SUPPLEMENT TO BIBLIOGRAPHY AND ABSTRACTS ON THERMOSTAT METALS - 1962 —— 1965

1962

No. 555. C. F. Alban and C. C. Perry, "Practical Methods for Design and Development of Current-Limiting Bimetals," Machine Design, December 6, 1962, Vol. 34, No. 28, pp. 169-172.

Practical methods to help the engineer converge on the optimum design in minimum time of bimetals heated by current passage. Design and similitude relationships given.

No. 556. R. C. DeVinney, "Thermoelastic and Thermal Expansion Properties of Iron-Nickel Alloys," Strain Gage Readings, October-November 1962, Vol. V, No. 4, pp. 23-30.

A literature survey of how the thermal expansion coefficients and the temperature coefficient of modulus can be controlled within wide limits in iron-nickel alloys.

No. 557. J. Kirchdorfer, "Devices for the Protection of Electric Motors," Technische Rundschau, No. 14, March 30, 1962, pp. 5-27.

A survey of present motor protection practice against thermal overloads. Short descriptions of all systems are given. Thermal overload relays using thermostat metals and inherent protective devices are explained in more detail. The coordination of the various elements in motor control of many types is explained to help the user in the proper selection of equipment.

No. 558. C. M. Proctor, "Temperature Control of Lab Baths," Instrum. Control Syst. (USA), May 1962, Vol. 35, No. 5, pp. 111-118.

Discusses the practical problems of maintaining constant temperatures in laboratory baths. Considers various types of sensing elements used mainly for controlling electrical heaters: bimetal strips, fluid expansion regulators, resistance thermometers and thermistors. Gives recommendations and circuit diagrams for building electrical regulation systems in the laboratory and considers the growth of algae and bacteria in the bath. (Science Abstracts)

No. 559. John Proctor and Frank Hall, "How to Choose a Timer," Product Engineering, February 19, 1962, pp. 96-111.

Discusses the three major functional categories of timers; clocks, control components and timing controls. Gives advantages and limitations inherent in each type. Included is the bimetal type thermal delay relay.

No. 560. W. K. Roots, "An Introduction to the Assessment of Line Voltage Thermostat Performance for Electrical Heating Applications," American Institute of Electrical Engineers Transactions Paper, 62-17, 14 pages, January 28-February 2, 1962.

The key indices of thermostat performance in electrical heating systems are explained. Response, offset, cycle time, droop, and similar terms are introduced and basic methods for their measurement in the field and laboratory are described. The correlation between field and laboratory tests is outlined. Modern thermostat components, such as snap action switches, shunt and series anticipators, are described and two fundamental methods of modulation are introduced.

No. 561. W. K. Roots, "Modulation Circuits for the Line-Voltage Control of Electric Heating by Anticipated Thermostats," American Institute of Electrical Engineers Conference Paper, CP 62-16, 10 pages, January 28-February 2, 1962.

Reduced voltage modulation and two stage modulation are compared. Reduced voltage circuits are examined incorporating both shunt and series anticipation. A circuit combining both types of modulation is presented. Partial solid state modulation is introduced and extended to cover sensing of wall temperatures. Demand control, shut down, and photo-luminescent features are described.

No. 562. Lars G. Soderholm, "Bimetal Linkage Compensates Relay for Ambient Variations," Design News, Vol. 17, No. 9, May 2, 1962, pp. 6-7.

Describes an ambient temperature-compensated thermal overload relay made by Furnas Electric Company. Unit uses a bimetal strip compensating linkage to provide constant trip characteristics regardless of ambient temperature variations.

No. 563. R. F. Stengel, "Temperature Sensors Add Flexibility to Steam Trap," Design News, Vol. 17, No. 10, May 16, 1962, pp. 16-17.

Describes steam trap made by Gustav F. Gerdts KG, Bremen, Germany. Unit incorporates temperature sensors of thermostat metal to vary the effective cross-section of a multistage expansion nozzle.

No. 564. "The Electric Controls Book Issue," Machine Design, Vol. 34, June 14, 1962, 257 pages.

Contains basic design facts about electric components, such as switches, relays, timers, and industrial controls, to aid in proper selection and application. Detailed information on types and manufacturers of such components as a guide to specifications.

