THE INTERNATIONAL MEASUREMENT CONFERENCE

THE second International Measurement Conference was held in the Engineering Societies Building, Budapest, during June 26–July 1. The host organization was again the Hungarian Scientific Society for Measurement and Automation, with Prof. György Striker as executive secretary.

The Conference was attended by some 550 delegates from twenty-two countries and 128 papers were presented in four, or sometimes five, simultaneous sessions. The four working languages of the Conference were English, French, German and Russian; but in fact no translation into French was available and for the first three days translation into English was practically non-existent. This breakdown in the translation service, coupled with the failure to provide reprints of the papers until the final day of the sessions, seriously reduced the value of the Conference.

The 128 papers were divided into eleven sections covering metrology and terminology; technology and organization in instrument manufacture, electronic measuring instruments, border questions related to measurement and automation, instruments and methods for measuring geometrical and mechanical quantities including geodetic measurements, instruments and methods for measuring thermal quantities, instruments and methods for physico-chemical measurements, instruments and methods for measuring electrical and magnetic quantities, instruments and measuring methods in radio engineering and instruments and methods for measuring radioactive radiation. Since papers from four different sections were presented concurrently, it was impossible for any one person with more than the most narrow field of research to attend all the papers in which he was interested.

The standard of the papers varied considerably from the specific to the most general survey and from new basic research to the re-statement of well-known principles: a reduction in number would have benefited all concerned.

Among the papers of general interest, that by T. Kemény (Hungary) described an automatic electronic potentiometer in which the conventional slide-wire had been replaced by a strain-gauge bridge. The four, all active, gauges of the bridge are attached in the standard configuration to a singly supported cantilever beam of low-energy-consuming elastic material. The free end of the beam is deflected by a cam driven through a gear train by the servo motor driving the pen carriage, until the out-of-balance voltage generated by the bridge is equal to the voltage being measured. Advantages claimed are no slide-wire maintenance or wear, high linearity and infinite resolution, and ease of generation of logarithmic and other non-linear scales merely by changing the cam. Other transducers, such as electro-magnetic, capacitive and inductive, were suggested, but only the strain gauge bridge has been tried experimentally.

A method for measuring small capacities of about 100 pF., with an accuracy of 1 per cent, was presented by K. Tarnay (Hungary). The method is said to combine the advantages of both heterodyne and resonance methods. Essentially, the unknown capacity and a standard are switched, at mains frequency, alternately into an oscillatory circuit, the

output being fed to a phase-sensitive rectifier and thence to a phase-sensitive voltmeter.

A paper by three Soviet authors dealt with a new instrument for the accurate measurement of power, current and voltage at frequencies up to 20 kc./s. A null method is employed in which the unknown alternating current or voltage is used to heat a resistance element, the temperature of which is monitored by a detector element consisting of a bank of some 35–40 thermocouples in series. The thermal e.m.f. is measured by means of a potentiometer and a direct-current voltage is then switched in in place of the unknown alternating current and is adjusted to give the same heating effect as measured by the potentiometer. The equivalent direct-current voltage is then measured by means of a second potentiometer of high accuracy. Good accuracy is obtained with power factors as low as 0.1 by using two heaters. The main source of error is said to be the reactance of the heater elements and shunts in the circuit, and this limits the frequency range. The overall error in comparison of alternating and direct current is less than 0.05–0.2 per cent, depending on range.

Prof. Gy. Striker (Hungary) discussed the possibilities of a long-range planning of instrumentation in a planned economy and suggested that the basic data required were the expected trend in capital investment in the respective industries and the index of instrumentation, that is, the ratio of instrument investment to capital investment and the expected changes in this index. Examples were given of how these factors may be fitted to equations to predict instrument requirements for a longer period.

