are useful to working scientists as well as being comprehensible to the uninitiated. *Scienza e Tecnica 69* has much to commend it. The selection of authors and topics is well conceived; the contributions, in spite of the need for translation into Italian from other languages, are surprisingly well up to date for a compilation of this size and the book itself is excellently designed, produced and illustrated.

The thirty-five articles, many by leading authorities in their field, are preceded by a section of short date-lined descriptions of scientific events such as the Nobel awards, launchings of spacecraft and particular research results. In the following section, on violence and the peaceful use of scientific knowledge, there are articles on the strategy of ABM systems by Marvin Kalkstein, the peaceful uses of nuclear explosions by Glenn Seaborg, and the sociology of violence in the United States by Louis Masotti and Don Bowen.

The next section, on medicinal advances, devotes what is perhaps excessive attention to the experimental techniques of heart transplant surgery, which is not the same thing as practical therapy. Nonetheless, the topics chosen are excellent in their own right. Christian Barnard concisely lays out the procedures for transplanting a heart, with the interesting note that, so as to avoid clotting, "immediately before death the donor is heparinized by intravenous injection of 2·5 mg/kg of heparin". A full but somewhat demanding review of transplant immunology by Marthinus Botha mentions the first known transplant of part of the human body. In the thirteenth century, Saints Cosmas and Damian transplanted a leg from an Ethiopian to a Roman Catholic priest, an operation recorded by Fra Angelico on the walls of San Marco in Florence.

Articles on geology, geophysics and archaeology make up the fourth section. Nino Lamboglia describes the equipment and techniques of underwater archaeology, while Carlo Lerici and Richard Linington give a lucid exposition of geophysical methods of archaeological surveying. There are also articles on the Upper Mantle Project, Earth resources satellites, marine geology and seismic forecasting methods in Japan. The quality of illustration in this section is outstanding.

Contributions from Antony Hewish on pulsars, Bruno Rossi on X-ray astronomy and Max Perutz on X-ray crystallography distinguish the section on pure research. Several of the articles, however, are likely to prove hard going for all but specialists. An essay on molecular orbitals which introduces the Schrodinger wave equation in its first paragraph is unlikely to gain a wide popular readership, and similar reservations apply to the treatments of thermonuclear fusion, storage rings and nerve growth factor. All these are highly technical articles the appeal of which could probably have been broadened by greater editorial attention, although this would doubtless have retarded the commendable speed of publication.

In a final section under the loose heading of "documentation", Alexander King, director of Scientific Affairs at the OECD, writes on technology gaps, putting his money on "Europe's fealty to tradition and resistance to change" as being the principal factor underlying the various gaps between Europe and the United States.

The notice in these pages of *S e T 68*, the predecessor to the present volume, hazarded the view that in spite of the volume's several excellent features, its price would probably put it beyond the reach of those who stood most to gain from it. The editor subsequently wrote to say that 35,000 copies had been sold. On this basis, an even more successful future must be predicted for *S e T 69*, the contents of which are better and more judiciously selected than were those of the previous volume. The absence of a simultaneous edition in English is surprising, because a good half of the articles in *S e T 69* must originally have been composed in that language.

NICHOLAS WADE

Obituaries

Professor Henryk Niewodniczański

HENRYK NIEWODNICZAŃSKI, a leading Polish physicist, died in Cracow on December 20, 1968 after a short illness.

Niewodniczański, a member of the Polish Academy of Sciences, was Professor of Physics in the Jagellonian University and Director of the Institute of Nuclear Physics in Cracow. Early in his career he was an authority on multipole optical radiation but in recent years his work was chiefly concerned with nuclear physics. He established an important centre for nuclear physics in Cracow and contributed much to the development of this branch of science in Poland.

Niewodniczański was born in 1900 in Wilno where he studied physics in the Stefan Batory University and where he obtained his PhD after presenting a thesis on molecular optics. He was most active in the field of atomic optics during the early thirties, and discovered several forbidden lines and confirmed experimentally the existence of magnetic dipole radiation. This was the starting point for many investigations undertaken in foreign laboratories.