1962

No. 565. "Time Delay Relays," Electromechanical Design, February 1962, Vol. 6, No. 2, pp. 39-62.
Considers the simple time delay relay. Thermal, thermal-magnetic, industrial thermal, pneumatic and hydraulic, mercury flow, electronic, welded module, flip-flop module, RC-binary module, RC-magnetic, clock, and copper slug time delay relays are discussed. Deals with manufacturers' units, emphasizes the common mechanisms, means of controlling delay periods, and factors affecting their accuracy.

1963

No. 566. C. F. Alban and C. C. Perry, "Design of Bimetal Actuators for Snap-Action and Constant-Friction Devices, "Electro-Technology, April 1963, Vol. 71, No. 4, pp. 75-78.
Conventional design relationships for the design of bimetal actuators are inadequate when the operated device exhibits mechanical hysteresis, as with snap action or uniform friction. For these cases, expressions are developed to provide for the additional factors involved, and their use in design described.

No. 567. Rudy Bergsma, "Improved Control System for Electric Ranges," Home Appliance Builder, November 1963, Vol. 28, No. 11, pp. 18-19.
Describes a new more sensitive control system developed by King-Seely that makes faster corrections on deviation from set temperatures and maintains close temperature regulation. A new thermal relay, the thermometal responder, and the senser all contribute to the improved unit.

No. 568. R. Brenner, "On the Problem of the Specific Bending of Thermobimetallic Strips," Z. Angew. Phys. (Germany), 1963, Vol. 16, No. 5, pp. 390-391.
States that the treatment given in Z. Angew. Phys. (Germany), Vol. 15, No. 2, 178-180, (February 1963) was incorrect and the Villarcean's formula is in agreement with the recent experimental values and is correct. (Science Abstracts)

No. 569. A. Christman, "Bimetal Measuring Instruments," Elektroteknikeren (Denmark), Vol. 59, No. 5, March 7, 1963, pp. 85-86.
Reviews various types of measuring instruments for machine tools. In particular, ammeters for maximum currents and maximum voltmeters of various types are considered. (Science Abstracts)

No. 570. W. S. Eberly, "Design Properties of Controlled-Expansion Alloys," Machine Design, May 9, 1963, Vol. 35, No. 11, pp. 236-242.
Characteristics of low expansion alloys, with 36% Ni-Fe alloy Invar being the most widely used alloy for low expansion applications. Properties of controlled expansion alloys, effect of processing temperature, uses, glass and ceramic sealing alloys and their applications. (Engineering Index)

No. 571. M. N. Filatov, "A Thermal Relay for Protecting Colliery Motors," Elektrotekhnika (USSR), November 1963, No. 11, pp. 65-69.
To prevent damage to an electric motor and yet at the same time make full use of its heat capacity it is important that thermal protection follows closely the actual temperature of the motor windings. The type TM-4 relay consists of a narrow brass case containing a bimetallic strip and an independent contact assembly, the strip being heated by conduction through the wall of the case to which it is clamped. The strip carries no part of the contact current and so its characteristics are not affected by the rest of the protective scheme. This type of construction results in a very low time constant of response. (Science Abstracts)

No. 572. E. A. Kaminskii, "On the Article by A. G. Gur'yanov 'Automatic Temperature Control'", Energetik (USSR), No. 2, February 1963, pp. 17-19.
With reference to previous published articles on automatic temperature control devices all incorporating contact-thermometers, reviews the apparatus which can be used in place of such thermometers where none are available. The devices discussed are various types of thermal signalling devices, bimetallic relays, and purely mechanical devices not involving electrical circuits. (Science Abstracts)

No. 573. W. J. Knoernschild, "Controlling Induction Generators," Allis-Chalmers Elec. Rev., Vol. 28, No. 4, 1963, pp. 22-24.
Controls for starting, operating and reducing of speed are discussed; protective devices against overload, short circuits and motor operation are reviewed, including switches, passive electric components, current limiting fuses, relays and circuit breakers. (Engineering Index)

No. 574. Franz Lihl and Josef Thony, "The Effect of Temperature on the Mechanical Properties of Iron-Nickel Alloys," Archiv fur das Eisenhuttenwesen, Vol. 34, No. 9, September 1963, pp. 701-712.
Tensile testing at -185 to +500C., notch impact testing at -185 to +1000C., measurement of the electrical resistance at 20 to 1000C., and magnetic, microscopic, and X-ray investigation of Fe Ni alloys containing 0.02 to 0.15% C and 5 to 99% Ni. Evaluation of the effect of microstructure on mechanical properties.

No. 575. P. P. M. Meincke and G. M. Graham, "Thermal Expansion of Invar," Proceedings of the 8th International Conference on Low-Temperature Physics, London, 1963, pp. 399-400.