An electronic statistical quality control apparatus which indicates average and variance directly was discussed by A. Ambrózi (Hungary). The method requires that the parameter to be controlled may be presented by means of a suitable transducer as a proportional alternating current. A batch of components is fed into the unit and the corresponding alternating-current signals are fed to a simple computer which then indicates the mean and the variance on meters, the chief advantage being the speed with which the required data can be obtained.

Two papers on measuring systems for flight testing of aircraft by J. K. Stotz and V. R. Boulton (United States) both stressed that main expenditure was the cost of data reduction which could take up to $\frac{1}{2}$ man-hr. per point. Strain gauge transducers are used wherever possible because of their inherent accuracy—0.1 per cent—and because they enable standardization of supply voltages and amplifiers as well as being easily calibrated by electrical simulation before and after a test. Recording is by magnetic tape either airborne or ground station, and overall system accuracies of 1–3 per cent may be obtained. Typical recorders have a band-width up to 90 kc./s. at a tape speed of 60 in./sec. Frequency multiplexing is used, up to 10 channels per tape track being common, while for low-frequency data, time division multiplexing at a rate of 900 samples/sec. is used. Such attention to the design of instrumentation and data handling equipment has reduced the data reduction cost by a factor of 4, produced 100 times as much data, which are four times more accurate, and are available for analysis in 1/15 of the time.

S. G. Rabinovitch, B. A. Seliber and V. I. Tchervyakova (U.S.S.R.) presented details of electrical measuring-instruments based on the photo-compensating amplifier. These included multi-range measuring units with a sensitivity up to 5×10^7 divisions per volt, panel amplifiers with 0.1 per cent accuracy and semi-automatic potentiometers, with an accuracy of 0.03 per cent, for instrument checking, etc.

B. Sternlicht (United States) described an indirect but extremely accurate method for measuring film thickness on bearings. He pointed out that there is a direct correlation between film thickness and temperature and he has used temperature-sensing elements for the measurement of the film thickness as well as the film temperature.

A novel technique for re-using resistance strain gauges was put forward by A. Bray (Italy). He pointed out that gauge factors cannot be given to an accuracy better than about ± 1.5 per cent, yet in many applications it is not possible to calibrate the gauge after it has been attached to the surface under test. The method entails using a second carrier of mica between the gauge and the test surface. The author used Eastman 910 cement, but it should be remembered that this is water-soluble. After the gauge has been used it may be recovered by splitting the mica. Experience has shown that the thickness of the mica must not be greater than 0.03 mm., and it must be about 6 mm. larger than the paper or foil base of the gauge. The mica will support 4,000 microstrain, and gauges have maintained a constant gauge-factor while being used and recovered four or five times.

T. M. Dauphinee presented the paper by Dauphinee, Kirby and Preston-Thomas (Canada) on the accurate measurement of temperature and depth in the ocean. Temperature was measured by means of a bifilar-wound copper-resistance thermometer cemented on to a thin-walled copper tube to give close thermal contact with the sea-water; accuracies of ± 0.01 per cent to depths of several kilometres have been achieved, as have accuracies of 0.2 per cent in depth measurement. Two methods were used for measuring depth, the sensing element of one being the bulb of a commercial mercury-in-glass regulator, change in depth being measured by the lowering of the control temperature that results from reduction in volume of the bulb due to the increase in pressure. The second method uses a water boiling-point apparatus with a thermocouple to measure the boiling temperature. An interesting planetary type of slip-ring was used to enable the cable to be wound on a drum winch. This consists of a copper stator and rotor, electrical connexion between the two being maintained by four hollow cylinders of thin spring bronze acting as planet wheels. The system was said to have thermal e.m.f.'s of less than $0.1 \mu\text{V.}$ and resistance variations of less than 0.01 ohm.

