience has been favorable with 3 substations of 35/6 kv in service since 1952. (*Science Abstracts*)

No. 2292. F. Houst, "The Rupture of Low Voltage Currents in Quenching Chambers," *Elektrotech. Obzorn*, Vol. 44, No. 9 (1955), pp. 476-486. (In Czech.)

The effect of partitions in quenching chambers on current rupture is not always favorable, since care has to be taken that they do not interfere with either the free progress of the arc, the scavenging of the hot gases, or the deionization of the breaks. Evacuation of the hot gases is also retarded by heat exchange between gases and metal partitions. Chambers without partitions are preferable unless partitions are carefully chosen. (*Science Abstracts*)

No. 2293. L. D. Gustov and V. M. Zhuk, "D.C. Supply for Solenoid Drives of Circuit Breakers," *Elekt. Stantsii*, No. 7, (1955), pp. 32-34. (In Russian.)

The solenoid drives a 220-kv circuit breakers demand 720 a, those of 110-kv breakers, 240 a from the 220-v station battery. In order to prevent the voltage from becoming too low during the action of the heavy drives their connection to the charging side of the battery regulating switch is recommended. (*Science Abstracts*)

No. 2294. G. V. Butkevich and L. K. Greiner, "Prospects of Development and Fundamental Problems in the Field of Circuit Breaker Construction," *Elektrichestvo*, No. 7 (1955), pp. 73-80. (In Russian.)

In the voltage classes 35, 110, and 220 kv the breaking capacities of Soviet circuit breakers must be increased to  $2-2.5 \times 10^6$  6-6  $\times 10^6$ , and 7-10  $\times 10^6$  kva, respectively.

Also, the 400-kv systems in erection will require breakers of  $1.5-2 \times 10^6$  kva breaking capacity. A very urgent problem is the development of special 13.8-15-kv breakers of rating for the large hydro-alternators of Siberia's new hydro-electric developments. The most difficult part of the development work is the provision of suitable testing installations. A parallel development of oil, small oil-volume, and air blast breaker types is envisaged, and the future will show the preferred fields of application of each of these types. (*Science Abstracts*)

No. 2295. "Oil Switches for Alternating Current Systems," Brit. Stand., No. 2631 (1955), 42 pp.

Sets out requirements for manually operated, 3 pole, 400 a oil switches for voltages of 3.3, 6.6, 11, 22, and 33 kv. The switches may include integral earthing devices. Requirements are stated for making capacity, breaking capacity, short-time current, limits of temperature rise, and certain details of construction. Tests to prove that the requirements are met include mechanical endurance, temperature rise, impulse voltage withstand (22 and 33-kv switches only), making capacity, breaking current and short-time current. Appendices give detailed information on selection, testing, and maintenance. (*Science Abstracts*)

No. 2296. O. A. Boyer and E. Korges, "Nontension Aluminum Connectors," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 844-849 = *Pwr. Apparatus Syst.*, No. 20, Oct., 1955.

Describes tests on commercially available connectors for aluminum conductors under severe conditions of changing load, high humidity, and contamination. A current of 100 a was carried for 1 hr at a time with 1-hr intervals to secure maximum effect of thermal expansion. Performance was based on resistance as measured by a double bridge. Indoor tests of 22 joints and later outdoor tests of 72 joints were made. (*Science Abstracts*)

No. 2297. A. Gianzini, "Silver as Contact Material in Low Voltage Apparatus for Motor Control," *R. C. 55 Rium. Assoc. Elettrotec. Ital. Bellagio*, 1954, Vol. 42, Fasc. 2, Paper 144, 6 pp. (1955). (In Italian.)

After describing the requirements for electric contacts, a discussion follows on the test results on various alloys and sintered materials. It is concluded that silver gives the best all-around results. (*Science Abstracts*)

No. 2298. N. I. Sokolov and A. A. Khaturov, "Automatic Reclosing Without Control of Synchronism," *Elektrichestvo*, No. 9, pp. 64-67 (1955).

Automatic reclosing without control of

synchronism on an interconnecting line of two systems not transmitting large powers takes place without current rushes and oscillations, thus without disturbance to consumers or the system, since the phase differences of the voltage vectors of the parts of the system vary relatively slowly. Automatic reclosing without control of synchronism of sections of a power system operating at 40 per cent rated power of the generators of the section with reclosing times of 1–1.5 sec is in the most unfavorable case only accompanied by inconsiderable oscillations and low voltage drops. Voltage recovery is rapid and almost complete 0.4–0.5 sec, after reclosing. A synchronous reclosing of two parts of a power system with a difference of 7 cps is possible without danger. The most severe case tested in which two sections out of step were reclosed after 6.4 sec led to recovery of synchronism after 25 sec.; in this case the generators of both sections worked at their rated output (100 per cent). (*Science Abstracts*)

**No. 2299.** L. Gosland, "Performance of Joints in Steel and Nonferrous Conduits and Fittings," *Rep. Brit. Elect. Res. Assoc.*, Rep. V/T119, 18 pp. (1955).

It is expected that the use of electrical conduit in wrought Al alloy, and fittings in wrought or cast aluminum alloys and Zn alloys, will increase and some tests have therefore been undertaken on the maintenance of electrical continuity of screwed joints between the various metals and between these metals and steel. (*Science Abstracts*)

**No. 2300.** E. D'Addio, "Contact Materials and the Requirements of Automatic Telephony," *R. C. 55 Assoc. Elettrotec. Ital.*, Bellagio, 1954, Vol. 42, Fasc. 2, Paper 143 (1955), 8 pp. (In Italian.)

The problem of preventing contact erosion is described and microphotographs are included to illustrate this effect. The electrical and mechanical properties of various contact materials are given. (*Science Abstracts*)

**No. 2301.** A. Butte, "Electrical Contacts for Automobiles and Aircraft," *R. C. 55 Rivun. Assoc. Elettrotec. Ital.*, Bellagio, 1954, Vol. 42, Fasc. 2, Paper 134 (1955), 6 pp. (In Italian.)

A discussion of the fundamental characteristics desirable in electrical contacts for ignition and other motor-vehicle equipment. Tungsten, silver, platinum-iridium are mainly considered. The chemical and physical properties of these materials are summarized, their crystal structure is discussed, and data are given of the minimum currents required to maintain arcing (with clean contacts) at various voltages. Other data for ignition apparatus, voltage regulators and electric

horns give the maximum voltages at the contacts when opening, the contact pressure and the number of operations per minute. The effect of oxides and unclean contacts on arcing is discussed, as is also the wear of the contacts due to arcing, and a summary is given of arcing and contact wear for closing and opening operations with and without capacitors connected across the contacts and with additional inductance connected in the circuit. The final conclusions are that tungsten is suitable for the contact breakers used in the general automobile industry but Pt-Ir is desirable for aircraft magnetos. (*Science Abstracts*)

**No. 2302.** T. Gerber, "Contact Metals and Relay Contacts. Characteristics and Comparative Investigations," *Tech. Mitt. PTT*, Vol. 33, No. 3 (1955), pp. 89–114. (In German.)

The physical properties of the metals commonly used for contacts are tabulated and discussed. A detailed account is then given of investigations of the relations between experimental values of the contact resistances and the modifications which the surfaces of the contacts undergo during prolonged operation under different loading conditions. The contacts used were: Ag and Ag alloys with Au and W; Au/Ni alloy; Pd; Pt and Pt alloys with Ir and Cu; W. The contacts were operated in Ericsson relays with the contact fingers horizontal, the make and break being about once per sec, and the total number of operations about  $10^7$  in most cases. In the first series of tests the contacts carried a direct current of 80 mA, in the second series no current, and in the third series h.v. sparks were passed for 3 min between pairs of contacts 2.5 mm apart. Tables and diagrams show the progressive changes of contact resistance in the first two series of tests. Contacts made from a 95/5 Au/Ni alloy showed no change of resistance in the first series, while in the no-current tests the resistance decreased slightly. Micrographs were reproduced which show the condition of the contacts in the first and second series of tests after  $10^7$  operations and in the h.v. spark tests after 3 min. The condition of the various contacts at the conclusion of the tests is described in detail in tables. The results of the tests are discussed. (*Science Abstracts*)

**No. 2303.** D. Fabrizi, "Application of Antiarc Metals in Low and Medium-Voltage Switchgear," *R.C. 55 Rivun. Assoc. Elettrotec. Ital.*, Bellagio, Vol. 42, Fasc. 2 (1955), Paper 114, 5 pp. (In Italian.)

Summarizes the advantages of contact materials containing both hard and conducting metals (such as W-Cu). The physical properties of materials available commercially in Britain, U.S.A., Germany,

and Austria are tabulated. (*Science Abstracts*)

**No. 2304.** G. R. Miller, "Automatic Throwing-On of Reserves in L. V. Plants of Industrial Works," *Energetik*, No. 7 (1955), pp. 1-4. (In Russian.)

Automatic throwing-on of reserves is recommended on the l.v. side rather than on the h.v. side. A.c. contactors are used up to 560-kva transformer rating. 750 and 1000-kva transformers require automatic circuit breakers. A reserve transformer capacity of 30-35 per cent is in most cases sufficient after allowance is made for dropping unessential load and for temporary overloading. Start conditions are to be watched and arrangements made, if necessary, for automatic restarting of motors, possibly staggered. (*Science Abstracts*)

**No. 2305.** "Low Voltage Central Load Distribution Boards," *Asea J.*, Vol. 28, No. 3 (March, 1955), pp. 43-54.

A description of 500-v distribution switchgear of standard unit type and switchboard type. (*Science Abstracts*)

**No. 2306.** M. Perolini, "Air-Blast Circuit-Breakers for H. V. Networks," *Rev. Elect. Mecan.*, No. 101, (April-May-June), 1955, pp. 1-24. (In French.)

Describes leading features and characteristics of the Alsthom "Pneumator" and includes particulars of numerous breaking capacity and other tests made at testing stations and in the field. The breaking capacities mentioned are 5200 mva at 150 kv, 10 gva at 250 kv, and 15 gva at 420 kv, no dangerous overvoltages being observed. Successful tests were also made at ambient temperatures from -26 C to +60 C. (*Science Abstracts*)

**No. 2307.** "Circuit-Breakers for High-Voltage Power Transmission Systems," *BTH Act.*, Vol. 26, No. 3 (May-June, 1955), pp. 76-79.

230 kv, 7500 mva, Type JW 419 oil circuit breakers for the British Columbia Electric Company's power transmission system are described. These breakers are of the lenticular tank, bulk-oil type fitted with resistance switching. The complete 3-ph. circuit breaker, which is operated by compressed air, consists of three identical single-pole units which are coupled together by operating rods, and links to form a 3-ph. equipment. (*Science Abstracts*)

**No. 2308.** M. Wittgenstein "Contact Wire Wear on Rigid and Fully Electric Trolleybus Contact Lines," *Elekt. Bahnen*, Vol. 28, No. 6 (June, 1955), pp. 138-140. (In German.)

Results of service experience of several trolleybus undertakings are compared, only

very little wear being found under the suspension points of the fully elastic line. Other advantages of this suspension are: longer distance between masts, lighter structures and foundations, reduced wear of the current collector, and higher speed of trolleybuses. (*Science Abstracts*)

**No. 2309.** P. Quinn, "Electroplating contacts," *Engl. Elect. J.*, Vol. 14, No. 2 (June, 1955), pp. 48-56.

The varied duties of contacts, e.g., low resistance and ability to withstand arcing, are reviewed, with notes on the choice of contact materials, especially precious metals, and on selection of appropriate manufacturing techniques. The major features of plating processes are tabulated for Ag, Pd, Au, Rh, and Pt with some remarks on alloy plating. (*Science Abstracts*)

**No. 2310.** K. Nakanishi, "Graphical Analysis of Voltage Distribution Controlling Non-linear Resistors in Multi-Break Circuit Breakers," *ETJ Japan*, Vol. 1, No. 2 (June, 1955), pp. 63-66.

See Abstract 2188k. (*Science Abstracts*)

**No. 2311.** M. G. Diehl, "Vertical or Horizontal Contact Travel," *Electrotechniek*, Vol. 33, No. 12 (June 16, 1955), pp. 222-224. (In Dutch.)