Data presented on the thermal expansion of Invar in the range 4-300°K. indicates that the coefficient of linear thermal expansion becomes negative below 62.5°K. resulting in a total expansion of 7.1×10^{-5} cm./cm. on cooling from 62.5 to 4°K. Various ideas are presented in an attempt to explain the negative values. It is recommended that Invar not be used for the construction of apparatus which must have a low coefficient of expansion at low temperatures.

No. 576. A. I. Minaev and V. V. Kerzhentsev, "Average Specific Heat Capacity of Thermobimetals and Alloys Used for Thermobimetallic Elements," Tsventnye Metally, No. 5, 1963, pp. 67-75. (In Russian)

Determination of the temperature dependence of the heat capacity of bimetals made of Ni-Cr iron alloys and Ni iron alloys at 20 to 400°C. by a special colorimetric apparatus.

No. 577. J. Palvolgyi, "Experiments of Preparing Invar Alloys," Paper from "Vasipari Kutato Int Evk," Budapest, 1963, pp. 206-207, 694, 706, 719, 733.

An alloy containing 0.1% C, 0.4-0.5% Mn, traces of Ti, 36-37% Ni, balance Fe, was developed for dilatation thermometers made in Hungary. The coefficient of thermal expansion of this alloy is 1.76×10^{-6} deg^{-1}. Another alloy, which is used in electronics for junctions with glass and ceramics, containing 0.1% C, less than 0.5% Si, 1.0% Mn, 45-46% Ni, balance Fe, or 0.1% C, less than 0.2% Si, 1.0% Mn, 27-28% Ni, 20-22% Co, balance Fe, is also suggested.

No. 578. A. F. Petrulenko, "Automatic Start-Up of Transformer Cooling Fans," Energetik (USSR), No. 1, January 1963, p. 23.

Describes a simple circuit for automatic or remote starting and stopping of transformer cooling fans. The circuit is based on a thermostat which measures the oil temperature and has maximum and minimum temperature contacts set at 55 and 50°C. respectively. The supply load is controlled by a current relay. (Science Abstracts)

No. 579. Ya. A. Rips, "O naivygodneishei forme termobimetallicheskikh elementov teplovykh apparatov zashchity i avtomatihe," Elektrichestvo, No. 10, October 1963, pp. 75-78.

Shape of bimetallic elements for thermal protection and control apparatus. Strip with lens shaped longitudinal profile cutoff at each end is shown to be the best shape of plane strip due to uniform distribution of temperature along element in steady state conditions. Method is given for calculating curvature for various currents. (Engineering Index)

No. 580. Raymond Sears, "Why Nickel is Used in Thermostat Metals," Inco Nickel Topics, Vol. 16, No. 2, 1963, pp. 4-5.
By varying the nickel content, nickel containing alloys can be used to provide both high and low coefficient of expansion thermostat metal components. Practically all the thermostat metals contain nickel in amounts varying from 5 to 60%. Described are some thermostat metals, the alloys used in these composites, production methods of bonding and applications.

No. 581. R. M. Sears, "Analysis of Matched Thermostat Metal Coils," Electromechanical Design, December 1963, Vol. 7, No. 12, pp. 52-56.
The effects on the resultant performance to be obtained from the shaft joining two thermostat metal coils is considered for both matched and mis-matched pairs of coils. The analysis is made for coils which are opposed for ambient compensation and for those applications where the two coils would be rotating in the same direction. Twelve different combinations of matched or mis-matched coils, opposed or rotating together with the same or different amounts of temperature change are possible.

No. 582. R. M. Sears, "Fundamentals of Thermostat Metals," Materials Research and Standards, December 1963, Vol. 3, No. 12, pp. 981-986.
A review of basic information on thermostat metals. Describes the effects of some properties of the individual alloys on the subsequent properties of the bonded materials. Certain of these properties of the bonded materials are discussed, the mechanism of deflection with temperature changes is analyzed, and the heat treatment of the completed parts is described.