At the same time Niewodniczański's interest turned to nuclear physics. His later research on this subject was greatly influenced by work done during his year at the centre directed by Lord Rutherford, the Royal Society Mond Laboratory and the Cavendish Laboratory in Cambridge, where he was in 1934–1935, and later in 1937 as a Rockefeller fellow.

He clearly understood that, after the terrible devastation of Poland during the Second World War, it was of prime importance to educate a new generation of young scientists. In the first few years after the war he gathered around him in Cracow young students whose careers he guided right through the university, and today they constitute an impressive research group.

As Director of the Institute of Nuclear Physics he initiated most of the work done there. The Institute is engaged in an extensive programme of research on nuclear reactions, nuclear spectroscopy, structural research applying nuclear methods, the theory of the nucleus and high energy particle interactions. Some industrial applications of nuclear physics are also being investigated. Niewodniczański himself was working on nuclear reactions and beta-spectroscopy.

Niewodniczański was a very active member of the Polish Physical Society. He understood the important part played by physics in contemporary life, and also knew very well the value of international collaboration. He was a member of the Scientific Council of the Joint Institute for Nuclear Research in Dubna, and a member of the Italian and American Physical Societies. He was in personal contact with scores of foreign physicists and had friends all over the world.

Correspondence

MKSA, Giorgi and SI

SIR,—Physicists are "recalcitrant"[1] about SI mainly because of a misunderstanding, which leads them wrongly to attribute undesirable features to it. One hopes that when SI is seen for what it is, it will receive the welcome it deserves.

The use of MKSA as base units removes factors of powers of 10 from electromagnetic equations in "practical" units; and, by introducing a logically independent electric base unit, requires the recognition of a new fundamental physical constant. The latter point is theoretically important, the former not. However, though the use of an electric base unit requires a formulation of electromagnetism with an electromagnetic constant, no particular treatment of it is indicated. I wish to examine alternatives. For this, a notation for two constants is required. These may be called the "electric and magnetic force constants", defined as the proportionality constants which relate the value of a source of field (electric and magnetic respectively) to the value of the field produced—and a pair of such sources to the force between them. The operation of a force constant is seen clearly in equations (1), (4) and (7) of Table 1. The electric and magnetic force constants will be represented by τ_e and τ_m respectively, their values depending on the system considered. ε_0 and μ_0 will be used with the specific values they customarily have.

SI units are "coherent" with the base units m, kg, s, A, °K, cd[2]. (The last two are irrelevant to electromagnetism and I shall ignore them.) This ensures that each "physical quantity" (given a specification of its measure in terms of the base units) has a unique unit; for "there exists for each physical quantity a single unit coherent with the base units of the Système Internationale d'Unité" (from preamble to recommendation 1 of *Comm. Intern. Poids Mesures* in ref. 3. The recommendation was abrogated (CIPM 1968), presumably the preamble stands as a statement of fact). Each "physical quantity" is meant in the narrow sense, according to which "electrostatic unit of charge" and "electromagnetic unit of charge" are units of two different "physical quantities". Only in this sense does uniqueness hold; and SI specifies a unit for all "physical quantities" in this sense. Thus it does nothing to specify which "physical quantities" (in the narrow sense) shall be used in electromagnetic theory—except negatively, that measures not derived from its given base units shall not be used. The several different SI formulations of electromagnetism involve different treatments of the force constants, and assume different evaluations of the physical quantities involved; each involves different "physical quantities" (narrow sense), and therefore a different selection of SI units. Each formulation is a "system" in a wider sense than the "SI" of units.