T. A. Perls (United States) described the use of pyroelectric transducers for heat-transfer measurements. A typical transducer of lead zirconate titanate 0.25 cm. in diameter and 0.05 cm. thick has a heat sensitivity of approximately 10 mV./W./cm.^2 with a 1 M.ohm load. At present it is necessary to calibrate the transducers if accuracies to better than ± 20 per cent are required: a quartz lamp in a gold-plated reflector has proved satisfactory for this purpose, over the range 100–0.1 W./cm.². Advantages of pyro-electric transducers suggested include small size, low cost, good frequency response,

high output, good linearity and ageing, and little sensitivity to temperature.

Dr. Cz. Graczyk (Poland) presented an account of a new method of measuring rate of flow of coal dust. The method is based on the application of a Venturi tube; two pressure drops are measured and it was shown that the dust concentration may be represented as a function of the ratio of the two pressure drops.

The measurement of dynamic flow by means of hot-wire anemometers of the constant-current and constant-temperature type were discussed by I. Kidron (Denmark), who pointed out the superiority of the constant-temperature type which will operate at frequencies several hundred times higher than a constant-current unit because of the reduced effect of the heat capacitance of the wire. The upper frequency limit increases with flow speed and is higher than 50 kc./s. at 100 m./sec. air speed. Kidron then discussed a newly developed hot-film transducer consisting of a thin platinum film fused to a glass support to give greater mechanical strength. The dynamic response is slowed by the heat capacitance of the glass support, but is still only 5 db. down at 50 kc./s. for 100 m./sec. air speed.

A novel bi-parametric displacement transducer with good frequency response and high sensitivity was described by Prof. N. Racoveanu (Rumania). The transducer consists of a magnetic core coil with a variable air-gap and also a condenser with variable plate-spacing. In use both coil air-gap and plate-spacing are varied together, modulating the frequency of a resonant circuit in a more linear manner than may be obtained by varying inductance or capacity alone. Designs with a plate condenser and a cylindrical condenser have been examined and a design with multiple concentric cylinders offers greatest linearity. Over the linear range of $2,000 \mu$ a sensitivity of 0.25 kc./ μ is obtained in the frequency-range 370–870 kc./s.

A. Haas (Hungary), in his paper on the calibration of contact type surface thermometers, stressed the need for intimate contact between the detector and the surface under investigation and complete thermal-equilibrium between the detector, the surface and the surrounding atmosphere. The ultimate aim was 100 per cent thermal coupling, as was achieved by the immersion technique with the ordinary mercury-in-glass thermometer. He then discussed a detector consisting of a thermocouple junction set in a copper block which had been developed at his Research Institute, and which is capable of accurate results with only 60 per cent thermal coupling, and in spite of varying ambient temperature. Another surface pyrometer with an accuracy of 1 per cent was described; this consisted of two iron constantan couples separated by a layer of mica and connected in opposition across a sensitive galvanometer. A heating element above the second couple enables conduction and convection losses to be compensated. The instrument is calibrated against a third couple set into the calibrating surface. It was emphasized that during calibration it was necessary to ensure that thermal coupling should be the same as would be met in use, and thus for calibrating a surface pyrometer for use on rotating drying cylinders, a special calibrating surface was designed. This cylinder was oil heated and thermostatted, and its circumferential speed was set so that approximate thermal similarity with practical conditions may be achieved for a small area of the surface and the atmosphere surrounding the pyrometer. The cylinder

has a Ward Leonard speed control and built-in thermocouples brought out via slip-rings so that the true calibration surface temperature is obtained.

Some ninety-five scientific institutions and manufacturing companies exhibited at the second International Instruments and Measurement Exhibition, which was held concurrently with the conference. The usefulness of the exhibition was reduced considerably by the lack of stand attendants and absence of literature on some stands. It was generally agreed by competent observers that nothing was shown by Eastern European countries which was in advance of equipment available in the West, and in many cases development in the former appeared to be 5–10 years behind the West. No Russian equipment was shown. Among Western exhibitors, emphasis was mainly on process instrumentation and control, particularly for the chemical industry, and on radiation counters of all types, while the Eastern countries exhibited more laboratory measuring equipment and in particular microwave equipment in the 8–10 cm. band for telephone and television uses.