Experiments with making and breaking ac show that less wear occurs with horizontal constant travel. Conditions for arc extinguishing are more favorable with horizontal contact travel, due probably to the effect of vertical air movement. (*Science Abstracts*)

**No. 2312.** A. Hochrainer, "Effect of Natural Frequency and Amplitude Factors on Interrupting Power," *Osterr. Z. Elekt. Wirtsch. (OZE)*, Vol. 8, No. 6 (June, 1955), pp. 185-192. (In German.)

Explains the setting up of restriking transients when interrupting 1 and 3-ph. circuits by air blast and oil circuit breakers, and discusses the measurement and influence of the arc characteristic. Numerical data for systems of various voltages are given in the form of a chart. (*Science Abstracts*)

**No. 2313.** Walter Rienäcker, "Bimetals" (Bimetalles) (German), *Zeitschrift für Metallkunde*, Vol. 46, No. 6 (June, 1955), pp. 429-434.

Contact and thermo bimetal; alloys utilized; elongation behavior; properties of industrial thermo bimetal. Table, graphs, diagram, 5 references. (*Battelle Technical Review*)

**No. 2314.** G. A. W. Rutgers, "The Alternating Current Arc With Heavy Currents," *Electrotechniek*, Vol. 33, No. 14 (July 14, 1955), pp. 253-257. (In Dutch.)

Discusses the theories of extinguishing and restriking a heavy a-c arc. Methods of measuring arc temperature are reviewed. Measurements described of arc current, voltage, radiation intensity, and diameter near zero current show that the arc diameter and therefore arc intensity immediately before zero current show that the arc diameter and therefore arc intensity immediately before zero current mainly determines the behavior of the arc after zero current. (*Science Abstracts*)

No. 2315. W. G. Thompson and H. V. Walker, "New Short Circuit Testing Station," *G.E.C., J.*, Vol. 22, No. 3 (July, 1955), pp. 135-145.

Outlines particulars of a short-circuit testing station to cater for the medium-power range of switchgear, providing for both a-c and d-c power tests on such equipment as high-speed d-c circuit breakers for traction (up to 3 kv); a-c and d-c contactors for traction purposes and industrial use, the high breaking capacity cartridge fuses. The capacity of the station provides for approx. 15 ka at 1.7 kv ac and 40 ka at 1 kv d-c obtained by means of mercury-arc rectifier equipment. The general features of the layout, control, recording, and safety precautions are outlined. (*Science Abstracts*)

No. 2316. H. Dorsch and M. Erche, "The Restriking Voltage Following the Interruption of Short Circuits," *Siemens-Z.*, Vol. 29, No. 8 (July, 1955), pp. 356-364. (In German.)

Equivalent circuits and formulas are given for calculating the natural frequencies of simple systems as viewed from the interrupting pole of the circuit breaker for short circuits with and without earth fault; the use is explained of symmetrical components for finding the equivalent circuits of the system for its transient behavior with symmetrical and asymmetrical short circuits. Finally practical values of the natural frequency are given as a function of size and voltage rating for overhead lines, cables, transformers, and generators. (*Science Abstracts*)

No. 2317. F. Schröter, "The Contact Resistance of Sliding Contacts," *Engineers' Digest*, Vol. 16 (Oct., 1955), pp. 468-471. Translated from *Elektrotechnische Zeitschrift (ETZ)*, Vol. 76, Pt. A, No. 14 (July 11, 1955), pp. 498-503.

Results of a detailed investigation of the influence of the oxide film at the metal surface between the brush and the commutator. Tables, graphs, 7 references. (*Battelle Technical Review*)

No. 2318. D. Rausch, "Rectifier Substations in Open-Air Kiosk Form," *A.E.G. Mitt.*, Vol. 45, No. 7-8 (July-Aug., 1955), pp. 359-361. (In German.)

Where space is limited, single-unit rectifier substations can be mounted in kiosks with access for maintenance from outside. The sides are hinged at the top and, when raised for access, provide weather protection. A convenient circuit is that of a ring-main unit. (*Science Abstracts*)

No. 2319. R. Jiu, "Relay Contact Bounce Measurements," *Electronics*, Vol. 28, No. 8 (Aug., 1955), pp. 137-139.

The relay contacts are included in a simple battery and resistor circuit and the fluctuations in voltage across the resistor are amplified and passed to a counter. This records the negative-going transients due to contact bounces. If the relay energizing voltage is also used to start a time interval meter, and the counter is preset to give a stop pulse to the meter, the time interval between application of the energizing voltage and any particular bounce may be measured. The effect of stray and cable capacitance on the waveform are discussed and it is shown how the time constant may be used to determine the duration of any bounce. Successive bounces are of shorter duration, so that by adjusting the time constant, by variation of resistance, until the  $n^{\text{th}}$  bounce transient just reaches the input trigger level of the counter, the duration of this bounce may be determined. A similar method, with the battery reversed, enables the duration of any contact period to be measured. The effects of battery voltage and the precision and stability of trigger level setting on the accuracy of measurement are discussed. (*Science Abstracts*)

No. 2320. W. R. Wilson, "High-Current Arc Erosion of Electric Contact Materials," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, No. 19 (Aug., 1955), pp. 657-664 (1955) = *Pwr. Apparatus Syst.*

Gives data on arc erosion rates for 11 elements. Testing equipment and conditions of tests are outlined with examples of calculation of erosion rates according to a theory of erosion processes put forward. Some notes are given on the performance of sintered materials and the effect of factors such as contact spacing, current magnitude, and polarity. (*Science Abstracts*)

No. 2321. J. E. Schrameck, "Air Supply System for Compressed Air Circuit Breakers," *Electronics Engng.*, Vol. 74, No. 8 (Aug., 1955), pp. 646-649.

Briefly describes a method of supplying compressed air for air-blast circuit breakers, providing adequate storage capacity at different operating air pressures and comparing three direct air supply units and air storage units, which may be used in conjunction when required. (*Science Abstracts*)

No. 2322. W. R. Wilson, A. L. Streater, and E. J. Tuohy, "Application of Volume

Theory of Dielectric Strength to Oil Circuit Breakers," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, No. 19 (Aug., 1955), pp. 677-688 (1955) = *Pwr. Apparatus Syst.*

Describes a method for calculating the 60 cps dielectric withstand voltages for oil circuit breaker designs at the drawing board stage. The reasoning is based on the oil dielectric strength determined by the volume theory and on the electric stress determined from testing scale models in an electrolytic tank. Notes on accuracy of the calculations are given. (*Science Abstracts*)

**No. 2323.** D. M. Umphrey and D. J. Marsden, "Design Problems and Field Tests Concerning Circuit Breakers for Switching Long 230 KV Lines, *Trans.*, Am. Inst. Elect. Engrs., III, Vol. 74, No. 19 (Aug., 1955), pp. 693-705 (1955) = *Pwr. Apparatus Syst.*

Resistors of 2400 ohms per pole for use in a 230-kv 6-break circuit breaker are designed so as to provide equal division of the restriking voltage during the interruption. The associated interrupter component on one of the contacts interrupts the residual resistor current immediately after the fault. Heat capacity and impulse voltage control by capacitance is provided to enable the breaker to withstand repetitive lightning strokes. The circuit breaker equipped with these resistors was subjected to a series of interrupting tests on lines of up to 242 miles long at operating voltages of up to 250 kv. The test results are tabulated and representative oscillograms shown. (*Science Abstracts*)

**No. 2324.** W. F. Skeats, "Short-Circuit Currents and Circuit-Breaker Recovery Voltages Associated with 2-Phase-to-Ground Short Circuits," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 688-693 = *Pwr. Apparatus Syst.*, No. 19 (Aug., 1955).

Recalls the conditions under which the two-lines-to-earth fault current and restriking voltage of normal frequency can exceed by maximum 15 per cent the maximum values of single-line-to-earth and 3-lines-to-earth faults. (See *Elect. Engng.*, Vol. 50, June, 1931, pp. 415-420; and *Gen. Elect. Rev.*, Vol. 42, pp. 353-356, Aug.; 479-485, Nov., 1939.) Such an occurrence depends on the combination of several unfavorable circumstances, hence is thus extremely unlikely. This is in accordance with practical experience. (*Science Abstracts*)

**No. 2325.** K. G. Darrow, V. E. Phillips, A. J. Schultz, and R. B. Shores, "Test Circuits for Capacitance Switching Devices," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 624-635 = *Pwr. Apparatus Syst.*, No. 19 (Aug., 1955).

Gives exact and approximate 1-ph. equivalent circuits for a number of 3-ph. arrange-

ments of capacitance, both faulted and unfaulted. The first and subsequent poles to open are considered, also the effects of neutral grounding conditions and shunting resistances. It is concluded that practical circuits for laboratory testing can be synthesized for any known system condition although some may only approximate the conditions of the 3-ph. circuit. (*Science Abstracts*)

**No. 2326.** I. B. Johnson, A. J. Schultz, N. R. Shultz, and R. B. Shores, "Some Fundamentals on Capacitance Switching," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 727-736 = *Pwr. Apparatus Syst.*, No. 19 (Aug., 1955).

Investigates how the restriking voltage of the first and second pole to interrupt is affected by the ratio of positive to zero sequence capacitance, the neutral earthing conditions of the source, the conditions after one restrike and the presence of a single line-earth fault. Theoretical findings were verified by oscillograms taken on the transient network analyzer. (*Science Abstracts*)

**No. 2327.** C. J. Balentine and K. G. Darrow, "The Results of 7 Years' Experience with High-Capacity Outdoor Oil Circuit Breakers," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 665-671 = *Pwr. Apparatus Syst.*, No. 19 (Aug., 1955).

Outlines the development of test facilities for high-capacity circuit breakers and describes briefly a new 330-kv, 25,000-mva design comprising two elliptical domed sections welded together. Particulars are given of ancillary apparatus and test performance. (*Science Abstracts*)

**No. 2328.** P. Barkan, "Dynamics of High-Capacity Outdoor Oil Circuit Breakers," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, No. 19 (Aug., 1955), pp. 671-676 (1955) = *Pwr. Apparatus Syst.*

A means of simplifying the complex linkage mechanism of large oil circuit breakers is described. Ideal performance is calculated and the influence of various factors on opening is assessed. (*Science Abstracts*)

**No. 2329.** R. M. Milton and F. Chambers, "Behavior of High-Voltage Buses and Insulators During Short Circuits," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, No. 19 (Aug., 1955), pp. 742-749 (1955) = *Pwr. Apparatus Syst.*

In view of the high breaking capacity (10 gva) required for circuit breakers on the 161-kv system of the T.V.A. tests were made to see how the associated busbar installations would react mechanically to high fault currents. The test methods used with a few particulars of individual tests are described. The main data are concerned with movement of the insulators and torsional and other stresses on them, but with the tubular AL

busbars used, it is suggested that the sag should not be excessive and that no welds should be made in the middle third of the span unless reinforced as with a sleeve. (*Science Abstracts*)

**No. 2330.** W. Hillig and F. Schultheiss, "Additional Relay System (Intermediate Relay Circuit) for a 110 KV Airblast Circuit Breaker with Rapid Reclosure," *Dtsch. Elektrotech.*, Vol. 9, No. 8 (Aug., 1955), pp. 275-278. (In German.)

Describes the circuit required to convert a circuit breaker (110 kv, 2500 mva) to rapid reclosure. A single 3-ph. reclosure with variable time delay is provided and is inoperative when the breaker is closed on a fault. An additional circuit for lines fed from both ends varies the time setting of the impedance relay for the first interruption to ensure that both breakers open simultaneously. (*Science Abstracts*)

**No. 2331.** D. Fabrizi, "Short-Circuit Tests on Medium- and Low-Voltage Circuit-Breakers," *Elettrotecnica*, Vol. 42, No. 8 bis. (Aug. 30, 1955), pp. 430-447. (In Italian.)

Describes the results of sc tests on low-oil-content switch gear for up to 30 kv 800 A fitted with arc control device, and on air circuit breakers up to 4000 A 600 v. Full test data are reported and there is a short section on d-c switchgear. (*Science Abstracts*)

**No. 2332.** B. Kiessling, "Air Type Circuit Breakers for 500 V," *Asea J.*, Vol. 28, No. 8-9 (Aug.-Sept., 1955), pp. 128-137.