An "SI system" of electromagnetism includes the force constant (or the pair of force constants); this is the only fixed point. When Giorgi introduced the idea of MKSA units in 1901[4], however, he had a particular systematization of electromagnetism in mind, and those who developed the MKSA idea generally thought that only this 4-base formulation was physically sensible. Thus, though they talked of the choice of units, they

Table 1. FORMULAE IN ALTERNATIVE SI SYSTEMS

$\varepsilon_0 = 8{\cdot}85 \times 10^{-12}$ F m^{-1}

SI–Giorgi–Kennelly	SI–Gaussian	SI–Electric	SI–Giorgi–Sommerfeld*
$\tau_e = \varepsilon_0$	$\tau_e = \varepsilon_0 = \tau$	$\tau_e = \varepsilon_0$	$\tau_e = \varepsilon_0$
$\tau_m = 1/c^2\varepsilon_0 = \mu_0$	$\tau_m = \tau$	$\tau_m = c^2\varepsilon_0 = \eta_0$	$\tau_m = c^2\varepsilon_0 = \eta_0$
The following formulae are common to Giorgi–Kennelly, Gaussian and electric systems			1–10 as other systems, except—
(1) $\mathbf{F} = \frac{q_1 q_2}{\varepsilon_r \tau_e 4\pi r^2}\,\hat{r}$	(2)‡ $\mathbf{T} = \frac{2m_1 \wedge m_2}{\mu_r \tau_m 4\pi r^3}$	(3) $\mathbf{F} = \frac{\mu_r \mathbf{I}_1 \mathbf{I}_2 l_1 \wedge (l_2 \wedge \hat{r})}{c^2 \tau_e 4\pi r^2}$	(2)‡ $\mathbf{T} = \frac{\mu_r 2m_1 \wedge m_2}{\tau_m 4\pi r^3}$
(4) $\mathbf{F} = q\mathbf{E}$	(5) $\mathbf{T} = m \wedge \mathrm{H}$	(6) See below	(5) $\mathbf{T} = m \wedge \mathbf{B}$
(7) $\mathbf{E} = \frac{q}{\varepsilon_r \tau_e 4\pi r^2}\,\hat{r}$	(8)‡ $\mathbf{H} = \frac{2m}{\mu_r \tau_m 4\pi r^3}$	(9) See below	(8)‡ $\mathbf{B} = \frac{\mu_r\, 2m}{\tau_m 4\pi r^3}$
(10) $\mathrm{div}\,\mathbf{j} + \partial\varrho/\partial t = 0$			
(6) $\mathbf{F} = \mathbf{I}l \wedge \mathbf{B}$	$\mathbf{F} = (\mathbf{I}/c)l \wedge \mathbf{B}$	$\mathbf{F} = \mathbf{I}l \wedge \mathbf{B}$	$\mathbf{F} = \mathbf{I}l \wedge \mathbf{B}$
(9) $\mathbf{H} = \frac{\mathbf{I}l \wedge \hat{r}}{4\pi r^2}$	$\mathbf{H} = \frac{(\mathbf{I}/c)l \wedge \hat{r}}{\tau 4\pi r^2}$	$\mathbf{H} = \frac{\mathbf{I}l \wedge \hat{r}}{\eta_0 4\pi r^2}$	$\mathbf{H} = \frac{\mathbf{I}l \wedge \hat{r}}{4\pi r^2}$
(11) $\mathbf{D} = \varepsilon_r \varepsilon_0 \mathbf{E}$	$\mathbf{D} = \varepsilon_r \mathbf{E}$	$\mathbf{D} = \varepsilon_r \mathbf{E}$	$\mathbf{D} = \varepsilon_r \varepsilon_0 \mathbf{E}$
(12) $\mathbf{B} = \mu_r \mu_0 \mathbf{H}$	$\mathbf{B} = \mu_r \mathbf{H}$	$\mathbf{B} = \mu_r \mathbf{H}$	$\mathbf{H} = (1/\mu_r)\eta_0 \mathbf{B}$
(13) Magnetic dipole moment of current loop in vacuum			
$m = \mu_0 \mathbf{I}\mathbf{A}$	$m = (\mathbf{I}/c)\mathbf{A}$	$m = \mathbf{I}\mathbf{A}$	$m = \mathbf{I}\mathbf{A}$
(14) Relativistc transformations			
	$[\gamma = 1/\sqrt{1 - \mathbf{v}^2/c^2}]$		As Kennelly
$\mathbf{E}'_\perp = \gamma(\mathbf{E} + \mathbf{v} \wedge \mathbf{B})_\perp$	$\mathbf{E}'_\perp = \gamma(\mathbf{E} + (\mathbf{v}/c) \wedge \mathbf{B})_\perp$	$\mathbf{E}'_\perp = \gamma(\mathbf{E} + \mathbf{v} \wedge \mathbf{B})_\perp$	
$\mathbf{D}'_\perp = \gamma(\mathbf{D} + (\mathbf{v}/c^2) \wedge \mathbf{H}_\perp$	$\mathbf{D}'_\perp = \gamma(\mathbf{D} + (\mathbf{v}/c) \wedge \mathbf{H})_\perp$	$\mathbf{D}'_\perp = \gamma(\mathbf{D} + \mathbf{v} \wedge \mathbf{H})_\perp$	
$\mathbf{H}'_\perp = \gamma(\mathbf{H} - \mathbf{v} \wedge \mathbf{D})_\perp$	$\mathbf{H}'_\perp = \gamma(\mathbf{H} - (\mathbf{v}/c) \wedge \mathbf{D})_\perp$	$\mathbf{H}'_\perp = \gamma(\mathbf{H} - (\mathbf{v}/c^2) \wedge \mathbf{D})_\perp$	
$\mathbf{B}'_\perp = \gamma(\mathbf{B} - (\mathbf{v}/c^2) \wedge \mathbf{E})_\perp$	$\mathbf{B}'_\perp = \gamma(\mathbf{B} - (\mathbf{v}/c) \wedge \mathbf{E})_\perp$	$\mathbf{B}'_\perp = \gamma(\mathbf{B} - (\mathbf{v}/c^2) \wedge \mathbf{E})_\perp$	
(15) Maxwell's equations of circulation			As Kennelly
$\mathrm{curl}\ \mathbf{H} = \dot{\mathbf{D}} + \mathbf{j}$	$\mathrm{curl}\ \mathbf{H} - \partial\mathbf{D}/c\partial t = \mathbf{j}/c\tau$	$\mathrm{curl}\ \mathbf{E} = -\dot{\mathbf{B}}$	
$\mathrm{curl}\ \mathbf{E} = -\dot{\mathbf{B}}$	$\mathrm{curl}\ \mathbf{E} + \partial\mathbf{B}/c\partial t = 0$	$\mathrm{curl}\ \dot{\mathbf{H}} = \mathbf{D}/c^2 + \mathbf{j}/\eta_0$	