No. 583. J. Strichforth, "Die Kruemmung freier Bimetallstreifen sowie allgemeiner freier Streifen mit beliebiger Ortsabhaengigheit der thermischen und elastischen Eigensihaften ueber den Streifenguerschnitt - 1," Mitteilungen Krupp (Forschungsberichete), Vol. 21, No. 3, November 1963, pp. 85-93.
Deflection of free bimetal strip and of any properties over cross section. Purpose of study was to check conditions under which accepted formulas for determination of deflection are or are not applicable, and to explain difference between measured and calculated values. This is done by using methods of theory of linear elasticity. (Engineering Index)

No. 584. M. Vasudevan and W. Johnson, "On Multi-Metal Thermostats," Applied Scientific Research, No. 6, Section B, Vol. 9, 1963, pp. 420-430.
A general expression for radius of curvature to which a multi-metal strip will bend when heated uniformly is developed. Using this expression and expressions obtained by Timoshenko for temperatures of buckling of a metal strip contained between supports and heated uniformly, a complete analysis of a tri-metal thermostat of equal metal thicknesses is made.

1963

No. 585. R. J. Weiss, "The Origin of the 'Invar' Effect," U. S. Army Materials Research Agency, Technical Report 63-07, June 1963, 15 pages, AD 416535.

The author shows that with a reasonable variation of the energy separation of alpha and gamma iron with concentration, quantitative agreement in the iron-nickel alloy system can be obtained with (1) the measured temperature dependence of the lattice parameter; (2) the variation of the Curie temperature with concentration; (3) the variation of the form of the magnetization curves with concentration; (4) the variation of the saturation magnetization (T = 0° K) with concentration; and (5) the variation, with concentration of the pressure dependence of the Curie temperature.

No. 586. "Chace Thermostatic Bimetal Design Catalog," W. M. Chace Company, Detroit, Michigan, 94 pages, 1963.

History of development of Chace bimetals, applications, typical elements, testing devices, design, temperature-resistivity properties, properties of Chace bimetals, design formulas for various elements, examples of calculations, and charts showing physical properties of each type of Chace bimetal.

No. 587. "Designers' Guide to Truflex Thermostat Metals," Metals and Controls, Inc., Attleboro, Massachusetts, 38 pages, 1963.

A description of the thermostat metals produced by Metals and Controls, Inc., giving detailed formulas, characteristics, and charts.

1964

No. 588. F. A. Bogochev, "Alloys With a Given Thermal Expansion and Special Elastic and Electrical Properties," Leningr Inst Aviats Priborostr, Leningrad, 1964, 60 pages.

A book in Russian containing data on the thermal expansion, elastic and electrical properties of alloys.

No. 589. S. F. Burlakov and M. I. Korolev, "Heat Treatment of Invar Type Alloys," Metal Sci Heat Treat Metals, No. 7-8, July-August 1964, pp. 507-508.

Testing of thermal expansion, dimensional stability and residual stresses in Invar alloys (Fe-Ni-Co) after various heat treatments, quenching in water from 600 to 1100 C., tempering and aging at 100°C. and at room temperature.

No. 590. Thomas W. Butler, Jr., and Paul T. Greiling, "Circuit Protector Trip Time Characteristics," Electromechanical Design, August 1964, Vol. 8, No. 8, pp. 44-47.

Trip time characteristics are compared for six types of protectors: normal speed and slow blow fuses, hot-wire and bimetal breakers, time lag and instantaneous magnetic breakers. Data on the effect of preload on trip time, comparing trip time of different types of protectors with and without preload, and the effect of ambient temperature on trip time is given.

No. 591. Jon Campbell, "Motor Protection," Machine Design, August 13, 1964, Vol. 36, No. 19, pp. 143-158.

Design guide gives a rundown of the abnormal, yet likely, conditions that cause motor overheating, describes various devices used to protect motors from overtemperature damage, and gives information on the selection of the best protectors for specific application.

No. 592. P. A. Ford, "Automatic Control of Space Temperature Using 'Dynamic Sensing'," Heating and Vent Engr, Vol. 37, No. 443, June 1964, pp. 669-672.

Method for measuring thermostat response time was devised so that response characteristics of various thermostats can be compiled, evaluated, and compared; step function technique is described that consists of allowing thermostat to stabilize for long period of time at constant temperature; then it is plunged into bath or moved quickly to test chamber where temperature conditions are different; solutions to meet requirements of room temperature sensing. (Engineering Index)

No. 593. K. C. Gogate, V. B. Ghate, and G. K. Ogale, "Study of Bi-metal Preparation by Electrodeposition," Trans. Indian Inst. Metals, Vol. 17, June 1964, pp. 65-68.

Describes a method of electrodepositing an iron-nickel alloy onto a brass plate so as to form a bimetallic strip. Tests concluded that the deflection was quite inferior to those for conventional brass-invar strip. The electrodeposited alloy was different from that of Invar and the deposit was of a layered structure.