Outlines the main features of a new range fitted with deionization plates for rated currents of 400-300 a at 500 v and designed to be compact and easily accessible in panel mounting and capable of rapid reclosing. A draw-out type is also illustrated. Particulars of the mechanism, operating gear, and contacts are given and a design for use on d-c circuits is discussed with notes on breaking capacity test results. (*Science Abstracts*)

**No. 2333.** M. M. Atalla, "Arcing of Electrical Contacts in Telephone Switching Circuits. V. Mechanisms of the Short Arc and Erosion of Contacts," *Bell Syst. Tech. J.*, Vol. 34, No. 5, Sept., 1955, pp. 1081-1102.

For Part IV, see Abstract 2195 (1955). Part V is a study of the mechanism of the short arc between closely spaced contacts and its erosion effects. The study is based on optical measurements of the erosion obtained on contacts after repeated arcing on closure or opening. Most experiments reported are essentially of the probing type designed to test specific postulates and assumptions. For short arcs initiated at 250 v, clean palladium, iron, and nickel contacts have shown a reversal, with arc duration, in the direction of net transfer. Net anode losses were ob-

tained with short duration arcs and net cathode losses with longer duration arcs. This reversal, however, did not occur with silver, gold, or copper. For longer arcs initiated as air breakdowns from 500 v, all the above metals indicated a net loss from the cathode. For arcs initiated at 250 v between fully activated contact, shallow cathode losses were generally observed with little or no build-ups on the anode. (*Science Abstracts*)

**No. 2334.** U. Bonef and L. LeGoff, "Modern Design of Regulation and Control Boards," *Rev. Gen. Elect.*, Vol. 64, No. 9 (Sept., 1955), pp. 421-432. (In French.)

Describes with illustrations details of control panels such as used in power stations, substations, and railway systems and the use of miniature circuit diagrams, colored lights, and other ancillary equipment. Attention is drawn to new techniques introduced for relays, measurements and signals, and the cable connections for these. (*Science Abstracts*)

**No. 2335.** Y. Baron, "Automatic Equipment for Switching and Isolating in Medium-Voltage Rural Distribution Networks," *Bull. Soc. Franc. Elect.* (Ser. 7), Vol. 5, Sept., 1955, pp. 629-636. (In French.)

Reviews various types of such networks and suggests suitable protective means for securing automatic switching and isolation of, for example, minor feeders without disturbing the rest of the system. Brief reference is also made to methods used in U.S.A. and Britain. (*Science Abstracts*)

**No. 2336.** H. Baatz, "Auto-Reclosing in Distribution Networks," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 18 (Sept. 11, 1955), pp. 640-644. (In German.)

Most faults on O.H. lines are transient and a prolonged interruption can be prevented by auto-reclosing. Experimental data regarding deionizing time show it to vary between 0.1 sec at 10 kv to 0.25 sec at 150 kv. Oscillograms showing the effect of a brief interruption on motor currents are given, together with details regarding the location of auto-reclosers on the system. (*Science Abstracts*)

**No. 2337.** B. Fleck and E. Maass, "Circuit Breaker and Switching Stations for Medium Voltage Distribution Systems," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 18, Sept. 11, 1955, pp. 664-672. (In German.)

Reviews German developments during the last 10 years in the 10-30 kv range. There is a gradual change to metal-clad gear for indoor stations while frame-mounted low-oil-content switchgear has been further developed. A good bibliography is included. (*Science Abstracts*)

**No. 2338.** K. Tsuchiva, "Contact Resistance of Operating Contacts," *J. Inst. Elect. Engrs. Japan*, Vol. 75 (March, 1955), pp. 226-230. (In Japanese.) Abridged translation in: *ETJ Japan*, Vol. 1, No. 3 (Sept., 1955), pp. 89-91.

The study of contact resistance is usually restricted to clean metal surfaces, films of water or oil independently, or film formed on the contact surfaces by electrical discharges. It has been found, however, that powdered oxide which has become detached from the contact surface causes a greater increase in contact resistance than the same oxide when still adhering to the contact surface. Tests were carried out on contacts, some prepared by melting and others by powder metallurgy. The following conclusions were reached: (1) powder metallurgy increases contact resistance; (2) the contact resistances of low-grade oxides of metals of low atomic valency, such as Cu, Fe, etc., and lower than those of high-grade oxides of the same metals except in the case of powdered low-grade oxides where they are higher; and (3) powdered oxides affect light-current point contacts but not heavy-current sliding contacts where the oxide is easily removed. (*Science Abstracts*)

**No. 2339.** J. H. Field, "The Representation of Impedances on the Resistance Network Analyzer," *Proc. Inst. Elect. Engrs.*, Vol. 102A, Paper No. 1894S (Oct., 1955), pp. 823-827.

A method has been developed whereby conventional network analyzer equipped only with resistors is energized from a 2-ph. ac supply and phase displacements due to reactances are obtained by injecting voltages which are constant in direction. The method is applicable to either load flow or fault studies if transient effects are absent. The additional equipment required is inexpensive when an orthodox resistance analyzer is available, and the accuracy of the solution is high. (*Science Abstracts*)

**No. 2340.** R. Righi, "The Commutation Function in General and Symmetrical Commutation Functions in Particular," *Ingegn. Ferroviaria*, Vol. 10, No. 10 (Oct., 1955), pp. 719-737. (In Italian.)

A complete mathematical study is given of the symmetrical functions, and it is pointed out that commutation circuits corresponding to such functions are advantageous as far as the economy of contacts is concerned. (*Science Abstracts*)

**No. 2341.** C. E. Asbury and C. J. Hartman, "Development of a Welded Aluminum Bus for Substations," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 834-839 = *Pwr. Apparatus Syst.*, No. 20 (Oct., 1955).

Labor and material savings up to 60 per

cent, compared to copper, can be effected, labor costs being less owing to the lower weights to be handled during erection. Details of fittings are given with the results of thermal and distortion tests under short-circuit conditions with currents up to 26 ka. (*Science Abstracts*)

**No. 2342.** J. L. Talento, "Aluminum Widely Used in Power Switchgear," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 639-644 = *Pwr. Apparatus Syst.*, No 20 (Oct., 1955).

Lists various properties of aluminum and its alloys including corrosion resistance, machinability, and application to switchgear and other installations. (*Science Abstracts*)

**No. 2343.** H. Schiller and P. Baltensperger, "Conditions Met in Swiss 150 KV Networks Relative to Short-Circuit Powers and Natural Frequencies," *Bull. Assoc. Suisse Elect.*, Vol. 46, No. 22, Oct. 29, 1955, pp. 1065-1067. (In French.)

Tabulates the results of an inquiry into short circuits interrupted by circuit breakers in 61 points in the 150-kv network and compares the values actually interrupted with the maximum possible short-circuit mva at the point in question. The value interrupted lies below 80 per cent of the maximum at low values of mva, and below 20 per cent at about 5000 mva. (*Science Abstracts*)

**No. 2344.** B. Cernavin, "The Effect of the Properties of Carbon Brushes on the Operation of the Repulsion Motor," *VDI Z.*, Vol. 97, No. 29 (Oct. 11, 1955), pp. 1016-1018. (In German.)

An investigation into the effect of 7 different qualities of brush on the relation to torque of speed, output, current, p.f., and efficiency. The results were very varied and only three qualities were suitable. The good brushes all showed polished faces. A repeat brush supplied by one maker at a later date showed great improvements. It is concluded that only the brush recommended by the motor manufacturer should be used. (*Science Abstracts*)

**No. 2345.** E. J. Field and D. L. Leatherberry, "A Power Class Recloser for Higher Speed Clearing of Distribution Circuits," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 986-993, *Pwr. Apparatus Syst.*, No. 20 (Oct., 1955).

Under the definition of "instantaneous" (no delay purposely introduced) some reclosures take 48 cycles to clear small fault currents. This paper suggests modifications in design and operating means for reclosers in circuits of up to 14.4 kv which provide rapid contact separation, that is, high acceleration. The new type developed requires little oil and is termed an oil column interrupter. On tests ranging from 2.5-15 kv



at p.f.  $4\frac{1}{2}$ —100 per cent and currents up to 20 per cent in excess of rated fault capacity, the circuit was opened in a time of approximately 1 cycle. The first reclosing time was reduced to some 20 cycles. (*Science Abstracts*)

**No. 2346.** P. Lafont, "Note on the Switching-Out of High Voltage Motors," *Rev. Gen. Elect.*, Vol. 64, No. 10 (Oct., 1955), pp. 485-490. (In French.)

A description of a series of tests carried out on a number of breakers of different types, the chief object being to determine the over-voltage obtained at the motor terminals. The factors of greatest influence are: length of cable between motor and breaker; conditions of operation of the motor; type of damping resistance in breaker. It is emphasized that the pneumatic breaker, with its ultra-rapid opening, is very suitable for the control of h.v. motors. A bibliography is added. (*Science Abstracts*).

**No. 2347.** F. Remde and H. Tolazzi, "Investigation of Flow Conditions in Circuit Breakers," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 19 (Oct. 1, 1955), pp. 704-710. (In German.)

Describes a technique for taking high speed photographs of the contact gap in a 10.4-kv, 300-a circuit breaker both with and without load. Small air bubbles are used as tracers and part of the contacts and the chamber were made from a transparent plastic. (*Science Abstracts*)

**No. 2348.** J. W. Cohen, "Some Examples of the Use of Implication in Switching Algebra," *Commun. News*, Vol. 16, No. 1 (Oct., 1955), pp. 2-10.

Enumerates the definitions and some important theorems of binary algebra. The algebraic expression of some conceptions used in designing switching circuits shows that binary algebra can be suitably applied in this field. An extensive explanation is given of the "implication," a concept used in statement calculus, and very important in switching methods. An example shows how the requirements for a relay circuit may be represented symbolically by means of implication, and how a symbolic formula may be deduced for each relay belonging to the circuit. This formula determines the relay circuit, including the necessary contacts. Symbolic formulas are stated for relays with more than one winding. A counting or sequence circuit is then worked out. First, the data are converted to symbolic expressions, and the successive states of the circuit are tabulated and numbered. From the table, a number of formulas are derived, namely, primary formulas for relays, etc.; and secondary formulas which may lead to simplification of the primary formulas and,

therefore, to a reduction in the number of contacts. (*Science Abstracts*)

**No. 2349.** B. Gevay, "Flexible Busbar Connections of Switchgear for High Current Rating," *Elektrotechnika*, Vol. 48, No. 10 (Oct., 1955), pp. 302-305. (In Hungarian.)

Basic mechanical problems are discussed of flexible busbar connections stressed by electromagnetic forces due to short circuits. It is concluded that  $\Omega$  shape connections are preferable. (*Science Abstracts*)

**No. 2350.** J. Biermanns, "Rating Limits for Circuit Breakers, Substations and Systems," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 20, Oct. 11, 1955, pp. 728-735. (In German.)

Although system short-circuit rating is increasing as (time), it is expected that the short-circuit current can be kept below 35 ka until 1970 by suitable system design. E.H.V. outdoor switchgear can cope with this but further development will be required in indoor M.V. plant. Substation design must take into account the mechanical and thermal effects on overhead lines and cables of this short-circuit current lasting up to 1 sec. (*Science Abstracts*)

**No. 2351.** N. W. Bell, "Small Signal Analysis of Floating Junction Transistor Switch Circuits," *I.R.E. Trans. Electron Devices*, Vol. ED-2, No. 4, Oct., 1955, pp. 10-13.

Characteristics of switch circuits using junction transistors are analyzed. The switch properties result from the large changes in small signal admittance of one junction of a transistor when the bias polarity of the other junction is reversed. The characteristics analyzed include the small signal, i.f. conductance, and associated potentials. The circuits are suitable for low-level modulators and commutators. (*Science Abstracts*)

**No. 2352.** R. T. Spurr, "Creep and Static Friction," *Brit. J. Appl. Phys.*, Vol. 6, No. 11 (Nov., 1955), pp. 402-403.