* η_0 is used for $1/\mu_0$, in partial fulfilment of Sommerfeld's wish: see ref. 8, pages 21 and 42. The Coulomb Law Committee[9] version of Sommerfeld is obtained by replacing m by m/μ_r.

‡ r at right angles to m_1 and m respectively.

thought of a particular formulation. The use of the designation "MKSA (Giorgi)" for a formulation, and not simply a system of units, is seen clearly in Table 2 on page 170 of ref. 5. Thus ambiguity has arisen, which must now be resolved.

The correct use of "SI" is clear: a particular system of units developed from the MKSA base units. It seems appropriate to say that a "Giorgi system" is a formulation of electromagnetism compatible with MKSA, and in which $\mathbf{B}=\mu_0\mathbf{H}$ in a vacuum (μ_0 understood to have dimensions). The formulations of electromagnetism currently associated with SI are of the Giorgi type. The two principal examples are "Giorgi–Kennelly", the original orthodox system, named after Kennelly who piloted it to acceptance in 1935[6], and "Giorgi–Sommerfeld", introduced in the same year[7,8]. These uses of the designations "Giorgi–Kennelly" and "Giorgi–Sommerfeld" are found in the Coulomb Law Report 1950—except that they misinterpret Sommerfeld[9]. A selection of formulae on both systems is presented in Table 1.

The use of SI units is not tied to the Giorgi formulae. I now describe two alternative SI systems. The "SI-Electric" system is the natural 4-base generalization of both the traditional "electrostatic" and "electromagnetic" systems. The essential characteristic of both these systems is that $\tau_m=c^2\tau_e$. In one of the traditional systems $\tau_e=1/4\pi$, in the other $\tau_m=1/4\pi$. In a general 4-base electric structure, one of the force constants is arbitrary, and the other follows from the above relation. For the SI-Electric structure $\tau_e=8{\cdot}85\times10^{-12}\text{Fm}^{-1}=\varepsilon_0$. This value of the electric force constant, in conjunction with MKS as mechanical units, and div $\text{j}=-\dot{\rho}$ to relate charge to current, determines the value of the unit of current as the ampere.