No. 594. B. Jubb, P. R. Greenwood, R. W. Wix and G. Ingham, "Built-in Protection for Motors, I. Overload Protection Devices Embedded in Motor Windings. II. A Modern Method of Motor Protection," Elec. Rev., Vol. 174, No. 11, March 13, 1964, pp. 404-407; No. 12, March 20, 1964, pp. 438-440.

Two articles on the principles and applications of direct temperature protection by thermostats and thermistors. Discusses the application

of three phase electric motors against overheating or burning-out by means of built-in thermostatic overload protectors. Indirect protection provided by starting equipment that rely upon inexact translation of motor current is less logical than protection systems actuated by direct measurement of winding temperatures. Built-in signal initiating and trip activating elements consist of four basic types: a solder pot surrounding the three wires at the star point; a thermostatic bimetal element with three heaters carrying motor current at the star point; thermostatic bimetal elements embedded in the windings, and thermistors embedded in the windings. Characteristics and applications of the various types are discussed. (Science Abstracts)

No. 595. I. Katz and E. U. Thomas, "Electromechanical Switches," Electromechanical Components & Systems Design, Vol. 8, No. 1 (Systems Designer's Handbook) January 1964, pp. 187-203.

Toggle, rotary selector, printed circuit, precision, heavy-duty limit, pressure, thermal, and mercury types are discussed that are mechanically actuated; factors affecting switch selection are presented; summary is given of contact resistance, classification of switches, effect of environmental characteristics, modes of operating and controlling switches, application for motor protection, definitions and ratings. (Engineering Index)

No. 596. N. F. Kazakov, A. V. Krivoshey, E. G. Sudenkov, V. I. Sokolov, et al., "Vacuum Diffusion Bonding of Thermoelement Bimetals," Tsvetnye Met, No. 10, 1964, pp. 66-67.

Experiments in vacuum diffusion bonding of bimetal strips for thermoelements or thermostats. The brass-Zr and Mn alloy-Mo thermoelements were diffusion bonded from 850 to 900 C. in vacuum in presence of pressure and cooled down to 150 C., in the same conditions. This practice eliminated the lamination defects in bimetals. Thermal expansion and specific bending coefficients of bonded bimetallic thermoelements.

No. 597. S. I. Kitsis, "Overload Protection for Motors having Repeated Short-Term Cycles of Operation," Elektrotekhnika (USSR), No. 1, 53, January 1964.

The bimetallic strip type of thermal-overload relay is widely employed for protecting motors; however, when it is required to use the full thermal capacity of the machine, it is difficult enough to match the thermal properties of motor and relay when the motor is running continuously, when the motor has a pulsating load the difficulties are multiplied. Thermal protection involving thermistors is complicated and its settings are affected by variations in the supply voltage. The most suitable form of protection for motors with heavy short-term load cycles is the thermal-overcurrent combined relay. The main disadvantage is again complexity. (Science Abstracts)

No. 598. V. N. Kushch, L. M. Lifshits and K. F. Morkin, "Temperature Stabilization of the Frequency of Quartz Crystal Oscillators," Elektrosvyaz' (USSR), 1964, No. 2. English translation in: Telecomm. Radio Engng Pt 1 (USA), February 1964, No. 2, pp. 34-39.
Oscillator requirements for peripheral service single-sideband radio stations without a pilot signal are considered. Design recommendations and experimental data for miniature heated thermostats are given. (Science Abstracts)

No. 599. A. P. Martin, "High Permeability," Elect. Times (GB), Vol. 146, No. 25, December 17, 1964, pp. 907-910.
The latest developments in manufacturing processes applications and properties of nickel iron alloys are described. It is noted that this group has the highest permeability levels and the lowest electrical losses of commercially available materials. Some information not generally available is included, flux reset parameters, switching time, shielding factors, impedance effects. (Science Abstracts)

No. 600. M. Mouton, "Circuit-Breaker-Isolators, Associated with Fuses, and Interrupter-Isolators, Their Application in Medium Voltage," Bull. Sci. Assoc. Ingen. Montefiore (AIM), (Belgium), Vol. 77, No. 6, Nov.-December 1964, pp. 629-647.
Relieving circuit-breakers of the task of dealing with short-circuits and entrusting it to fuses, allows designing lighter, simpler and cheaper breakers which will perform efficiently their duty of dealing with service loads and overloads. A short description is made of fuses and breakers of such design and indication is made of their field of application (operation and protection of transformers, h.v. motors and capacitors), giving the particular requirement for each application. Characteristics of the combined protection by the breaker, bimetal tripping elements and fuses are produced. The interrupters differ from circuit-breakers by the absence of locking and tripping device. In association with fuses they can be used for switching transformers, whose protection is entrusted to the l.v. breakers. A very compact design allows easy mounting in restricted spaces. Mention is made of h.v. (150 kV) outdoor interrupter-isolator with a quenching chamber filled with SF_6. (Science Abstracts)