It is shown that the static friction between a soft metal hemisphere and a flat surface increases with the length of time the surfaces have been in contact and that this increase is due to creep. Such creep might account for the difference between static and dynamic coefficients of friction. (*Physics Abstracts*)

**No. 2353.** L. H. Germer and W. S. Boyle, "Anode and Cathode Arcs," *Nature* (London), Vol. 176 (Nov. 26, 1955), p. 1019.

Describes briefly how short arcs, that is those less than  $1\ \mu$  in length may be classified into anode and cathode arcs by the electrode marks. Two photographs of cathode marks are shown. See also Abstract 2410. (*Science Abstracts*)

**No. 2354.** J. Lees and S. Walton, "The Influence of Pressure on Metal-Germanium

Contacts," *Proc. Phys. Soc. B*, Vol. 68, Pt. II (Nov., 1955), pp. 922-928.

The dependence of the electrical properties of the germanium immediately below a point contact on the stress existing in the region is investigated. Electrical and optical methods of measuring the area of these contacts gave different results. This anomaly is shown to arise from the variation of the resistance of the germanium with pressure. (*Physics Abstracts*)

**No. 2355.** E. Marx and L. Schmitz, "Heavy Current Switchgear with Detonators for Very Short Switching Times," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 21, Nov. 1, 1955, pp. 765-769. (In German.)

Two units suitable for 12 ka, d-c and several kv are described. In one a torsion contact bridge is restrained from opening by a bar and released when the latter is shattered by the detonators; in the second unit, the conductor itself is fractured by the explosion. Both types have arcing contacts with magnetic and pneumatic blow-out devices. The interval between opening impulse and fault current peak is 1.2 and 0.3 msec in the two cases. (*Science Abstracts*)

**No. 2356.** E. E. Rooste, "Manufacture of Electric Contact Alloys and Sintered Iron Bearings," *Australasian Engineer* (Nov., 1955), pp. 53-55.

Outlines the manufacture of W-Cu and Mo-Ag alloys which are given as typical examples of the infiltration technique for the manufacture of contact alloys. Graphs, micrographs, photographs, table. (*Battelle Technical Review*)

**No. 2357.** Peter Klaudy, "Properties and Possible Uses of Liquid Contacts." *Electrotechnische Zeitschrift*, Vol. 76, Ausgabe A, No. 15 (Aug., 1955), pp. 525-532 (sent you 1/13/56). Can add: English translation, *Engineers' Digest*, Vol. 16 (Nov., 1955), pp. 516-517. (*Battelle Technical Review*)

**No. 2358.** G. Haase, "Wiring Methods for Switchgear Panels," *Siemens-Z.*, Vol. 29, No. 11 (Nov., 1955), pp. 505-512. (In German.)

In recent years there has been little change in panel wiring technique and efforts towards neat layout by bundling have resulted in individual wires being more difficult to trace. For control and relay panels there are advantages in running each wire directly between points to be connected; not only is the quantity of wire a minimum but the cost of wiring drawings is saved. Wiring may also be run in large-diameter conduit having a discontinuous slit: wires can be easily inserted or removed. The latter method is preferable where the number of wires is large. (*Science Abstracts*)

**No. 2359.** W. B. Ellwood, "The Measurement of the Transient Power and Energy Dissipated in Closing Switch Contacts," *Bell Syst. Tech. J.*, Vol. 34, No. 6 (Nov., 1955), pp. 1191-1223.

A new technique is described for the measurement of the power and energy dissipated in the contact gap of a glass sealed reed relay (switch) on the closure of a special coaxial circuits of which the switch is a part. The method used two c.r.o.'s with provisions made to study time intervals of from 1 microsec to -1 m microsec. Experimental results on a few switches are outlined. (*Science Abstracts*)

**No. 2360.** S. S. L. Chang, "Optimum Switching Criteria for Higher Order Contactor Servo with Interrupted Circuits," *Trans. Am. Inst. Elect. Engrs.*, II, Vol. 74 (1955), pp. 273-276 = *Applic. & Industr.*, No. 21 (Nov., 1955).

Investigates criteria for a high-order contactor servo by extension of the phase-space method and gives examples of solution of a typical third order case derived from Bogner and Kazda and of the general case covering the fourth or higher orders. (*Science Abstracts*)

**No. 2361.** "Short-Circuit Low-Voltage Systems," *Trans. Am. Inst. Elect. Engrs.*, II, Vol. 74 (1955) pp. 276-286 = *Applic. & Industr.*, No. 21 (Nov., 1955).

Describes studies made to ascertain the maximum probable sc duties at almost any point in a wide range of 1.v. radial 3-ph. 60 cps power systems supplied through transformers. Network systems and systems with local generation are not included. Some 30 curves are given which connect sc current values and distance from transformer for various sizes of transformers and sizes and arrangement of conductors and p.f. (*Science Abstracts*)

**No. 2362.** H. Böcker, "Natural Frequencies of the Restriking Voltage in Power Systems," *Elektrotech. Z. (ETZ) A*, Vol. 76, No. 22, Nov. 11, 1955, pp. 792-795. (In German.)

Summarizes the contents of papers read at a meeting of Essen in June, 1955, on full scale tests and network analyzer investigations and their discussion with contributions from power system operators, manufacturers, and research organizations. Difficulties in the proper representation of systems on the network analyzer are stressed and a few full scale tests are recommended as a check of network analyzer results before final regulations are made for switchgear testing. (*Science Abstracts*)

**No. 2363.** R. W. Sillars, "The Effect of Field Emission on the Behavior of Semi-

conductor Contacts," *Proc. Phys. Soc. B*, Vol. 68, Pt. II (Nov., 1955), pp. 881-893.

If the potential applied across a contact between two conducting bodies exceeds one or two volts, it is likely that the current flowing will be augmented by field emission around the area of intimate contact. This condition is analyzed for conductors with no surface barrier, by treating the relation between surface field and emitted current density as a step function and solving Laplace's equation with this boundary condition. With contacting bodies of normal shapes it is found that the current will vary as the square or three-halves power of the applied voltage. Some experimental observations on semiconductors with negligible barrier effects are shown to be consistent with the predictions of this analysis. A similar analysis can be applied to metallic bodies which are not quite in contact, and shows that the emitted current is so concentrated as to cause melting of the metal even at very low currents. (*Physics Abstracts*)

**No. 2364.** F. P. Bowden and E. H. Freitag, "Some Recent Experiments in Friction," *Nature* (London), Vol. 176, Nov. 19, 1955, pp. 944-947, Friction of Solids at High Speeds, pp. 944-946.

Peripheral speeds of 1000 m per sec were obtained with a steel ball spinning, in vacuo, in a rotating magnetic field, and the friction of the steel surface was measured by allowing the spinning ball to touch another surface (copper or bismuth) and observing the deceleration. At low sliding speeds (200 m per sec) the friction was high ( $\mu = 1.7$ ), falling to  $\mu = 0.2$  at 600 m per sec. Micrographs of the worn surface show transition from heavy wear at low speeds to small wear at high speeds, with evidence for extensive melting at higher speeds. The low friction is due to a molten metal film acting as a lubricant, analogous to water on ice. (*Physics Abstracts*)

**No. 2365.** E. Samal, "Electrical and Mechanical Measurements on Contacts and Relays," *Arch. Tech. Messen*, Issue No. 239 (ref. J 04-6), Dec., 1955, pp. 281-284. (In German.)

A review of methods of measuring contact resistance, contact pressure, insulation resistance and capacitance between contacts. The crossed-wire method of measuring contact resistance of materials under varying pressure is described, as well as an arrangement for life testing switches using a motor drive to enable 100,000 operations to be performed in 6 days. (*Science Abstracts*)

**No. 2366.** H. Jedicka, "Improvement of a Thermostarter for Fluorescent Lamps," *Elektrotech. Z. (ETZ)* B, Vol. 7, No. 12, Dec. 21, 1955, pp. 451-452. (In German.)

A starter depending on the expansion of a heated wire is described. It is noted that in its original form the starter required a special choke with an additional winding for supplying heating current. In the new starter the wire is heated by the current flowing in the series circuit comprising the choke, lamp filaments, expanding wire, and the closed starter contacts. This arrangement gives insufficient period of preheating of the lamp filaments, although a good clean break of the starter contacts is ensured. Additional delay is introduced by means of a bimetal-actuated contact which initially bypasses the expanding wire. About 2 sec are required for the bimetal to heat up sufficiently to divert the main preheating current into the expanding wire, which then operates as before. Compensation for ambient temperature variations is provided, and the starter has been tested under a variety of operating conditions with satisfactory results. The device is claimed to give a flicker-free start which tends to prolong lamp life. (*Science Abstracts*)

**No. 2367.** S. A. Bottonari and J. H. Sprow, "A New High-Capacity Anode Air Circuit Breaker," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 1297-1303 = *Pwr. Apparatus Syst.*, No. 21 (Dec., 1955).

Discusses the design and performance of an air circuit breaker fitted with de-ion grid and arc chute for use in the anode circuit of a mercury-arc rectifier to isolate the anode when required on arc-back or backfire. A 6-pole assembly can be made up from independent and identical pole units suitable for use in systems with ratings up to 1 kv dc and 3 ka anode current. Each unit has a breaking capacity of 75 ka. Performance on tests is illustrated by oscillograms. (*Science Abstracts*)

**No. 2368.** K. Chen and E. W. Boehne, "Testing of D.C. Interrupters on A.C. Test Circuits," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 1073-1080 = *Pwr. Apparatus Syst.*, No. 21 (Dec., 1955).

Proposes means for using existing a-c proving station resources for testing breaking capacity of d-c circuit breakers. Criteria for simulation of d-c tests on a-c circuits and the need for accurate control are discussed. The question of equivalence is analyzed mathematically and graphically. (*Science Abstracts*)

**No. 2369.** M. W. Anderson, "Power Auto-transformer Current Interruption with an Air-Break Disconnect Switch," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 1157-1163, = *Pwr. Apparatus Syst.*, No. 21 (Dec., 1955).

Deals with investigations, field testing, and analysis of tests in which both the ex-

citing and paralleled load currents of a bank of power auto-transformers were broken by a 3-ph. air-break switch, without arcing horns, rated at 1.2 ka, 190 to 230 kv in adverse weather conditions. The effects of various circuit conditions, and the performance required are discussed. (*Science Abstracts*)

**No. 2370.** Report on the Operation of Switches Capacitors. *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, 1255-1261 (1955) = *Pwr. Apparatus Syst.*, No. 21 (Dec., 1955).

Discusses shunt capacitor switching as used for improvement of transmission and distribution system conditions and the various switching means adopted. Formulas for features such as inrush currents and inrush frequencies are given with notes on points to take into account when selecting a method for controlling switched capacitors. 47 refs. (*Science Abstracts*)

**No. 2371.** M. J. Reilly and D. E. Weston, "A New 500 Megavolt-Ampere Air Magnetic Circuit Breaker of Simplified Design." *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74, pp. 1093-1100 (1955) = *Pwr. Apparatus Syst.*, No. 21 (Dec., 1955).

Describes design development of this type of circuit breaker for use on 13.8-kv circuits and performance and mechanical requirements with observations on the nature of circuit conditions during operation. The magnetic blow-out and the construction of the barrier stack are also discussed and representative test data included. (*Science Abstracts*)

#### 1956

**No. 2372.** E. Vogelsanger and P. Joss, "Latest Investigations on Minimum-Oil Circuit Breakers," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 130, 16 pp. (1956).

To interrupt the highest s-c currents the laterally vented quenching chamber is employed. Main attention is paid to the avoidance of voltage surges when interrupting small inductive and capacitive currents. However, in some cases, the supply network or a transformer on no-load may cause high voltage surges. The effectiveness of the interruption by steps in conjunction with a resistance attenuating these voltage surges is studied. Transmission lines under no-load condition can be switched off without restriking by employing a forced oil flow. With this respect, the voltage at the break should not exceed an upper limit. Consequently, for highest voltage circuit breakers the multiple break is necessary. (*Science Abstracts*)

**No. 2373.** S. J. M. Denison and D. G. Taylor, "The Use of Digital Computers in Obtaining Solutions to Electric-Circuit Problems Involving Switching Operations," *Proc.*

*Inst. Elect. Engrs*, Paper No. 2120 M (Part B Suppl. No. 1, pp. 35-46, 77-83).