Equipment exhibited by the Hungarian Measuring Instrument Research Institute included a six-channel transistorized amplifier for pressure pick-ups, strain gauges, thermistors, etc., with an input impedance of 10^{12} ohms and an output impedance of 1 ohm, with a frequency-range of direct current to 5 kc./s., and better than 5 per cent linearity. A transistorized servo amplifier measuring $6 \times 6 \times 20$ cm. contained a two-stage pre-amplifier and a class B push-pull power amplifier stage, with an output capacity of 12 W. and working temperature range of -40 – $+50^\circ$ C. Other transistorized modular blocks of the same dimensions included current and voltage amplifiers, 400 c/s. RC oscillators, a direct-current amplifier with a gain of 100 and a non-contacting relay which was basically an inductive pick-off from a moving pointer unit, with a sensitivity of ± 0.5 mm. pointer movement and a switching capacity of 500 m.amp. at 50 V. supply.

A self-compensating ionization vacuum gauge on show was a transistorized miniaturized version of the Modion gauge and covered the range 10^{-8} – 10^{-3} mm. in a single span. A differential β -ray thickness meter suitable for measuring coating weights of paper or impregnation weights of fabric had an accuracy of 1 per cent for an impregnant weight-range of 0.5 to $2 \times$ the fabric basis weight. The time constant of the measuring unit was variable between 5 and 20 sec. Several other examples of β - and γ -radiation measuring equipment were on display.

The Czechoslovak Export Agency (KOVO of Prague) showed a long range of electronic equipment and accessories, including a high sensitivity direct-current oscilloscope with a band-width to 7 Mc./s. 3 db. down; alternating-current sensitivity 9 mV./cm., direct-current 25 mV./cm., input impedance 1 M.ohm at 30 pF. or 70 ohms direct current, time-base 5–500 kc./s., with provision for external input to X plates. A two-channel oscilloscope had a sensitivity of 10 mV./cm. and band-width to 1 Mc./s. with beam switching at 120 kc./s., and a two-gun oscilloscope with similar sensitivity had a frequency-range to 2 Mc./s. 3 db. down. The O.P.D. oscilloscope for slow-speed phenomena had a 25-cm. diameter, high-resolution tube. Maximum sensitivity was 100 mV./cm., a band-width of 0–6 kc./s., and a slowest time base sweep of 1.5 min. The 'Meopta' oscillo-

scope camera shown had an $f/1.8$ lens of 35-mm. focal length and held 6 m. of 35-mm. film. It is a continuous recording camera with a maximum film speed of 1,000 m./sec.

A semi-automatic valve tester with punched card setting up was shown also, and an electronic null point indicator with CRO indication for indicating alternating-current bridge balance.

The Polish Exterior Trading Co. for Electrical Technology, Warsaw, showed a limited range of equipment, somewhat out of date by Western standards. Also exhibited were chemical balances and thermographs, a phase-contrast microscope and a projection microscope, refractometers and pH meters, a disappearing-filament-type optical pyrometer and a twin-beam oscilloscope with a band-width of 10 c.p.s. to 5 Mc./s. A valve test meter looked about 1945 vintage. The sole electromagnetic flow meter exhibited was on the stand of Eckardt of Stuttgart, together with a proportional pneumatic controller, diaphragm operators, a twin-channel recorder and various Bourdon tube and diaphragm pressure units, and a smart-looking range of edge-on panel meters.

Precision slide-wire potentiometers were exhibited by Carl Zeiss of Jena. These were to DIN R5 standard with linearity of 1 per cent and a torque movement of 35 gm. cm. for the smaller sizes. Armoured and sealed versions were also available for use in basic heavy industries and in corrosive atmospheres. A precision instrument potentiometer requiring a torque of less than 2 gm. cm., and a small, low-inertia, magnetic clutch were also shown. A photo-multiplier with a cathode diameter of 140 mm. and maximum gain of 10^7 was on display together with selenium cells with a spectral response said to be nearer the human eye than any other available, making it eminently suitable for colour matching, etc.