No. 601. S. L. Pertosvskii, "On the Use of Type SK Starters to Indicate Differences Between Controls and Positions of Switchgear," Energetik (USSR), November 1964, No. 11, pp. 39-40.
Pulse-pairs are used at present in Russian power stations and substations to provide a winking signal light when switchgear contacts do not correspond

to the control instructions. These pulse-pairs are unreliable and expensive, and it is proposed that they should be replaced by type SK starters for this purpose. These starters consist of sealed glass capsules filled with neon and containing a bimetallic strip which opens and closes the contacts. The winking signalling system based on starters is described. These starts cost 14.5 kopeks and are very reliable as the bimetallic strip is housed in an inert gas and has very long life. The system has been tested and is recommended for use in all new station control systems, but an editor's note points out that Russian factories are now going over to starterless fluorescent lighting systems as starters are considered unreliable. (Science Abstracts)

No. 602. J. T. Riedel, "A Thermostatic System for Separation and Purification of Gases Used in Detectors of Radiation of Ionization," Przeglad Elektron, (Poland), Vol. 5, No. 8, 1964, pp. 365-375.
Discusses the theoretical side of the problem and the working conditions of a thermostatic system for separation and purification of gases. Diagrams of the thermostat are given and the evaluation of its constants and parameters is illustrated. Temperature and pressure characteristics of the main elements of the thermostat are included. (Science Abstracts)

No. 603. W. K. Roots and J. M. Nightingale, "A survey of Discontinuous Temperature Control Methods for Electric Space Heating and Cooling Processes. I - The Survey," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 1-12.
The historical background of electric space heating and cooling, and automatic temperature control, is summarized, and developments since World War II outlined. Recent investigations into the selection of nonlinear automatic temperature control systems and the block diagram representation of the controlled process is covered. The choice of temperature tranducers, the location of the primary feed-back element, snap acting control elements, the control equation, and the actuating signal equation are discussed.

No. 604. W. K. Roots and J. M. Nightingale, "A survey of Discontinuous Temperature Control Methods for Electric Space Heating and Cooling Processes. II - Selected Bibliography," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 13-16.
Some 219 selected references on electric space heating and cooling, automatic temperature control, and allied subjects, are listed in the order in which they appear in the text of Part I. They are also classified under subject headings.

No. 605. W. K. Roots and J. M. Nightingale, "Two Position Discontinuous Temperature Control in Electric Space Heating and Cooling Processes. I - The Control System," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 17-27.

The simplest forms of 2-position discontinuous temperature control systems for the electric space heating-cooling process are described. Simple and complex forms of the controlled process are represented by block diagrams. Secondary feed-back conditions for optimum compensation, and the effects of overcompensation, are discussed. Actuating signal equation behavior, injection of overriding commands into the primary feedback loop, and the controlled process analog and the control equation are covered.

No. 606. W. K. Roots and J. M. Nightingale, "Two-Position Discontinuous Temperature Control in Electric Space Heating and Cooling Processes. II - The Controlled Process," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 27-38.

A new phase-plane diagram representing the electric space heating-cooling process controlled by a 2-position system is presented. The time-temperature diagram represents the cycling of the controlled process under conditions of dynamic equilibrium. The correction of the inherent error due to process transit delay is described.

No. 607. W. K. Roots and J. M. Nightingale, "Multiposition Discontinuous Temperature Control in the Electric Space Heating Process," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 38-50.

Three new schemes for 3-position temperature control are described. A new method is introduced for analyzing and predicting the behavior of a multi-position temperature control system. Two new methods of predicting or analyzing the behavior of the multiposition temperature-controlled electric space heating process are described. Expressions are derived for the evaluation of the important performances indexes and figures of merit of such processes. New 4-position temperature controlled schemes are described. The applications of these new techniques to other fields of control, and their limitations, are mentioned.