The analysis of electric circuits by matrix methods is well established as a means for obtaining differential equations relating the electric quantities to the impedance properties of the circuit. A brief summary is given of the mesh method of circuit analysis and a procedure derived for expressing the resulting equations as simultaneous first-order differential equations. Reference is made to a digital-computer program by which equations of this type are solved using a step-by-step method; nonlinear features are dealt with by supplementing the program with a set of special instructions. Ideal rectifying elements are regarded as switches whose opening and closing are either partly or entirely dependent on currents and voltages; the difficulties introduced by their presence in a network are discussed in general terms. Two special programs are described which were made for the computer Deuce, dealing respectively with problems associated with 3-ph. and 2-ph. power-rectifier installations. An example is given of the calculation of the input and output currents of a 2-ph. rectifier operating under steady-state conditions; another program is used to make a harmonic analysis of the results. The need is discussed for a general program incorporating certain nonlinear features and capable of dealing with rectifier circuits for which there are less than a certain number of equations. A description is given of an iterative method for dealing with rectifying elements. The method is capable of yielding solutions of any desired accuracy, and mathematical justification is given. A scheme for a general program based on the method is described and the range of possible application discussed. (*Science Abstracts*)

**No. 2374.** A. Olin, "11 kv Metal-Clad Truck-Type Switchgear," *ASEA J.*, Vol. 29, No. 4, pp. 39-46 (1956).

ASEA have designed new types of metal-clad switchgear with draw-out components. An account is given of an indoor design for a maximum rating of 11 kw. (*Science Abstracts*)

**No. 2375.** S. Knothe, A. Myslicki, A. Podgorski, and Z. Skoczynski, "Some Problems of Power Circuit-Breakers Testing," *Conf. Int. G. Res. Elect. (CIGRE)*, Paper 115, 14 pp. (1956).

Analyzes the performance required of circuit breakers and discusses breaking-capacity criteria with a view to unifying test practice so that direct comparison of test results can be made. For example, it is suggested that the momentary current rating should be defined by introducing a parameter  $I^{*t}$  and to compare breaking capacities a max interrupt-

ing-current value and a safety-factor value should be used. (*Science Abstracts*)

**No. 2376.** H. Becker, "An Installation for Synthetic Tests on High Voltage Circuit Breakers," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 117, 20 pp. (1956).

Reviews requirements for and limitations of synthetic testing methods for hv circuit breakers and describes an installation to furnish a high power laboratory for high power circuit-breaking tests. The construction of special apparatus required for the modified Skeats diagram utilized is described. (*Science Abstracts*)

**No. 2377.** Report on the activity of CIGRE Study Committee, No. 3-High-Voltage Circuit-Breakers. *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 139, 7 pp. (1956).

An account of work on: (1) natural frequencies and amplitude factors; (2) switching overvoltages; (3) indirect tests; (4) post-arc currents; and (5) evolving faults. (*Science Abstracts*)

**No. 2378.** E. K. Venstrem, V. I. Likhtman, and P. A. Rebinder, "On the Electrocapillary Effect of the Lowering of Hardness and the External Friction of Metals," *Dokl. Akad. Nauk SSSR*, Vol. 107, No. 1 (1956), pp. 105-107. (In Russian.)

Zero-charge potentials at the solid metal-electrolyte interface reported by various investigators for Zn, Pb, Cd, Au, Pt, Te, and Sn are summarized. New results obtained by the pendulum sclerometer method are reported for lead in an acid solution. When the pendulum deforms and fragments the solid, the electrocapillary effect is the inverse of that obtained with a pendulum with friction-damped oscillations, such as was used in the experiments described by J. O. M. Bockris and R. Parry-Jones. (*Physics Abstracts*)

**No. 2379.** A. Keil, "Proof of Oxidation Processes in the Spark," *Spectrochimica ACTA*, Vol. 7 (1956), p. 367.

**No. 2380.** W. Merl, "Material Transfer in Contacts of Gold and Gold Nickel," *ETZ*, A, Vol. 8 (1956), p. 201.

**No. 2381.** A. Keil, "Chemical Corrosion of Sinter Materials on a Silver Base," *Z. f. Metallkunde*, Vol. 47 (1956), p. 243.

**No. 2382.** N. M. Chernyshev. "Consideration of the Aperiodic Component in the Breaking Current," *Elektrichestvo*, No. 5, 1956, pp. 42-46. (In Russian.)

Considers the correct definition of the breaking capacity of circuit breakers and its corollary symmetrical v. asymmetrical breaking capacity. It is made clear that

in most cases of short circuit clearance there will not be an aperiodic component left at the instant of actual contact separation, if there was any at all, during the first 0.1 sec of the sc current, and the conditions under which an aperiodic component may be set up are very clearly defined. These conditions concern the elements of the system contributing the bulk of the short circuit reactance. If this part consists of lines, normal transformers, concrete reactors or the sum of the reactances of such elements, there is practically no aperiodic component in the breaking current. Where sc reactance is mainly due to generators, very large transformers and reactors, the aperiodic component may be considerable. In modern interconnected power systems, the maximum powers on short circuit arise mostly at interconnecting points and here the line resistances are most effective in damping out aperiodic components. It is therefore concluded that the definition of the breaking capacity must in the main be based on the symmetrical power of short circuit, although special investigations should always be made on system conditions giving rise to aperiodic components and the ability of the breaker to deal with them. (*Science Abstracts*)

**No. 2383.** H. Edels and F. W. Crawford, "The Determination of the Free Recovery of Gaps After Arc Interruption," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 102, 14 pp. (1956).

A technique is described by means of which the free recovery of gaps after arc interruption may be accurately determined in the form of time-dependent reignition voltage curves. Curves are given showing gap recovery after 10-40 A d-c carbon arc interruption in air, nitrogen, and argon for a pressure range 100-750 mm Hg and with gap separations of 1, 3, and 5 mm. The results in general may be satisfactorily understood on the basis of thermal considerations, but attention is drawn to the existence of unique pauses in the recovery which are, it is suggested, determined by the minimum spark breakdown process. (*Science Abstracts*)

**No. 2384.** W. Rieder and A. Eidinger, "Magnetic Blast in Circuit Breakers," *Conf. Int. G. Res. Elect. (CIGRE)*, Paper 107, 9 pp. (1956).

Describes an investigation of the action of a magnetic field on the arc in circuit breakers with a view to establishing data on its efficacy in various conditions, especially in the case of breaking weak currents. (*Science Abstracts*)

**No. 2385.** J. P. Skillen and D. H. McKeough, "A New Circuit Breaker Designed to Meet Canadian Requirements," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 111, 14 pp. (1956).

Outlines the development of a circuit breaker designed to meet the requirements of the Canadian market and gives the reasons why the Jetaire interrupter was evolved rather than adopting improved oil circuit breakers or a conventional European air-blast circuit breaker. Particulars of the design and tests are included, the four ratings being 115 and 138 kv and 500 and 5000 mva. Other ratings are contemplated. (*Science Abstracts*)

**No. 2386.** I. S. Aronovich and V. V. Gurvich, "Survey of Isolating Switch Designs for 380-400 KV," *Elektrichestvo*, No. 1, pp. 60-64 (1954). (In Russian.)

The designs compared are of Swedish (ASEA), Swiss (Brown-Boveri), French (Delle), German (TRO/AEG), U.S.A. (R & I; Delta-Star), and USSR (Elektroapparat) origin. Generally, these types represent later stages of development of well established and well known models, with adaptations to the higher voltage following largely the same principle in all the models compared. Although the ratings of the various designs differ somewhat, the tabulated performance data show much smaller differences, and the mechanical characteristics and thermal durability of the stressed elements are equally good, considering the presumed differences in the climatic conditions under which the circuit breakers operate. (*Science Abstracts*)

**No. 2387.** F. V. Bezrukov, "Expulsion Tubes Type RTV," *Elektrichestvo*, No. 3, pp. 45-48 (1956). (In Russian.)

The U.S.S.R. expulsion tubes RTV, use, as a gas generating material, a p.v.c. plastic which evolves much larger quantities of gas than the conventional fiber. It is a good insulator and does not deteriorate during long periods in the open, since it is unaffected by moisture. These tubes are available for 6-220 kv systems, with dry breakdown strengths from 35 to 780 kv and wet breakdown strengths of 32 to 760 kv. The breaking capacities extend to 15 ka, the makers guaranteeing, as a minimum, these ruptures of the upper limiting current, followed by two ruptures of the upper limiting current. The pressure at the current zero of the breaking current is still 60 per cent of the maximum pressure as against only 47 per cent for the usual fiber bakelite tubes, thereby improving the conditions of de-ionization of the internal gap. All the relevant characteristics of the series of tubes are given in graphs and tabulations. The comprehensive tests yielded results confirmed by operational experience. (*Science Abstracts*)

**No. 2388.** A. M. Cassie and F. O. Mason, "Post-Arc Conductivity in Gas-Blast Circuit-Breakers," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 103, 18 pp. (1956).

The post-arc conductance observed in a gas-blast circuit breaker is shown to depend on the gas flow, that is, on the axial pressure gradient in which the arc column is situated. The time constant, or constants, associated with the arc column are similarly related to the pressure gradient. The experiments cover a current range up to 18 ka rms at 7-10 kv rms, and peak values of post-arc current of 23 a have been observed. A dynamic equation taking account of both conduction and connection losses is set up, and the question of time constants discussed. This is used to interpret the experimental results. (*Science Abstracts*)

**No. 2389.** H. Thommen, "The Most Recent Progress in the Field of Air-Blast Circuit Breakers," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 119, 24 pp. (1956).

Describes with diagrams, illustrations, and oscillograms, the development of multi-break air-blast circuit breakers to increase considerably the breaking capacity. Reference is made to improvement of the distribution of the voltage gradient by the use of capacitors (without resistances), to resistance switching and to nozzle design. The model developed is provided with high speed control such that the total breaking time is not greater than 40 msec. It is capable of dealing with high-speed reclosure. (*Science Abstracts*)

**No. 2390.** V. Gusa, I. Krzhizh, I. Ladnar, and L. Chernyi, "Drying of Compressed Air for High-Voltage Circuit Breakers," *Elekt. Statsii*, No. 2, pp. 26-31 (In Russian.)

The reduction of the relative humidity through expansion from 30 kg per sq cm to 15 kg per sq cm is not sufficient if the plant has to work at temperatures of -20 C. Additional drying is obtained through silica-gel filters and an arrangement is described by which two filters work alternately and are automatically taken out of service and dried when their moisture content has reached a certain value as indicated by the fall in electrical resistivity of a silica-gel indicator. Drying of the filter then takes place through passing of hot air. When the filler is dry enough, the heater and the air circulation are automatically switched off. (*Science Abstracts*)

**No. 2391.** P. Miljanic, I. Obradovic, and V. Vuckovic, "A.C. Network Analyzer with Generators and Loads Represented by Current Sources," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 322, 5 pp. (1956).

An analyzer in which power outputs of generator units and inputs to load units are set up directly and independently. The substitution of the usual voltage-generator units and load impedances by current transformers is the essential characteristic of the new construction. The solving of various power

system problems, especially of load studies, becomes more rapid and easier and it is possible to study directly the effect of various changes in the system upon its behavior. The construction is simple and the cost low. (*Science Abstracts*)

No. 2392. A. A. Khachaturov, "Surge Currents and Torques on Throwing-On Generators Without Synchronization," *Elektrichestvo* No. 2, pp. 21-26 (1956). (In Russian.)

Automatic reclosing after short circuits with control and recovery of synchronism is not always successful in interconnected power systems or systems supplied by several stations working in parallel. In the latter case, self-synchronization is possible, but not in the former. The third possibility, namely, reclosing without synchronization is interconnected systems and powerful systems with several sources of supply, was extensively investigated by the Central Electrical Research Laboratory of the USSR. This method was found quite feasible and quite harmless if line and generator reactances are considerable. However, it is always necessary to check the maximum current surges and torques set up by unsynchronized reclosing by the formulas presented in the paper; the power angle at which the maximum torque is set up is 135 deg for a hydrogenerator, 120 deg for a turbogenerator, and the theoretical surge current must not have an amplitude factor  $>3$  for a hydrogenerator or  $>5$  for a turbogenerator. (*Science Abstracts*)

No. 2393. S. Fukuda and F. Mori, "Restriking Voltage Conditions on the Japanese Systems," *Conf. Int. Gr. Res. Elect. (CIGRE)*, Paper 105, 14 pp. (1956).

