SPECTROPHOTOMETRIC EQUIPMENT

THE forty-fifth scientific meeting of the Colour Group of the Physical Society was held on March 30 at the Royal Photographic Society, 16 Prince's Gate, South Kensington, S.W.7, to discuss "Photo-electric Spectrophotometers and Tricolorimeters". The meeting was arranged to explain the difficulties that may be encountered by those contemplating work with these instruments, and to compare the different methods of measurement. Dr. W. S. Stiles was in the chair, and about ninety people were present.

The discussion was opened by Dr. T. Vickerstaff (Imperial Chemical Industries, Ltd.), who had recently been in the United States, and who described American instruments. He said that most research associations there seemed to possess a Hardy recording spectrophotometer and that each owner appears to have done something to improve it. Improvements included those to lengthen the life of the lamp, to overcome difficulties due to polarized light, to reduce scattered light, to improve the efficiency of the sphere-photo-electric cell unit, and to facilitate fitting the paper accurately on the drum. A new design is being made in which a linear wave-length scale is provided both for the visible and near infra-red ranges.

Another widely used and generally approved instrument is the Cary recording spectrophotometer, with an operational wave-length range from $0{\cdot}21\mu$ to $0{\cdot}6\mu$ and marked ranges from $0{\cdot}2\mu$ to $0{\cdot}35\mu$ and $0{\cdot}3\mu$ to $0{\cdot}8\mu$. The slit widths at which this instrument operates are exceedingly small, about $0{\cdot}0002\mu$. This is a welcomed improvement on the Hardy instrument, in which the sum of the slit widths is $0{\cdot}02\mu$. The Snow-Duplex cathode ray spectrophotometer was seen, but an opinion on its performance was not possible owing to the conditions prevailing at the time. The non-recording Beckman is widely used, and a cheaper model with a direct-reading meter is being marketed.

Three calculators to give C.I.E. chromaticity co-ordinates from the spectral transmission curves were seen. One at the General Aniline Company was coupled directly to the Hardy spectrophotometer and evaluated the summations during the recording. An accuracy of 0·0005 was claimed.

The photo-electric tricolorimeters seen were the Hunter reflectometer and the P.P.G.I.D.L. colour eye. Both these instruments used photo-electric cells with filters to obtain the required C.I.E. distribution curve sensitivity.

General requirements for spectrophotometry were indicated by Mr. H. G. W. Harding (National Physical Laboratory). He said that direct-current light sources are desirable so that sectors can be used. Double monochromators are necessary, and the wave-length control should focus the optical system and alter the slit widths so that a fixed wave-band can be chosen throughout the spectrum. Some of the slits should be curved, and the exit slit should be straight for thermopile work. Some routine measurements require detectors to measure energy ratios of 10^8 to 1, and although it is preferable that the photo-electric cells should act only as out-of-balance detectors, the linearity of their response has to be relied on for such measurements. Reflexion measurements for colorimetry should be made under C.I.E. conditions, and annular cathode photo-electric cells would facilitate this. Completed instruments should be tested separately for wave-length calibration by line sources, and for linearity by neutral glass filters. Automatic instruments that would deal with large specimens are desirable; those now available are very valuable, but they are not as accurate as manually operated instruments, neither will they measure very low transmissions.

Dr. A. Sommer (E.M.I. Research Laboratories) explained how different parts of the spectrum range between $0{\cdot}2\mu$ and $1{\cdot}3\mu$ can be detected by antimony–cæsium cathodes in quartz or glass envelopes, bismuth–silver–cæsium cathodes and silver–oxygen–cæsium cathodes. Gas-filled cells are unsuitable for precision measurements, he said, and the vacuum types are generally used. Multiplier cells are useful for very low illuminations and for light signals of high frequency. Antimony–cæsium multiplier cells are made with multiplication factors of the order of 10^8. Two types of antimony–cæsium multiplier cell are made in Great Britain, one in which the light passes through the bulb to the cathode on the opposite side (thick-layer type), and another in which the semi-transparent photocathode is deposited directly on the inside of a flat entrance window. The latter type has an improved red sensitivity and reduced blue sensitivity compared with the former, and it has the advantage that a luminous surface can be held within a few millimetres of the cathode. Quartz windows are to be fitted to these cells.

Particular needs for spectrophotometry were outlined by Mr. J. R. Stansfield (Hilger and Watts, Ltd.). He said that hydrogen lamps with a current stability of 1 part in 20,000 give a radiation output constant to better than 0·05 per cent, and tungsten filament lamps can give similar stability, although greater care is necessary in controlling the power supplies. The variations in Nernst filaments and glow-bars for infra-red radiation make double-beam spectrophotometry desirable.

The elimination of stray light should receive particular attention, and although double monochromators are necessary for some work, single monochromators are adequate for many purposes, as some can give a stray light intensity of less than 0·1 per cent of the pure radiation intensity. Double-beam spectrophotometry eliminates errors due to fluctuations in the source of radiation; but as exact equality of two monochromators is difficult to obtain, the practice of passing the two beams alternately through one monochromator is now being adopted. The photo-electric cells of the detectors should, where possible, be used only as indicators of inequalities between successive beams of light. More multiplier cells should be made available, especially ultra-violet sensitive ones, and there is a need for accurate high-speed recorders.