No. 608. W. K. Roots and J. M. Nightingale, "Quasi-Continuous Temperature Control in the Electric Space Heating Process," IEEE Trans. Applic. Industr., No. 70, January 1964, pp. 50-69.

Quasi-continuous temperature control is needed when electric space heating is applied to temperature-dependent processes. Multiposition systems cannot supply the accurate control often required. Discussed are the controlled process representation, quasi-continuous systems, controlled process behavior, nonlinear quasi-continuous control elements, and system performance.

No. 609. L. G. Rubin, "Measuring Temperature," Int. Science & Technology, No. 25, January 1964, pp. 74-78, 80, 83-84, 86, 88.
Review of currently employed common methods of temperature measurements--expansion thermometers, thermocouples, resistance, optical, etc.; their comparative accuracy and areas of application, existing temperature scales, and some possible future developments such as application of Moessbauer effect. (Engineering Index)

No. 610. Edward U. Thomas, "Circuit Breaker Applications," Electromechanical Design, July 1964, Vol. 8, No. 7, pp. 169-179.
Article lists a number of axioms regarding the choice and understanding of circuit breakers. It also deals with different types of loads and different types of breakers, and it relates these to data, charts, definitions and tables.

No. 611. W. H. Wilson, "An Appraisal of the Operating Characteristics of Room Thermostats," Symposium on Electricity and Space Heating (London: Institution of Electrical Engineers, 1964), 6 pages.
On-off or two-step action switching devices actuated by sensitive elements subject to the temperature of the space to be controlled are considered in detail; operating currents may be as high as 20A. Instrument characteristics are determined in a special test cabinet and the performance is considered in detail and shown graphically. From the discussion, the requirements in an ideal thermostat are given. (Science Abstracts)

No. 612. "Automatic Temperature Controls-- Temperature Limit Controls for Electric Baseboard Heaters," NEMA-Publ DC 10 1964, 4 pages.
Publication describes constructional details, classifications, ratings, and other characteristics of temperature limit controls and control systems of continuous-sensing or spot types, which are suitable for mounting inside electric baseboard heaters for purpose of breaking power circuit when heater reaches abnormally high temperatures; control systems described are nonadjustable, operate at factory preset temperatures, and may be of automatic or manual reset type. (Engineering Index)

No. 613. "Automatic Temperature Controls--Integrally-Mounted Thermostats for Electric Heaters," NEMA-Publ DC 13 1964, 3 pages.
Standards cover classification and ratings, manufacturing, and testing of thermostats which provide temperature controlled contact action, and which are factory installed and supplied as part of heating device, such as space heater, baseboard heater, or control section for baseboard heater. (Engineering Index)

1964

No. 614. "Automatic Temperature Controls--Integrally-Mounted Thermostats for Room Air Conditioners," NEMA Publ DC 14 1964, 3 pages.
Publication describes constructional details, classifications, ratings, ranges, differentials and other characteristics of thermostats; provisions regarding manufacturing mounting and testing of thermostats are included. (Engineering Index)

No. 615. "Automatic Temperature Controls--Room Thermostats," Publ DC 3 1964, NEMA, New York, New York, 12 pages, 1964.
Publication describes constructional details, ratings and methods of rating, sensitivity and methods of determining sensitivity of all types of a-c room thermostats, including heating, cooling, heating-cooling, and electric heating wall-mounted room thermostats. (Engineering Index)

No. 616. "Development of Thermostatic Bimetals," National Metallurgical Laboratory, C.S.I.R., Jamshedpur, India, Annual Report 1962-1963, 1964, pp. 85-86.
Thermostatic bimetals are used for indicating and controlling temperature and as thermal relays, circuit breakers and overload protection devices. At present India has to import all bimetals. Report on investigation of manufacturing techniques for producing both ferrous and non-ferrous bimetals. A bimetal was investigated with copper-base material as the high expansion component. Brass was melted over Invar under a reducing atmosphere. The composite was then cold-rolled to appropriate thickness with intermediate annealing. Work is in progress on bonding aluminum bronze and silicon bronze by this technique.

No. 617. "Electric Controls Reference Issue," Machine Design, December 31, 1964, Vol. 38, No. 30, 230 pages.
Contains design data and product directory sections of four divisions of on-off electric controls: switches, relays, timing devices, and power devices. Included are temperature switches, time delay relays, circuit breakers, and overload relays.