The results are given of a survey of the inherent restriking voltage characteristics representative of the present Japanese m.v. and h.v. systems. The proposal for standardization of the inherent restriking transients is given for the revision of the Japanese specification for power circuit breakers based on the data obtained. The method of attack is also given. (*Science Abstracts*)

No. 2394. I. S. Aronovich, "400 KV Isolating Switch for the Transmission System Kuibyshev-Moscow," *Elektrichestvo*, No. 1, pp. 36-41 (1956). (In Russian.)

The isolating switch completing the rupture of the current in v.h.v. circuit-breakers when it has been initiated by the multiple breaks in the quenching chamber must satisfy very stringent conditions, such as to be able to break currents up to 2000 a, to withstand forces up to 400 kg in the pull rods of the mechanical drive and wind loads corresponding to wind speeds of 25 m per sec with a safety factor of 3; when one of the porcelain elements of the insulating support breaks, none of the parts of the switch itself must

fall down nor any switching operation be initiated; full freedom must exist to place earthing connections at the side deemed most suitable, and several of them; each pole of the switch must have, in addition to a manual drive, a 380-v motor drive, and the earthing devices as well. The total time for completing any switching operation by means of the motor drive must not exceed 30 sec; the insulation level must correspond to that required by the standards and operation must not be affected by ice coats up to 10 mm thick on the breaker. These conditions are satisfied by the type RONZ-400 developed since 1953 and described in detail. (*Science Abstracts*)

No. 2395. L. K. Greiner and V. V. Afanas'ev, "Design of 380-400 KV Circuit Breakers," *Elektrichestvo*, No. 2, pp. 27-32 (1956). (In Russian.)

The types considered in the survey are those developed by ASEA, Brown-Boveri, Delle, Oerlikon, and Sprecher & Schuh, which are contrasted with the construction brought out by the All-Soviet Electrotechnical Institute. It is seen that the main principles of all these designs are very much the same, in so far as air-blast types with multiple-breakers and isolators for the final break in air prevail, although Delle and Oerlikon produce small oil-volume breakers and brown-Boveri operate the isolator in compressed air. The guaranteed breaking capacities are between 8000 and 12,000 mva, but the effective values are much closer together. (*Science Abstracts*)

No. 2396. G. S. Puzyr'skii and S. V. Biryukov, "Investigation of the Arc-Quenching Capacity of the Isolating Mechanism of an Air-Blast Circuit-Breaker for 400 kv," *Elektrichestvo*, No. 2, pp. 32-37 (1956). (In Russian.)

The isolating mechanism investigated forms part of a 400-kv/2000 a/10,000-mva circuit breaker and is shown to possess the required faculty of breaking the current on the voltage divider of the quenching chamber. During the tests the mechanism broke easily an active line current of 1.27 a at 700 kv under normal atmospheric conditions, at knife angles 44-45 deg. The dynamic strength, that is, the relation between breakdown voltage and shortest distance knife-fixed contact on circuit-making is greater than the static strength, which corresponds to that of a rod-rod gap of the same length. This fact combined with the satisfactory mechanical characteristics of the mechanism enabled the breaker to be tested in full duty (make-break) cycles without applying the full operating voltage. The same method can also be applied to 110, 154, and 220-kv circuit breakers of a similar design. The voltage divider was found to possess the required

thermal stability for actual operation at 400 kv. Although there is no trip-free device provided on the mechanism, instantaneous tripping after closure on a short circuit is possible and accurate. (*Science Abstracts*)

**No. 2397.** N. A. Gozhenko and Yu. M. Altaiskii, "Resistance of a Metal-Semiconductor Contact for Large Contact Potential Differences," *Zh. eksper. Teor. Fiz.*, Vol. 30, No. 2, pp. 401-402 (1956). (In Russian.)

The barrier resistance for contacts to  $\text{Cu}_2\text{O}$  was found to vary with the degree of occupation of surface levels as affected by absorption of vapor (water, acetone, etc.). The type of variation appeared to depend on whether the c.p.d. metal- $\text{Cu}_2\text{O}$  was small (Au, Cu) or large (Zn, Al), a transition being observed near c.p.d. = 0.50 v. The effects were interpreted in terms of a lowering of the impurity level near the surface, the transition being ascribed to its crossing the Fermi level. (*Physics Abstracts*)

**No. 2398.** I. G. Nekrashevich and S. P. Mitkevich, "Some Relationships of the Phenomena of the Electrical Erosion of Metals in a L.V. Discharge in a Liquid," *Zh. Tekh. Fiz.*, Vol. 26, No. 1, pp. 90-95 (1956). (In Russian.)

The erosion of the electrodes in a l.v. capacitor discharge in transformer oil was investigated. The weights of eroded electrode material were determined for Pb, Zn, Cu, Co, Ni, Fe, Al, Cr, and W electrodes in various combinations. An approximate quantitative relationship for the erosion in discharges between electrodes of the same materials was found. A qualitative interpretation of the observed relationships of erosion between electrodes of different materials is presented. (*Physics Abstracts*)

**No. 2399.** B. M. Nekrasov and I. M. Radashkovich, "Arc Welding of Contacts in Starting and Control Devices," (*Elektrosvarka kontaktov puskoreguliruiushchei apparatury*). (In Russian.) Svarochnoe Proizvodstvo, No. 4, pp. 18-22 (1956).

Welding of ag and powdered metal contacts calls for the use of spot welding machines with precise regulation of electrode pressure (25 to 100 kg) and high welding current. Diagrams, photograph, table, micrograph. (*Battelle Technical Review*)

**No. 2400.** K. Millian and W. Rieder, "Contact Resistance and Contact Surfaces," *Z. Angew. Phys.*, Vol. 8, No. 1, pp. 28-34 (1956). (In German.)

An experimental investigation of the resistance of an electrical contact consisting of crossed cylinders. The dependence of the resistance on the contact metal (copper, silver, tungsten), on surface treatment, contact load, and the growth of surface films is examined. (*Physics Abstracts*)

**No. 2401.** O. Loh, "Current Voltage Peaks and Thermal Loading of Contacts During the Switching of Capacitors on to the System and to Parallel Capacitors," *Arch. Elektrotech.* (Berlin), Vol. 42, No. 3, pp. 164-183 (1956). (In German.)

Equations are given for current and voltage transients occurring during the switching of capacitors to the system or to parallel capacitors. The switching capacity of a given contactor is determined by the ratio of the square of the peak current to the square root of the natural frequency. A chart is given for reading this quantity directly from the capacitor rating to be switched in parallel to that already working on the same busbars depends on the ratio of the system inductance to that of the circuit between the capacitors. The findings have been verified by tests on 380-v capacitors and various contactors. Greater contact wear was measured for switching to the system than for switching to parallel capacitors. (*Science Abstracts*)

**No. 2402.** V. Zajíc, V. Atimr, M. Dolčal, and J. Škaloud, "Testing Method for D.C. High Speed Circuit Breakers Using an A.C. Source," *Elektrotech. Obsor.*, Vol. 45, No. 2, pp. 75-83 (1956). (In Czech.)

A complete analytical theory of the operation of high-speed heavy current d-c breakers is presented and used for determining the required constants of a s-c test circuit. It is found that higher accuracy may be obtained by using an a-c rather than a d-c supply for the test circuit. Certain necessary modifications, incorporated in a special auxiliary device, are described. Results of tests are reported. (*Science Abstracts*)

**No. 2403.** J. Kracik, "Calculation of the Pressures in an Explosion Chamber," *Elektrotech. Obsor.*, Vol. 45, No. 2, pp. 84-90 (1956). (In Czech.)

Although the original type of explosion chamber is no longer used in modern oil circuit breakers, it lends itself more easily to an investigation of the pressure processes during vapor and gas formation and oil discharge from the chamber. The analytical treatment, even in this simplest case, cannot give more than a first and second approximation; however, even the first approximation is in very good agreement with experimental results. Electrical Research Association. (*Science Abstracts*)

**No. 2404.** Fernard Bedard and Hans Meissner, "Measurements of Contact Resistance Between Normal and Superconducting Metals," *Physical Review*, Vol. 101, Ser. 2, Jan. 1, 1956, pp. 26-30.

The contact resistance between crossed wires of Pb and Sn, Pb and Cu, Sn and Cu, and Sn and In separated by their natural oxide layers was measured at constant tem-



peratures as a function of current direction and magnitude. Diagrams, table, graphs. 9 ref. (*Battelle Technical Review*)

**No. 2405.** R. W. Stineman and P. L. Epstein, "Sensing Methods Applicable to a 3-Phase Load Transfer Contactor," *Trans. Am. Inst. Elect. Engrs.*, II, Vol. 74 (1955), pp. 471-475 = *Applic. and Industr.*, No. 22 (Jan., 1956).

Outlines the requirements and shortcomings of conventional load transfer contactors in 3-ph. electrical systems for aircraft with a brief review of fundamental concepts involved. A contactor using sequence-filter sensing circuits is described and an improved 3-ph. design derived which weighs  $7\frac{1}{2}$  lb and is rated at 175 A/ph. (*Science Abstracts*)

**No. 2406.** A. H. M. Arnold and L. H. Ford, "D.C. Circuit Interruption and Arc Characteristics at Low Air Pressures," *Proc. Inst. Elect. Engrs.*, Paper No. 1935U, Jan., 1956, 9 pp. To be republished in Vol. 103A (1956).

Measurements were made of the voltage and current in d-c arcs over a range of air pressures using silver, copper, and tungsten electrodes. The investigation showed that, although the arc characteristic at low pressures is less favorable for breaking large currents than it is at atmospheric pressure, comparable switch performance may usually be obtained either by an increase of gap length, or by an increase in the number of series breaks. Simple empirical relationships for the arc characteristics based on the experimental data obtained are given for silver and tungsten electrodes. Tests on the interrupting capacity of switches gave results which were in reasonable agreement with predictions made from these empirical formulas. (*Science Abstracts*)

**No. 2407.** D. Walsh, A. W. Bright, and T. J. Bridges, "Electrode Deterioration in Keep-Alive Discharges in Transmit-Receive Switches," *Brit. J. Appl. Phys.*, Vol. 7, No. 1 (Jan., 1956), pp. 31-35.

An investigation of the behavior of electrode materials in a discharge containing water vapor is described. Most common stable metals, as well as a semiconducting ceramic were tried. Some information is given on the increase of maintaining voltage and sputtering with time for both normal and abnormal glow discharges. Measurements of the rate of cleanup of water vapor in normal discharges have also been made. (*Science Abstracts*)

**No. 2408.** B. Adkins, W. Philipp, and A. Hossie, "Electrical Machines for Aircraft," *Proc. Inst. Elect. Engrs.*, Paper No. 1971U, publ. Jan., 1956, 12 pp. To be republished in Vol. 103A (1956).

Machines both for d-c and a-c are considered and are classified as generators, motors, and converting machines. The well established engine-driven blast-cooled d-c generator receives much attention. The use of high temperature insulation, brazed connections, impregnated brushes, high permeability magnetic materials, and other special features are discussed in some detail. D-c motors, while offering more variety, give rise to fewer difficult design problems. A-c generators may run over a wide speed range, as in many present-day installations in which most of the output is rectified in order to provide a d-c supply, or they may be driven at constant speed from a variable ratio gear coupled to the main engine or from a separate turbine. The insulation and constructional problems are similar to those of the d-c generator. A-c motors, inverters, and rotary transformers introduce their own problems in relation to starting, regulation, and other requirements. (*Science Abstracts*)

**No. 2409.** S. Mészner, "Nomogram for the Determination of Short Circuit Stresses in Heavy Current Busbars," *Elektrotechnika*, Vol. 49, No. 1 (Jan., 1956), pp. 23-26. (In Hungarian.)

The basic problems of mechanical stresses are summarized under resonance conditions and a nomogram worked out which enables a quick check of the natural frequency and maximum mechanical stresses of heavy current busbars. Attention is drawn to the national standards. (*Science Abstracts*)

**No. 2410.** L. H. Germer and W. S. Boyle, "Two Distinct Types of Short Arcs," *J. Appl. Physics*, Vol. 27, No. 1 (Jan., 1956), pp. 32-39.

