Valley, Ventura County, California. In the history of North American mammal life this fauna has a position immediately antecedent to that of the Titanotherium Zone. Above this stage in the Sespe is a considerable thickness of land-laid material and some of these deposits are without much doubt lower Oligocene in age although in the absence of fossil remains this cannot be definitely proved at the present time.

[2] Gilbert, G. K., *U. S. Geog. Surv. West 100th Mer., Wheeler Surv.*, **3,** 33 (1875).

[3] Turner, H. W., *U. S. Geol. Surv. 21st Ann. Rpt.*, Pt. 2, 197–208 (1900).

[4] Spurr, J. E., *Jour. Geol.*, **8,** 633 (1900).

[5] Spurr, J. E., *U. S. Geol. Surv. Bull.*, **208,** 19, 185 (1903).

[6] Spurr, J. E., *U. S. Geol. Surv. Prof. Pap.* **42,** 51–70 (1905).

[7] Ball, S. H., *U. S. Geol. Surv. Bull.*, **308,** 32–34, 165–166 (1907).

ADOPTION OF THE METER-KILOGRAM-MASS-SECOND (M.K.S.) *ABSOLUTE SYSTEM OF PRACTICAL UNITS BY THE INTERNATIONAL ELECTROTECHNICAL COMMISSION* (I.E.C.), *BRUXELLES, JUNE, 1935*

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At its plenary meeting in June, 1935, in Scheveningen-Bruxelles, the I.E.C. unanimously adopted the M.K.S. System of Giorgi, as a comprehensive absolute practical system of scientific units.

The last preceding international action of a similar character was in 1881, when the International Electrical Congress of Paris[1] adopted the centimeter-gram-second (C.G.S.) system.

Commencing with that action in 1881, various International Electrical Congresses, up to that of 1893 at Chicago,[2] and since then, the I.E.C.,[3] have adopted, by successive steps, the well-known series of nine practical electromagnetic units (*ohm, volt, ampere, farad, coulomb, joule, watt, henry* and *weber*). These practical units are recognized as not pertaining to the C.G.S. system; but as being derived therefrom through a corresponding series of decimal multiples (10^9, 10^8, 10^{-1}, 10^{-9}, 10^{-1}, 10^7, 10^7 and 10^8). It was pointed out by Clerk-Maxwell,[4] that the series might be considered as belonging to a practical absolute system having for its fundamental units the length of an earth-quadrant, (10^9 cm.), the mass of an eleventh-gram (10^{-11} g.) and the mean solar second of time (Q.E.S.). In the Q.E.S. system, the numerical value of μ_0 space permeability, was unity, the same as in the C.G.S magnetic system. The units of length and mass in the Q.E.S. system are so awkward that neither Maxwell, nor any unitologist since his time, has ever seriously proposed the practical adoption of the Q.E.S. system. It has remained an academic curiosity.

In 1901, however, Prof. G. Giorgi of Rome[5] showed that if the numerical value (rationalized) of space permeability μ_0 were taken* as $4\pi \times 10^{-7}$, the entire series of electromagnetic practical units could be considered as belonging to a new practical absolute system, having as unit of length the international meter of Sèvres, as unit of mass the international kilogram of Sèvres and as unit of time the mean solar second. Prof. Giorgi communicated a paper on the subject of his proposed system to the International Electrical Congress of St. Louis, in 1904.[6] The proposal gradually received support from physicists and engineers, until it was formally recommended for consideration by the U. S. National Committee of the International Union of Pure and Applied Physics (I.P.U.) at Chicago, in June, 1933,[7] and also by the Electric and Magnetic Units and Magnitudes (E.M.M.U.) Committee of the I.E.C., at Paris,[8] in October, 1933.

At its recent plenary Holland-Belgium meeting, the I.E.C. found that none of its national committees, after examining the Giorgi system, were opposed to its adoption, while the delegates from fourteen countries were (with one abstention), unanimously in its favor. The I.E.C. therefore adopted the M.K.S. system with certain reservations; namely:

(*a*) It was recognized that four fundamental units are needed to complete the basis of the system; because on the basis of the M, K and S units, it would be possible to construct a number of electromagnetic systems to the exclusion of the practical volt-ampere-ohm series. The missing fourth unit might be selected from among the nine practical units of that series. The choice of the fourth fundamental unit was deferred until an opportunity had been offered to consult the opinions of the Symbols, Units and Nomenclature Committee (S.U.N.) of the I.P.U. and also of the Comité Consultatif d'Electricité (C.C.E.) of the Comité International des Poids et Mesures of Sèvres. Meanwhile, it was recognized that the study and use of the M.K.S. system could go on uninterruptedly, without waiting for the formal adoption of the fourth fundamental unit.