1965

No. 618. D. T. Eash, "Tensile Tests on 'Invar' Sheet at Cryogenic Temperatures," U. S. Atomic Energy Commission, Los Alamos Scientific Laboratory, Report LA-3192-MS, February 3, 1965, 12 pages.
The tests reported were conducted on a 0.005 in. thickness mill-annealed sheet of invar to establish data on its yield strength, notched-strength/unnotched-strength ratio, ductility and toughness at cryogenic temperatures (20 and 77°K) and 300°K. The data established are tabulated and included are photographs of the specimens examined before complete failure.

No. 619. W. S. McCain and R. E. Maringer, "Mechanical and Physical Properties of Invar and Invar-Type Alloys," DMIC Memorandum 207, Battelle Memorial Institute, Columbus, Ohio, August 31, 1965, 70 pages.

This pamphlet deals with the mechanical and physical properties of Invar and Invar-type alloys. Most of these are basically iron-nickel alloys which display unusual temperature dependencies of the thermal expansion and/or thermoelastic coefficients. Described are the compositions and properties of the most useful of these alloys. Specific alloys discussed are as follows: Invar, Super Invar, Stainless Invar, Elinvar, Ni-Span alloys, Vibralloy, Iso-Elastic, as well as some experimental alloys.

No. 620. V. C. Miles, "Thermostatic Control Principles and Practices," George Newnes Ltd., London, 1965, 215 pages.

A book on domestic and industrial measurement and control of temperature. It deals with the thermostatic devices for automatically effecting various temperature controls.

No. 621. J. L. Ornstein, "Computer Speeds Selection of Thermostat Metals," Materials in Design Engineering, March 1965, Vol. 61, No. 3, pp. 115-117.

Computer permits calculation of overall properties and thickness of a composite made up of three or more layers of different materials. Method also shows how much of each material to use to produce a required value of resistivity, maximum flexivity, or corrosion resistance.

No. 622. Peter Pentcheff and Dimiter Christemoff, "Magnetostrictive Bimetal," Intern J. Control, Vol. 2, No. 1, 1965, pp. 75-83.

The general characteristics and advantages of magnetostrictive bimetals are discussed. The magnetostrictive bimetal consists of two alloys bonded together whose coefficients of linear magnetostriction are different. When a magnetic field is applied, the degree of bending depends upon the field strength and the alloy properties. Formulas are given and differences between theoretical and experimental are explained.

No. 623. H. C. Wiedemann, "Bimetal Elements," Product Engineering, March 29, 1965, Vol. 36, No. 7, pp. 84-87.

U-shape bimetal elements can be designed to produce every response characteristic from high-deflection low-force to low-deflection high-force by varying the proportions of the various sections of the element. They can also be designed to produce no deflection under uniform heating. Simplified performance equations incorporating dimensionless form factors and graphs presenting the form factors for all possible proportion combinations are given.

No. 624. "Aircraft/Aerospace Cable," Electromechanical Design, August 1965, pp. 50-55.
Describes a means for approximating the time-temperature curve of a given conductor so that manufacturers of circuit breakers can recommend an adequate protective device for specific applications.

No. 625. "Bimetallic Belleville Snaps Itself," Machine Design, Vol. 37, No. 25, October 28, 1965, p. 151.
A bimetallic Belleville spring, housed within an impact anvil, forms a simple accelerometer calibration device. A d-c voltage applied to the spring heats it thus causing it to deflect. At a certain point, the spring snaps into a negative deflection, pulling the anvil away from the housing. At this point the heater current is interrupted and as the spring cools, it eventually snaps back to its original position, imparting a calibrated impact between the anvil and housing.

No. 626. "Electronic Circuit Protection," Electromechanical Design, Vol. 9, No. 5, May 1965, pp. 72-75.
Presented is data on the relationship of typical circuit protectors to the protection of wire and electronic equipment. The majority of circuit protectors are not satisfactory for protecting electronic equipment.

No. 627. "Sun-Pressure Vanes Stabilize Spacecraft," Machine Design, March 18, 1965, Vol. 37, No. 7, pp. 22-23.
Describes the solar-pressure vane portion of the attitude-control system used on the spacecraft, Mariner IV. Bimetal elements are heated by a change in sunlight passing through slotted shades. The element deflection positions the solar-pressure vane so that torque is introduced opposing motion of the spacecraft.

No. 628. "Thermostatic Bimetal, Data Sheet No. 4," British Driver-Harris Company, Ltd., Stockport, England, 31 pages, 1965.
A catalog containing information on the thermostatic bimetals supplied by British Driver-Harris Company, Ltd. Included are descriptions and properties of the various types, design data and equations.