The "SI-Gaussian" system is the natural 4-base generalization of the traditional Gaussian system. The force constants are equal to each other, becoming simply the "electromagnetic force constant" τ. In the traditional Gaussian system, $\tau=(1/4\pi)$. In the SI-Gaussian system, $\tau=\varepsilon_0$, as for the SI-Electric system.

No future satisfaction rests with the adoption of any of the Giorgi approaches. Electrical engineers use Kennelly, so it is obscurantist to adopt Sommerfeld in the name of "uniformity". Further, both Kennelly and Sommerfeld are physically incoherent, so theoretical physicists have good grounds for rejecting them. The objection is not that **B** and **H** "really are" physical quantities of the "same nature", but that the Giorgi systems lead to confusion, and ultimately error. Both non-Giorgi systems are physically sensible, so one can hope that they may prevail. SI-Electric should be adopted as the general norm, and for all quantitative statements, for it has the practical advantage of eliminating c from elementary formulae. The conversions between SI-Electric and SI-Gaussian, and to either from the traditional formulae, are so simple (in remarkable contrast with Giorgi) that theoretical physicists may work with SI-Gaussian, and even set $\tau=1$ or $1/4\pi$, as they now work with $c=1$—the re-introduction of the required constants is trivial.

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Metrication and Decimalization: the Next Round

SIR,—So far as Britain is concerned the present round of metrication and decimalization, at the official level, may be thought of as extending from about 1950 to 1980. This includes the Hodgson and Halsbury reports, their implementation, and the official adoption of MKSA or SI.

During the subsequent thirty years, there is a *prima facie* case for a further round of metrication and decimalization. Three innovations seem worth considering. (1) A system of electrical and magnetic units, consistent with the watt and joule, where the practical unit of current is the passing of 10^{18} electrons per second (and electrons, not charges). (2) The replacement of the mole by a kind of decimal mole, consisting of 10^{24} molecules. (3) The citation of the mass of small natural entities, as well as larger ones, in metric units. So far as is known this instance of metrication was proposed first in 1951 (ref. 1) and in these columns. The other points ((1) and (2)) are straightforward cases of decimalization. It can greatly simplify calculations[2] to eliminate factors such as 6·24181 and 6·02252. Besides the usual advantages, these proposed reforms (*a*) can make it much easier to move, in thought, between the level of magnitude of atoms and the level of magnitude of laboratory objects; and (*b*) can make it much easier to move across from one discipline to another.

While of benefit in the physical sciences, these reforms seem likely to be especially useful in the biological sciences and at the research level, when considering electrons, atoms, molecules, organelles and cells. Provided these ideas get consumer trials from many people, they might well become adopted officially by about the end of the century.

Yours faithfully,

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Museum on the Move

SIR,—In the editorial comment (*Nature*, **221**, 1094; 1969) on the letter from Dr W. R. P. Bourne (**221**, 1177; 1969) regarding the move of the British Museum Bird Room from London to Tring, the British Trust for Ornithology (BTO) is quoted as being in favour of the move, together with other ornithologists.

The comment was not intended to be a statement of BTO policy and the BTO does not wish to prejudice the views of either side. BTO members, as a whole, are not aware of the move and the majority are not affected by it. Most BTO members are amateur bird watchers and not professional ornithologists.

I believe that a misunderstanding has arisen as a result of some comments which I made over the telephone to one of your correspondents last week. I obviously did not make clear the distinction between BTO members, who are on the whole amateurs, and the professional ornithologist who regularly consults the collection at the Bird Room. Members of the BTO staff would obviously gain convenience by the move to Tring as collection and library could be consulted easily and quickly without the necessity of a trip to London.

Yours faithfully,

KEITH G. CLARK

British Trust for Ornithology,
Beech Grove,
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