(*b*) Two countries made reservations on the question of retaining the *kilogram* as one of the four fundamental units. This is a theoretical question which does not affect the practical adoption and use of the M.K.S. system.

(*c*) The question as to whether the new system should be "rationalized" or "nonrationalized" was left undetermined for the present. It was recognized that much difference of opinion exists on this question; not only among the different countries in the I.E.C.; but also among different writers in each country. After sufficient time may have elapsed to permit opinions to crystallize and unify, it may be possible to reach an international decision. In the mean time, it is optional for any writer to adopt either "rational" formulas, following the lead of the Gaussian and Heaviside-Lorentz C.G.S. systems, or nonrational formulas, following the lead of the classical C.G.S. systems of Maxwell.

It is, however, agreed that whether the units and formulas selected by a writer are "rational" or "nonrational," the M.K.S.?. system is a single electromagnetic system, and that there is no need for a pair of parallel electrostatic and magnetic subsystems, as in the classical C.G.S. system. Every physical quantity should be represented in the M.K.S.?. system by one and only one unit. On the other hand, the M.K.S.?. system leaves the various existing C.G.S. systems entirely undisturbed; so that while the new system offers a great simplification to all students of electro-technics, it adds no new burden to students of physics.

In the future, it seems likely that new units belonging to the C.G.S. system will be open to the reception of impersonal names, if desired, like the *erg*, *dyne*, *phot*, etc. On the other hand, new units belonging to the M.K.S. system will be open to the reception of personal names, if desired, like the *ohm*, *volt*, *ampere*, etc. A temporary incongruity was unfortunately brought about by the International Electrical Congress of Chicago, in 1893, which passed a resolution that all practical magnetic units should be kept within the C.G.S. system. This led to personal names being adopted for certain C.G.S. magnetic units; the *gilbert*, *oersted*, *maxwell* and *gauss;* but it is to be hoped that with time and good-will, these exceptions can be ultimately cleared up.

The following table contains an incomplete list of M.K.S. units:

TABLE 1

M.K.S. UNITS AND THEIR CORRESPONDING C.G.S. UNITS

NO.	QUANTITY	SYMBOL	M.K.S.U.	C.G.S.U.	C.G.S.U. IN ONE M.K.S.U.	M.K.S.U. IN ONE C.G.S.U.
Mechanic						
1	Length	L	meter	centimeter	10^2	10^{-2}
2	Mass	M	Kilogram	gram	10^3	10^{-3}
3	Time	T	second	second	1	1
4	Area	S	m.^{2}	cm.^{2}	10^4	10^{-4}
5	Volume	V	m.^{3}	cm.^{3}	10^6	10^{-6}
6	Frequency	f	hertz, cy./sec.	cy./sec., hertz	1	1
7	Density	d	kg./m.^{3}	g./cm.^{3}	10^{-3}	10^3
8	Specific gravity		numeric	numeric	1	1
9	Velocity	v	m./sec.	cm./sec.	10^2	10^{-2}
10	Slowness		sec./m.	sec./cm.	10^{-2}	10^2
11	Acceleration	a	m./sec.^{2}	cm./sec.^{2}	10^2	10^{-2}
12	Force	F	joule/m.	dyne	10^5	10^{-5}
13	Pressure	p	joule/m.^{3}	barye	10	10^{-1}
14	Angle	α, β	radian	radian	1	1
15	Ang. velocity	ω	rad./sec.	rad./sec.	1	1
16	Torque	τ	joule/radian	dyne $\perp$ cm.	10^7	10^{-7}
17	Moment of inertia	J	kg. m.^{2}	g. cm.^{2}	10^7	10^{-7}