M. A. W., Messergate and Armaturenwerk, showed a self-balancing potentiometric recorder with a 250-mm. scale-length. Sensitivity was 0.1 per cent, reproducibility 0.5 per cent, response time better than 1.5 sec., minimum range 2 mV. f.s.d. suppressed zero available, models with 1, 3, 6 and 12 channels, chart speeds 0.2–3,600 mm./hr. This appeared to be the standard recorder on Eastern European equipment. A miniature recorder of the chopper-bar type was also shown and a thermocouple temperature-indicator/transmitter/controller of the lamp and pointer-vane type with 0–5 m.amp. transmission.

The most interesting pneumatic control equipment was to be found on the stand of G.S.T. (Automatic Temperature Control C.), Berlin. As well as high- and low-pressure pneumatic differential potential cells and a force-balance electropneumatic converter for thermocouple e.m.f.'s was a well-engineered three-term controller with push-button selection of hand or automatic control and balance, with a proportional band setting between 2 and 1,000 per cent, integral and derivative action times of 0.36 sec. to 200 min. and a sensitivity of better than 0.01 per cent. Also on display was a flow-metering unit which monitored the flow-rate of the main stream fluid and at any desired time interval would meter into it by means of a solenoid valve any desired proportion of a second liquid component. Fritz Hollige (Freiburg) demonstrated the 'Helcoscriptor' high-speed recorder available with 1–8 channels. All can be used with heated stylus on sensitized paper writing and are flat to 100 c./s. for 30-mm. recording width, or with cold stylus on carbon paper flat to 130 c./s. Sensitivities of 10

mm./V. input and paper speeds up to 200 mm./sec. are available.

Hottinger Measuring Techniques, Ltd., Darmstadt, showed a range of miniature inductive pick-offs suitable for carrier frequencies of 5 and 50 kc./s., the minimum range being 20×10^{-4} mm. f.s.d., and a maximum operating temperature of 90–120° C. according to type. Strain gauges with a minimum gauge-length of 3 mm., and which would withstand a maximum strain of 2 per cent up to 200° C., were also exhibited together with a strain gauge bridge torque-meter transmitting a maximum torque of 1,000 metre kiloponds, at 4,000 r.p.m. with a reproducibility of 0.5 per cent and an output of 1.5 mV./V. supply at maximum torque loading; silver/silver graphite slip-rings with up to 12 channels, with brushes that may be replaced during running, were capable of running at 6,000 r.p.m. continuously and 12,000 r.p.m. intermittently.

Krohne of Duisburg displayed their range of rotameter-type flow-meters with magnetic pick-off of float position to provide remote indication, and a float-type density meter with inductive pick-off which fits directly into the process stream line and is independent of fluid velocity; the most sensitive range is 0.99–1.01 gm./c.c. and the accuracy of this range is $\pm 1\frac{1}{2}$ per cent. Heating or cooling coils

and built-in temperature compensation are available. AB Lars Ljungberg, Sweden, demonstrated the 'Agnar' burette, a new and ingenious approach to precision metering, titrating and decanting. The burette has no tap, and is essentially a syringe in which the piston is positioned by means of a screw drive. Various syringe sizes are available, the 2 ml. size delivering 1 ml./rev. of the coarse knob and 12 μ l./rev. of the fine knob. The drive is reversible, thus the burette is equally suitable for drawing off any volume from 1 μ l. to 20 ml.

The Yokogawa Electric Works, Ltd., Tokyo, exhibited a range of direct-current precision measuring instruments including a good-looking miniature portable Wheatstone bridge. Panel meters were contemporary in style but appeared crudely manufactured and designed without regard to their function of precise indication of a measured quantity. Fully transistorized printed-circuit strip-chart recorders of about 4-in. and 8-in. chart-width had self-folding charts facilitating reading of back records. A three-term electronic controller was on view but no information about it was available.