Mr. G. T. Winch (General Electric Co., Ltd.) was unfortunately not able to address the meeting. His contribution was read by Mr. R. G. Horner, and Miss B. M. Young answered questions about it. A description was given of the dispersion and mask method, in which a spectrum is formed and a mask used in the plane of the spectrum to limit the transmission of light of each wave-length. The method is theoretically perfect; but many precautions are necessary if the accuracy of visual methods, namely, 0·01–0·02 in the chromaticity co-ordinates for a 2°-field, or 0·001–0·004 for a 15°-field, are to be obtained without resource to substitution methods. The requirements have been met by temperature control of the photo-electric cell, which is linear to a few parts in 10,000 for a 10 to 1 light ratio, having grid leak values up to 10^{12} ohms in a D.C. amplifier giving a limiting sensitivity of about 10^{-11} lumen to get adequate sensitivity, obtaining a spectral resolution of about $0 \cdot 0003\,\mu$ in a 30-mm. spectrum and by producing masks by the Kodak etch-bleach process. The $\bar{x}$, $\bar{y}$, $\bar{z}$ and spectrum band masks are mounted on a wheel, and a blue temperature-conversion filter is used to compensate for the yellowing of sphere paint when it is part of the instrument.

A general discussion followed, and many aspects of spectrophotometry and colorimetry were considered. At the end of the discussion it seemed that the fully automatic recording spectrophotometers for ultraviolet and visible radiation made in the United States are giving good service, and that the photo-electric colorimeters developed in Great Britain are likely to give the same to colorimetry. It was pointed out that annular cathode photo-electric cells have been made in Britain.

The meeting was closed by a description and demonstration of the new Hilger Uvispek photo-electric spectrophotometer. This manually operated instrument, which covers the wave-length range from $0 \cdot 21\,\mu$ to $1 \cdot 0\,\mu$, should be of great value in the field of spectrophotometry.

H. G. W. HARDING

AUTOMATIC CONTROL-SYSTEM TERMINOLOGY

AT the request of the Ministry of Supply, the British Standards Institution is preparing a "Glossary of Terms used in Automatic Controlling and Regulating Systems". This is divided into four Sections, the second of which, on "Process Control"*, has been published recently; Section 3, which is in preparation, will cover the nomenclature of position control, and Section 4 will deal with automatic regulators; Section 1, which is to contain the terms common to all closed-loop servo systems, will be prepared when the other three have been completed. Every definition is given a four-digit reference number, indicating its section, subsection and position therein.

Section 2 is a welcome publication, representing the first serious attempt which has been made in Great Britain to bring some semblance of order into a field where chaos has reigned supreme. The existing confusion is due partly to historical accident, for the three main divisions of control engineering were developed separately by groups having little contact with each other. For example, the designers of engine-speed governors, of thermostats and of military fire-control equipment failed to appreciate in the early stages that they were all concerned fundamentally with the same problem: namely, that of increasing the accuracy of performance of their equipment, under ever more stringent conditions of load and disturbance, while maintaining an acceptable standard of stability in the system as a whole. It was due to this lack of contact that three separate systems of nomenclature are now current; not only is the same phenomenon referred to by several different names, but also, even worse, the same word is often used by different engineers to indicate quite distinct phenomena.

The aura of mystery which surrounds the whole subject of automatic control in the minds of many engineers can be attributed largely to its illogical and unscientific terminology. In fact, the situation is even more chaotic than that stated above, for there is a considerable variety of usage even among the workers in a single field; a most valuable purpose will be served by the new glossary if it does no more than standardize the practice within each of the three separate fields, and it is to be hoped, therefore, that every control engineer will adhere to the recommended usage.

The glossary could be of more fundamental importance if it also helped to introduce a greater degree of uniformity between the separate fields of control. It is difficult, with only one part now available, to judge to what extent it will do this; but the task is undoubtedly a difficult one, for the technical differences between the fields are in some respects considerable, though by no means as great as is generally believed. It is regrettable, perhaps, from this point of view that it has been found necessary to separate the glossary into sections, for this will tend to emphasize a distinction which is in many instances more apparent than real.

As an example, consider the word 'offset' (definition 2203); in position control practice this is called the 'steady state error'. Is the latter term to be scrapped, or are we to have two names for the same thing? Again, is it impossible to persuade process control engineers to use the terms 'input', 'output' and 'error', in place of 'desired value', 'controlled condition' and 'deviation'? The former sound scientific, the latter sound amateur. The sign of the deviation is defined differently from what is customary for *position* control in Great Britain and in the United States. The Americans are unlikely to alter their practice, so that this will perpetuate the present ridiculous anomaly of having two contradictory definitions in use simultaneously; for it is a sad fact that the only books on control engineering come at present from the United States.

The intention is to review the present standard in a year, and suggestions for improvement are requested. The following comments may therefore be of some value. Terms for 'input element' and 'difference element' are not defined; they might be combined to form an 'input unit'. 'Measuring unit' (2106) is defined in terms of 'measuring element', which is listed among those terms the use of which is deprecated; this emphasizes the point that it is, in fact, necessary. 'Floating control' is not mentioned as a synonym for 'integral action'; it should at least be given, if only to deprecate this common usage. 'Proportional band' (2502) has another meaning, different from that given, namely, "the range within which controller action is linearly related to deviation"; if its use in this sense is deprecated, some alternative should be provided. Finally, the term 'two-step action' (2408) is an unsatisfactory alternative to 'two-position action' (deprecated), since such a control has only one step, though it has two positions.

It would, of course, be possible to make other minor criticisms; but these do not detract from the entirely admirable intention behind this glossary and the treatment which, so far as one can judge at present, maintains the high traditions of the British Standards Institution.

R. H. MACMILLAN

* British Standard No. 1523 : 1949. Glossary of Terms used in Automatic Controlling and Regulating Systems. Section 2 : Process Control. Pp. 21. (British Standards Institution, 24/28 Victoria Street, London, S.W.1.) 2s. 6d.