Energetic					
18 Work or energy	W	joule	erg	10^7	10^{-7}
19 Angular work $\tau\beta$	W	joule	erg	10^7	10^{-7}
20 Volume energy	W	joule/m.^{3}	erg/cm.^{3}	10	10^{-1}
21 Active power	P	watt	erg/sec.	10^7	10^{-7}
22 Reactive power	jQ	var	——	10^7	10^{-7}
23 Vector power		watt ∠	——	10^7	10^{-7}
Thermal					
24 Quantity	H	kg. calorie	g. calorie	10^3	10^{-3}
25 Temperature	θ	°C. or °K.	°C. or °K.	1	1
Luminous					
26 Luminous flux	ψ	lumen	lumen	1	1
27 Illumination	E	lux	phot	10^{-2}	10^2
28 Brightness	b	candle/m.^{2}	stilb	10^{-4}	10^4
29 Focal power	f	diopter	——	10^{-2}	10^2
Electric					
30 E.m.f.	E	volt	——	10^8	10^{-8}
31 Pot. gradient	H_e	volt/m.	——	10^6	10^{-6}
32 Resistance	R	ohm	——	10^9	10^{-9}
33 Resistivity	ρ	ohm.meter	——	10^{11}	10^{-11}
34 Conductance	G	mho, siemens	——	10^{-9}	10^9
35 Conductivity	γ	mho/m., siemens/m.	——	10^{-11}	10^{11}
36 Reactance	jX	ohm	——	10^9	10^{-9}
37 Impedance	Z	ohm ∠	——	10^9	10^{-9}
38 Quantity	Q	coulomb	——	10^{-1}	10^1
39 Displacement	Q	coulomb	——	10^{-1}	10^1
40 Current	I	ampere	——	10^{-1}	10^1
41 Current density	i	ampere/m.^{2}	——	10^{-5}	10^5
42 Capacitance	C	farad	——	10^{-9}	10^9
43 Spec. ind. capy.	ϵ/ϵ_0	numeric	numeric	1	1
Magnetic					
44 Flux	Φ	weber	maxwell	10^8	10^{-8}
45 Flux density	B	weber/m.^{2}	gauss	10^4	10^{-4}
46 Inductance	L	henry	——	10^9	10^{-9}
47 Rel. permeability	μ/μ_0	numeric	numeric	1	1

Table 2 lists the principal units of the M.K.S. system which are affected by the principle of "rationalization." The table shows that the rationalized units are already furnished with international names; although some of them are cumbersome and may perhaps be replaced by new shorter names in the future. None of the unrationalized units appear, as yet, to have international names. It might be possible to use the names *pragilbert* and *praoersted* for Nos. 51 and 52 nonrationalized; but the prefix *pra*, suggested at the I.E.C. meeting of Stockholm, in 1930, has met with but little international support up to the present time.

TABLE 2

M.M.S. SYSTEM ELECTRIC AND MAGNETIC UNITS CHANGED BY RATIONALIZATION

NO.	QUANTITY	SYMBOL	NAME OF M.K.S. UNIT RATIONALIZED	UNRATIONALIZED	NO. OF UNRAT. U. IN ONE RAT. U.
Electric					
48	Electric flux	ψ	coulomb	——	
49	Flux density	D	coulomb/m.^{2}	——	
50	Space inductivity	ϵ_0	farad/m.	——	
50a*	Num. value of ϵ_0		$10^7/4\pi c^2 =$ 8.854×10^{-12}	$10^7/c^2 =$ 1.113×10^{-10}	
Magnetic					
51	Magnetomotive force	$\mathfrak{F}$ or M	ampere-turn	——	4π
52	Potential gradient	H	amp.-turn/m.	——	4π
53	Space permeability	μ_0	henry/m.	——	$1/4\pi$
54*	Num. value of μ_0		$4\pi \times 10^{-7} =$ 1.257×10^{-6}	10^{-7}	
55	Space reluctivity	υ_0	m./henry	——	4π
56	Num. value of υ_0		$10^7/4\pi =$ 7.958×10^5	10^7	
57	Permeance	$\mathfrak{P}$	weber/amp.-turn	——	$1/4\pi$
58	Reluctance	$\mathfrak{R}$	amp.-turn/weber	——	4π
59	Pole strength	m	weber	——	$1/4\pi$
60	Magnetic moment	$\mathfrak{M}$	weber.meter	——	$1/4\pi$
61	Magnetization	$\mathfrak{J}$	weber/m.^{2}	——	$1/4\pi$

* Owing to admitted small discrepancies of a few parts per myriad, between certain existing practical unit standards and their absolute theoretical values, the future adoption of a fourth fundamental M.K.S. unit might slightly alter[9] these numerical "constants." In 50a, the transmission velocity c is taken as 2.998×10^8 m./sec.

* Equivalent to 10^{-7} unrationalized.

[1] International Congress of Electricians, Paris, 1881, Resolutions.

[2] *Proc. Int. Elec. Cong. Chicago*, Chamber of Delegates (1893).

[3] *Proc. Int. Elec. Commission* (1906–1935).

[4] J. Clerk-Maxwell, "A Treatise on Electricity and Magnetism" (1881).

[5] G. Giorgi, "Unità Razionali di Elettromagnetismo," *Atti dell A.E.I.* (1901).

[6] G. Giorgi, "Proposals Concerning Electrical and Physical Units," *Trans. Int. Elec. Cong. St. Louis*, **1**, 136–141 (1904).

[7] *Bull. Natl. Res. Coun.*, No. **93**, 1933, *Int. Union Pure and Applied Physics*, Chicago, p. 2.

[8] I.E.C. Document R.M. 105, Meeting of E.M.M.U. Subcommittee, Paris, Oct., 1933.

[9] I. E. C. Document, June, 1934, "Memorandum on the M. K. S. System of Practical Units" by G. Giorgi.