Short field emission arcs are of two types, those which vaporize metal predominantly from the anode by electron bombardment, and those in which the metal of the arc is supplied from the cathode largely by the melting of points by the field emission currents flowing through them. These are approximately called "anode arcs" and "cathode arcs." A single anode arc erodes a pit in the anode and leaves a corresponding roughened area on the cathode. A single cathode arc, on the other hand, leaves on the cathode a widely dispersed array of individual pits which tend strongly to lie along scratch lines; in many cases no mark at all can be found on the anode after an arc of this type. Anode and cathode arcs differ in arc voltage, which is higher for cathode arcs than for anode arcs, and in other ways. Both types of arcs have been observed for many metals, but the data reported here are for palladium only. For clean surfaces of palladium all arcs are of the cathode type at a striking potential of 400 v but at 300 v and at lower voltages anode arcs are observed also, becoming more

frequent as the voltage is lowered. For surfaces activated by carbonaceous material only arcs of the cathode type occur at all striking potentials. In an anode arc, metal is transferred in both directions, as measured by radioactive tracers, but the net transfer metal from cathode to anode only, and the magnitude per unit of arc energy is less than the transfer in an anode arc. (*Physics Abstracts*)

No. 2411. H. B. Boerema, "The Type Testing of a Tap-Changer for 150 KV Transformers with an Output of 50 MVA," *Smil. Meded.*, Vol. 11, No. 1 (Jan.-March, 1956), pp. 6-21. (In Dutch.)

Details of the test on the tap-changer for the on-load regulation of the transformer are given with conclusions on the ability of the tap-changer to withstand service conditions. (*Science Abstracts*)

No. 2412. E. Rabinowicz, "Autocorrelation Analysis of the Sliding Process," *J. Appl. Phys.*, Vol. 27, No. 2 (Feb., 1956), pp. 131-135.

A simple model of the sliding process is developed in which the junctions are of the same size, but have different shear strengths, and, using an artificially obtained friction trace, it is shown that the size of the junctions may be deduced through a simple autocorrelation analysis. Applied to real friction traces obtained at slow sliding speeds, the technique gives an average junction diameter of 9 by  $10^{-4}$  cm, in good agreement with previous estimates, while a different statistical method gives a value of 5 by  $10^{-4}$  cm. (*Physics Abstracts*)

No. 2413. L. Orgeret, "Problems Raised by the Breaking of Currents and Different Methods Used for Circuit Breaking," *Bull. Soc. Franc. Elect.*, Vol. 6 (Feb., 1956), pp. 123-140. (In French.)

Discusses arcing phenomena in relation to breaking short circuit a-c arcs at m.v. and h.v. including the special cases of passage of the current through zero and restriking voltage transients as applied to oil and gas blast circuit breakers. Post-arc conductivity, resistance switching, and magnetic blowout arrangements are also considered. The basic designs of commercial types of circuit breakers are briefly reviewed with illustrations and divided into 3 classes: self-generated blast (arc suicide), blast produced by external means (arc assassination), and lengthening the arc to produce extinction (natural death of the arc). (*Science Abstracts*)

No. 2414. G. W. Clayton, "Switching of Shunt Capacitors and Reactors," *Engng. J.* Vol. 39, No. 2 (Feb., 1956), pp. 109-115.

The article is devoted almost entirely to capacitor switching; it is pointed out that the most troublesome phenomena do not arise

when switching shunt reactors. After a theoretical section on conventional lines, the question of circuit breaker selection is discussed in relation to each of the kinds of stress imposed by capacitor switching. (*Science Abstracts*)

No. 2415. L. E. Backer, P. Barth, R. A. Huse, and D. W. Taylor, "Transfer Tests on Station Auxiliary Busses," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 74 (1955), pp. 1441-1449. *Pwr. Apparatus Syst.* (Feb., 1956).

Particulars are given of tests on station auxiliaries when transferred from one power supply source to another by throw-over and when the throw-over is interrupted. It is necessary that certain system conditions should be recognized and the appropriate action taken as in the case of a slowly decreasing source voltage persisting long enough to affect adversely the auxiliaries when throw-over should occur; and say the voltage drop due to starting a large motor which should not cause throw-over. The importance of correct functioning is illustrated by reference to boilers fired by pulverized fuel and the possibility of explosion if the auxiliaries operate incorrectly. Feedwater and other problems are also discussed with explanatory curves and notes on relay operation. (*Science Abstracts*)

No. 2416. Joel P. Kesler, "Selecting Adequate Electrical Switching Equipment," *American Water Works Association, Journal*, Vol. 48 (Feb., 1956), pp. 153-165.

Criteria for the simple knife switch, the manual and magnetic-motor starter, the circuit breaker, and other devices having contacts which close and open a power circuit. Photographs, diagrams. 6 ref. (*Battelle Technical Review*)

No. 2417. R. H. Savage and D. L. Schaefer, "Vapor Lubrication of Graphite Sliding Contacts," *J. Appl. Phys.*, Vol. 27, No. 2 (Feb., 1956), pp. 136-138.

A fundamental study of graphite sliding contacts shows that atmospheric concentrations of only a few parts per million of the larger organic molecules are sufficient to prevent the severe wear of graphite which occurs in a dry atmosphere. The experimental results suggest roughly the empirical rule that the minimum relative "humidity" of a vapor for effective lubrication decreases logarithmically with chain length in the region 5 to 15 Å. (*Physics Abstracts*)

No. 2418. W. S. Boyle and F. E. Haworth, "Glow-To-Arc Transition," *Phys. Rev.*, Vol. 101, No. 3 (Feb. 1, 1956), pp. 935-938.

The conditions for the glow-to-arc transition at moderately high pressures (50 to 1300 mm Hg) have been studied experimentally. It is found that over the whole pressure range the transition is certain when the field at the

cathode reaches a critical value. This result is shown to be consistent with a field emission mechanism for the transition. Calculations of the critical field based on this process are found to be in good agreement with the fields which are determined experimentally. (*Physics Abstracts*)

**No. 2419.** E. Selzer, "On Certain Properties of Imperfect Electric Contacts with Application to Earthing and to Methods of Recording Earth Currents," *C.R. Acad. Sci. (Paris)*, Vol. 242, No. 7 (Feb. 13, 1956), pp. 884-887. (In French.)

A short discussion of contact resistance with applications to contacts between metals and liquids. (*Science Abstracts*)

**No. 2420.** P. F. Kurz, "The Useful Friction Recorder," *Am. J. Phys.*, Vol. 24, No. 3 (March, 1956), pp. 174-175.

A simple apparatus for recording frictional forces and changes in such forces encountered in traversing plane surfaces is described. Typical records are presented and the flexibility of the apparatus is discussed. (*Physical Abstracts*)

**No. 2421.** L. D. McConnell and J. D. Findley, "A New High-Power Cathode Circuit Breaker," *Trans. Am. Inst. Electrical Engrs.*, II, Vol. 75 (1956), pp. 39-43 = *Appl. & Industr.*, No. 23 (March, 1956).

This circuit breaker has been designed for the largest rectifiers available to limit the arc-back current to 75 ka at 1000 v. A magnetic de-ion interrupting chamber is used and an extremely high initial acceleration of the moving contact is obtained by using water cooling and a special alloy armature in the magnetic hold-on system. Details of interrupting tests are given. (*Science Abstracts*)

**No. 2422.** "Network Analyzer on D.C.," *Quad. Stud. Not.*, Vol. 12 (March 1, 1956), pp. 147-153. (In Italian.)

An illustrated description of an analyzer representing the network of Milan. A standard voltage for the actual 380/222-v network was taken as 380 v, the standard load was taken as 200 kva, and the values for the analyzer were then chosen as 10 v, 100 mv, with a basic resistance of 1 k $\Omega$ . The supply is a cadmium-nickel battery, charged from the mains via transformer and oxide rectifier. The various meters used are described, and an example of a calculation is given. (*Science Abstracts*)

**No. 2423.** S. Vørts, "The New Danish Network Analyzer," *Ingeniøren*, Vol. 65, No. 9 (March 3, 1956), pp. 209-218. (In Danish). Summary (1 p.). (In English.)

A detailed, illustrated description of an analyzer using electronic generator units and conjugate impedance representation, capacitors representing inductive reactances

and loads. The frequency used is 500 cps, base values 20 v, 20 ma, 1000 ohms. (*Science Abstracts*)

**No. 2424.** C. J. O. Garrard and D. A. Muret, "Isolators for Very High Voltages," *Elect. Rev.*, Vol. 158, No. 12 (March 23, 1956), pp. 421-425.

Discusses briefly basic types of h.v. isolator construction and insulator design with useful references to various national standards and I.E.C. proposals for ranges up to 400 kv. The importance of correct design from the point of view of safety, cost and performance is stressed. Performance figures for an insulator stack for a British 275-kv isolator are given with illustrations showing Swedish, German, and Swiss designs. (*Science Abstracts*)

**No. 2425.** W. R. Bennett, "Characteristics and Origins of Noise. Part I," *Electronics*, Vol. 29, No. 3 (March, 1956), pp. 154-160.

Electrical noise imposes the ultimate limit on the performance of any communications system. Discusses such types as thermal, vacuum-tube, contact and ignition noise, static, interference and quantizing noise originating in analog-to-digital conversion systems. (*Author*)

**No. 2426.** H. Diehl, "New Signalling and Control Equipment," *A.E.G. Mitt.*, Vol. 46, No. 3-4, (March-April, 1956), pp. 111-113. (In German.)

The equipment described is for use in control rooms of electrical power systems, and is designed to occupy the minimum panel space. It comprises a relay with operation indicator and reset button, a switch-position indicator, and several forms of remote control switch. (*Science Abstracts*)

**No. 2427.** J. H. Banks and K. C. Parton, "The Use of the Blackburn A.C. Network Analyzer in the Analysis of Power System Faults," *Proc. Inst. Elect. Engrs. Monogr.* No. 174S, published April, 1956, 8 pp. To be republished in Part C.

Describes the use of the analyzer in analytical and analogue methods of investigating faults on 3-ph. power systems. In the analytical approach, after defining the faults in matrix form by symmetrical components, the ensuing equations are solved using the Blackburn analyzer without the need for further matrix manipulation. In the analogue method, it is shown how the constraints imposed upon the phase voltages and currents can be applied directly to the sequence networks by the connection of symmetrical component operational matrices at the fault positions. No knowledge of the relationships between the symmetrical component currents is required, but it is necessary to know the relationships existing between the phase voltages and currents by virtue of the applied

faults. The "equivalent series" connections of the sequence networks, derived recently by Kirschbaum in America for application to the conventional type network analyzer, are shown to be unnecessary when using the Blackburn machine. Finally, systems containing unsymmetrical simultaneous faults are investigated using both methods. (*Science Abstracts*)

**No. 2428.** J. H. Banks and K. C. Parton, "The Use of the Blackburn A.C. Network Analyzer in the Analysis of Power System Faults," *Proc. Inst. Elect. Engrs. Monogr.* No. 174S, published April, 1956 (Vol. 103C, pp. 342-349).

Republication of the monograph abstracted in Abstr. 2427 (1956). (*Science Abstracts*)

**No. 2429.** W. B. Ittner, III, "Bridge and Short Arc Erosion of Copper, Silver, and Palladium Contacts on Break," *J. Appl. Phys.*, Vol. 27, No. 4 (April, 1956), pp. 382-389.

The bridge and short arc erosion of copper, silver, and palladium contacts and a number of alloys of these materials has been measured as a function of the break current in a circuit containing only a small amount of inductance. A theory is presented for calculating the arc duration, the charge passed by the arc, and the arc energy. Under the described conditions the total charge passed in the arc as well as the arc energy is proportional to the square of the rupture current. Short arc erosion in such a circuit will show, therefore, the same current dependence as bridge transfer. While it is possible to effectively separate the two types of erosion by controlling two processes may not be completely independent. (*Science Abstracts*)

**No. 2430.** W. Merl, "Material Transfer on Gold and Gold-Nickel Contacts," *Elektrotech. Z. (ETZ)* A, Vol. 77, No. 7 (April 1, 1956), pp. 201-205. (In German.)