A new instrument under development by DISA Elektronik measures departures from constancy of the angular velocity of rotating equipment at speeds up to 100,000 r.p.m. J. A. PLACE

ASSESSMENT OF PAIN IN MAN AND ANIMALS

A THREE-DAY symposium on the assessment of pain was organized by the Universities Federation for Animal Welfare (UFAW) in collaboration with Prof. C. A. Keele, presided over by Sir Russell Brain, and held in the Department of Pharmacology at the Middlesex Hospital Medical School during July 26–28. UFAW had been asked to arrange such a symposium by Dr. C. Radouco-Thomas, secretary of the Collegium Internationale Neuro-Pscho-Pharmacologicum in Geneva, who made many useful suggestions. In his presidential address, Sir Russell Brain referred to the usefulness of bringing together the peripheral and central aspects of the neurology of pain and the need for reconsidering views which at present are widely held on the subject; he said that UFAW's interest in the latter arose from the fact that pain sensations in many species appear to differ little from those experienced by man.

After Dr. K. D. Keele (London) had reviewed the history of theories of pain from primitive times, Prof. C. A. Keele (London) outlined a technique used by himself and his colleagues in which a blister is formed on the arm and the blister base is then stimulated in various ways, the resulting sensations being reported by the subject. The receptors appeared to be stratified in depth. The sensation at low levels of stimulation was not painful, and he proposed the term 'metæsthesia' for it under those conditions. Dr. Robert Smith (London) dealt with the quantitative relation between stimulus and sensation and described metæsthesia produced with potassium and polypeptide stimulations.

Prof. J. A. B. Gray (London) took the chair at a discussion of peripheral pain mechanisms. Dr. A. G. M. Weddell (Oxford) dealt with the structure of the nerve terminals in the skin as they appeared in electron and optical microscopy. Prof. Y. Zotterman (Stockholm) dealt with the specificity of cutaneous

nerve fibres and the search at sub-microscopical level for the cause of this specificity. Dr. A. Iggo (Edinburgh) discussed the conduction in single C fibres of impulses initiated by noxious stimuli in the viscera, muscles and skin. Prof. H. Hensel (Marburg) showed a film record of afferent impulses in human single cutaneous nerve fibres. Dr. W. Koll (Göttingen) described the effects of morphine and other drugs on nociceptive spinal reflexes. An open discussion of the specificity of peripheral mechanisms followed.

Prof. D. Hill (London) presided over a session on central mechanisms of pain. Dr. D. R. Bowsher (Liverpool) and Prof. D. Albe-Fessard presented a joint paper showing that somatic sensations fall into two classes: discriminative sensations travelling by lemniscal pathways to the cortex via the thalamus and entailing a perception of location, and non-discriminative sensations travelling by extra-lemniscal pathways. Dr. G. Gordon (Oxford) described the electrophysiological approach to central mechanisms of somatic sensation. Dr. P. W. Nathan (London) dealt with traces of pain remaining in the nervous system, as in the case of phantom limbs. Dr. J. Hankinson (Newcastle upon Tyne) described the relief of pain by destruction of intracerebral structures under the guidance of stereoscopic radiography. In the ensuing discussion, Prof. J. Scherrer (Paris) and Dr. G. L. Kidd (Liverpool) suggested possible mechanisms of phantom pain, and Dr. M. R. A. Chance (Birmingham) directed attention to audiogenic seizures which do not arise in rodents unless these are deprived of escape routes.

Prof. O. L. Zangwill (Cambridge) took the chair for a session on the assessment of pain in man. Dr. H. K. Beecher (Boston, U.S.A.) discussed some working hypotheses and described his work on the effect of drugs on high-level intellectual performance.