Au-Ni contacts containing between 0 and 17 per cent Ni were tested on a vibrating rig at 4.3 A 6 v dc for 1.8 by 10<sup>4</sup> operations. It was found that mass transfer depends both on composition and on the circuit inductance over the range 0.06-20  $\mu$ H. The shape of worn contacts also varies with inductance. (*Science Abstracts*)

**No. 2431.** W. G. Bourne and A. Grieve, "Aircraft Switchgear," *Proc. Inst. Elect. Engrs.*, Paper No. 2087U, publ. April, 1956, 10 pp. To be republished in Vol. 103A (1956).

The paper emphasizes the importance of close cooperation between the aircraft designer and the electrical equipment manufacturer to avoid incompatibility of requirements and to ensure that all normal and abnormal operating conditions are fully appreciated. It indicates that, as generated powers increase, specialized design for most components will

be necessary. The design of current carrying elements and methods of assessing the rupturing capacity of switchgear are considered, together with the effects of voltage, frequency, and altitude on these parameters. The types, functions, and general methods of construction of control relays and switching equipment are discussed in relation to weight-saving and reliability. The design of equipment to operate at very high temperatures and altitudes, and the need for further development work on insulating materials and constructional methods are considered. (*Science Abstracts*)

**No. 2432.** J. E. Jennings, A. C. Schwager, and H. C. Ross, "Vacuum Switches for Power Systems," *Electrical Engineering*, Vol. 75 (April, 1956), pp. 350-354.

Practical use is made of the high insulating and current interrupting ability of a high vacuum. Tests show that vacuum switch with but  $1/10$ -in. contact travel can clear 79-amp at 66 kv rms and has a breakdown strength of 100 kv rms. Graph, photographs, diagrams. 2 ref. (*Battelle Technical Service*)

**No. 2433.** P. Baltensperger and P. Schmid, "Current and Post-Arc Conductivity in H.V. Circuit Breakers," *Bull. Assoc. Suisse Elect.*, Vol. 47, No. 8 (April 14, 1956), pp. 333-340. (In French.)

Describes means for accurately measuring post-arc current in an oil circuit breaker, a low oil content circuit breaker, and a gas blast circuit breaker (without reactance switching) all rated at 10 kv and having breaking capacities of 80, 250, and 200 mva respectively. Oscillograms showing post-arc current and recovery voltages are given and the results discussed and conclusions drawn. (*Science Abstracts*)

**No. 2434.** K. Sailer, "The A.C. Network Model of the Austrian Electricity Authority," *Elektrotech. u. Maschinenbau (EM)*, Vol. 73, No. 7-8, (April 15, 1956), pp. 158-165. (In German.)

Design of the model was commenced in 1948 in collaboration with the makers, Siemens and Halske. A condition was that while representing the Vienna system it should be capable of wide extension and also adaptable for use as a general analyzer. When the model was moved the opportunity was taken to introduce many refinements which are described in detail. (*Science Abstracts*)

**No. 2435.** M. Böttger, "The 'Hard Gas' Circuit Breaker," *Elektrotech. Z. (ETZ)* B, Vol. 8, No. 4 (April 21, 1956), pp. 124-125. (In German.)

Describes 10-kv 400-a switchgear in which the arc is extinguished by gas driven off by a solid under the heat of the arc. 3-ph. breakers are suitable for wall or truck mounting and are

fitted with a high speed operating mechanism. (*Science Abstracts*)

**No. 2436.** H. Floerke, "Metal-Clad Low-Voltage Switchgear for 500V, A.C.," *Siemens-Z.*, Vol. 30, No. 4 (April, 1956), pp. 198-199. (In German.)

Boards 220 cm high contain a busbar chamber at midheight with circuit breakers, switch fuses, or fused outlets for 100 to 300 a above and below. Special narrow rack-operated bus-section units have been developed. There are no division walls between adjacent units and the busbars are carried on arc-resistant barriers. (*Science Abstracts*)

**No. 2437.** H. L. Peek and M. G. Dyer, "Introduction of Hydraulic Operation to Low-Voltage Air Circuit Breakers," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 75 (1956), pp. 226-232 = *Pwr. Apparatus Syst.*, No. 23, (April, 1956).

Outlines a form of hydraulic operator intended to meet the need for reducing space occupied, and for providing an effort which is extending beyond the range of a-c solenoids. This development arose when considering a specification for breaking capacities of 50 ka and over for l.v. circuit breakers having mechanically trip-free linkage. The hydraulic method gives smoother operation and reduces mechanical shock to a minimum. (*Science Abstracts*)

**No. 2438.** A. Hochrainer, "The Motion of Short Circuit Arcs in High Voltage Switchgear," *Elektrotech. Z. (ETZ)*, A, Vol. 77, No. 10 (May 11, 1956), pp. 302-308. (In German.)

Experiments were carried out on 110-cm long arcs of 1.4-8.4 ka between two conductors running at 60 deg down from the feed point. At high currents the electromagnetic forces cause the arc to run downwards, but at 1.4 ka thermal effects preponderate and the arc rises. For intermediate currents the arc runs down but restrikes higher up. (*Science Abstracts*)

**No. 2439.** J. S. Halliday, "The Measurement of Frictional Forces at Vibrating Contacts," *J. Sci. Inst.*, Vol. 33, No. 6 (June, 1956), pp. 213-217.

A simple machine is described which is used for the investigation of wear phenomena at vibrating contacts. It is shown theoretically how the frictional forces at the contacts can be measured and the experimental tests substantiate the theory. Some friction measurements are given which were obtained using brass specimens immersed under silicone oils having a wide range of viscosities. It was found that the friction was least for the medium viscosity oils. The higher friction with the high viscosity oils arose because these oils were pushed aside from the contacts, and with the lowest viscosity oils be-

cause they were not as effective in preventing the growth of intermetallic welds as the medium viscosity oils. (*Physics Abstracts*)

**No. 2440.** C. H. Flurschein, "Switchgear. A Review of Progress," *Proc. Inst. Elect. Engrs.*, Paper No. 2012, publ. June, 1956 (Vol. 103A, pp. 239-262).

In British switchgear, development since 1945 has been directed mainly towards the improvement of interrupting performance, measured by reliability and speed of interruption of short circuits, and by the prevention of overvoltages when disconnecting open-ended lines or small reactive currents. It has also been directed towards reducing the size and cost of switchgear and the buildings in which indoor gear is mounted. The techniques of oil, air-break and air-blast interruption, and of multi-break design, with various forms of voltage division, have all been exploited to assist in achieving these aims. There is now little room for further reduction in the minimum size of switchgear for a given voltage, but the mva rating for the smallest frames, already doubled in this period, will no doubt continue to increase in the future. The upper limit of mva has increased 7 times, in the period under review, and there are no obvious limitations to further progress; it is to be expected that the mva rating available in circuit breakers of British design will continue to exceed those required on contemporary networks. (*Science Abstracts*)

**No. 2441.** W. Switney and C. L. Carlson, "Use and Properties of Extruded High Strength Aluminum for Electric Bus Conductors," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 75 (1956), pp. 449-553 = *Pwr. Apparatus Syst.*, No. 24 (June, 1956).

Extruded and heat-treated high strength Al bus conductors offered by the major suppliers of electric buses were found to be similar in all respects. Except for electrical conductivity, the new conductor alloy is similar to the extruded and heat-treated architectural alloy designated as 6063-T6. Current carrying tests were made on one of the available alloys to establish 60 cps current ratings for this new bus material. The results of these tests are applicable to the other high strength bus materials. Short-circuit tests were also made to determine adequate spacing between bus supports for various 3-ph. fault currents and also to compare the relative strength of buses made of this new alloy and Cu. (*Science Abstracts*)

**No. 2442.** D. T. J. ter Horst, "Modern Views on the Interruption of Short-Circuits in High-Voltage Electrical Networks," *Ingenieur*, Vol. 68, No. 23, E.61-E.68 (June 8, 1956). (In Dutch.)

Various types of present-day circuit breakers are described, and arc rupturing is dealt

with in some detail. The modern conception of post-arc conductivity is considered; an attempt is made to describe a high-current arc in the steady state on the basis of thermodynamical equilibrium of the arc plasma. (*Science Abstracts*)

**No. 2443.** B. P. Baker and R. E. Friedrich, "Control of Voltage Gradients in High-Voltage Watch-Case Multibreak Oil Circuit Breakers," *Trans. Am. Inst. Elect. Engrs.*, III, Vol. 75 (1956), pp. 286-292 = *Pwr. Apparatus Syst.*, No. 24 (June, 1956).

Contains particulars of impulse and 60 cps withstand-voltage tests and a study of voltage distribution and field gradients using a 330-kv pole unit with the breaker in the fully closed, partially open, and fully open positions. The effect of the shape of the tank and of the live parts is discussed and one set of tests was designed to simulate direct lightning strokes. (*Science Abstracts*)

**No. 2444.** R. T. Spurr, "The 'Ploughing' Contribution to Friction," *Brit. J. Appl. Phys.*, Vol. 7, No. 7 (July, 1956), pp. 260-261.

When a hard surface is slid over a softer surface part of the frictional resistance is due to the force required to plough asperities of the harder surface through the softer. It is shown how this ploughing contribution to friction can be obtained for hard steel balls and wedges sliding on soft metals. (*Physics Abstracts*)

**No. 2445.** A. M. Sletten and T. J. Lewis, "Characteristics of the Trigatron Spark-Gap," *Proc. Inst. Elect. Engrs.*, Monogr. No. 193M, publ. Aug., 1956, 8 pp. To be republished in Part C.

The behavior of the trigatron three-electrode spark gap in air has been investigated and its characteristics obtained with particular reference to its use as a controlled high-voltage switch. It is found that the voltage range over which it may be triggered satisfactorily depends, not only on the polarities of the main gap and triggering voltages, but also on the energy of the discharge. The breakdown time lag is also determined by these same voltage polarities and also by the time constant of the trigger discharge circuit. From these characteristics and certain other relevant observations, a theory of the breakdown process in such a spark gap is suggested, involving the propagation from the trigger of a low-density easily ionized region. Finally, a brief investigation of the successful use of a trigatron in a diverter circuit capable of diverting the discharge energy in a spark

gap subjected to direct and impulse voltages of 300 kv and in a circuit providing accurate "chopping" of impulse voltages waves, is reported. (*Science Abstracts*)

**No. 2446.** W. Hirst and J. K. Lancaster, "Surface Film Formation and Metallic Wear," *J. Appl. Phys.*, Vol. 27, No. 9 (Sept., 1956), pp. 1057-1065.

The interactions between surface asperities which occur during sliding are of primary importance in both friction and wear. In consequence, many of the phenomena observed during investigations into the nature of friction should have their counterpart in wear. An experimental study is described of the way in which wear is affected by factors already known to influence friction. It is shown that when a relatively soft metal slides on a harder one, the relationship between the wear and the sliding distance may be one of three general types. Each type is associated with the formation of a surface film during sliding. The extent to which these films (oxide, adsorbed boundary lubricant, etc.) prevent intermetallic contact influences the relationship between the wear rate and the applied load. With several metals there is a discontinuity in the wear rate-load relationship, and two distinct regimes of wear are obtained. The transition between these two regimes is associated with the breakdown of a protective surface film. Finally, it is suggested that the generation of protective surface films during sliding comprises an essential part of the "running-in" process of machinery. (*Physics Abstracts*)

**No. 2447.** C. Adamson and A. M. S. El-Serafi, "Representation of Saliency on A.C. Network Analyzers," *Proc. Inst. Elect. Engrs.*, Monogr. 198S, publ. Sept., 1956, 8 pp. To be republished in Part C.

Existing methods of representing saliency on network analyzers are discussed. These include combined-reactance methods and two methods using a d-c signal to represent the emf of the synchronous machine. A simple method of representing saliency, in association with a network-analyzer generator unit, is then described, together with the associated electronic circuits. The results of a problem involving saliency, which has been solved by means of the apparatus described, are presented and the results are discussed. It is concluded that the method employed is more economical than those previously published, and is well within the normal limits of accuracy for electrical power-system analysis. (*Science Abstracts*)