in the community turn for special advice. Associated with the department of medicine of the university must be clinical professors who are the recognized leaders in their art.

This is vital for the student, for from the example of the experienced clinician he can best acquire proficiency in the art of medicine.

It is vital for the senior associates who must be relieved from unnecessarily arduous clinical duties and should be afforded opportunities to gain themselves that clinical experience and competence which they will ultimately need.

It is vital for the clinic itself, because if the department of medicine of the university be not the recognized clinical center of the community, it will be unable to command the personnel that it should have; it will be unable to do its full duty to patient, to student or to the community; and it will be in grave danger of falling into isolation and mediocrity.

The third great function of the university clinic is that of research. Research means study, analytical and experimental, in ward, in laboratory, in consulting room. A clinic that is properly equipped for the care of its patients and for teaching will be properly equipped for research. The qualified teacher in any branch of medicine is of necessity a student. There is no place in the medical school of to-day for the mere vulgarizer of knowledge. What we try to do to-day is not to feed the student with assertions but to teach him how to teach himself. We seek to teach him methods and encourage him rather to doubt and to prove for himself the truth or error of the assertions of others.

The modern school of medicine and the modern hospital should make it possible for the members of the staff to pursue research, to study their problems more thoroughly by increasing their freedom in every possible way, through adequacy of salary and through affording opportunities in hospitals and laboratories for post-graduate study in the shape of fellowships and voluntary assistantships which enable the chief to contribute to the advances of the medical science and art through the active work of the increasingly large body of young men who are every day seeking the opportunity to give their time to the elucidation of special problems under the advice and direction of a master.

It is, I believe, greatly to the advantage of hospital and university that special opportunities be afforded the head of a department and his chief associates for holding such consultations as they may desire to hold *at the clinic*. This is time saving; it centralizes the work of the teachers at the point of their main activities, and it brings to the clinic an invaluable stream of selected cases of special interest —special problems referred to them by their colleagues from near and far.

Much of such material may not be directly utilizable for teaching purposes before the general student body, but it is invaluable for the staff, especially those members of the staff who are studying special problems.

Every effort should be made to free the chief of a service from unnecessary responsibility or anxiety, for the multiplicity of duties falling on the shoulders of the director of a large department of medicine to-day have come to be a rather heavy load.

The recognition that such men must be adequately salaried is a great step forward.[3] But beyond this the question as to how to deliver the director from the whirlpool of administrative duties is puzzling and serious.

I have said enough. There is no fixed model; no one way by which alone medicine can be or should be taught. I have given you a few of the thoughts which have arisen from my own experience. You have the opportunity, under exceptionally favorable circumstances, of solving the problems in your own way.

The sight of these beautiful buildings, the conversation with those privileged friends who have the chance to show to the world what they can do with the opportunities that lie before them, remind me of the days nearly thirty-five years ago now, when I came to Baltimore, but a year after the opening of the Johns Hopkins Hospital. In those days I was but an insignificant member of the fortunate group of men who had the joy, free and unfettered, of shaping the destinies of that institution.

May you be as free! May your happiness in your work be as great! May your accomplishments be greater!

W. S. THAYER

BALTIMORE

A SYSTEM OF "DEFINITIVE UNITS" PROPOSED FOR UNIVERSAL USE[1]

ABSTRACT: It is proposed that physicists discard the CGS and Heaviside units, which are responsible for much confusion and needless mental effort, and

[3] The effort to put the medical school and medical teaching more and more on an university basis, that is being made in many of our better medical schools, is not a revolution in methods; it is an evolution springing directly from ideals which have always guided the wisest students and teachers and practitioners.

[1] Read at the International Mathematical Congress, at Toronto, August, 1924.

employ exclusively a single system of "definitive units." The units suggested include the international meter, the international kilogram, the second, the mechanical watt, the international mercury ohm and they conform with the other international units as closely as is compatible with self-consistency. The system is not only definite and absolute, but also comprehensive, readily visualized and, in large part, already employed under well-established names. The system was proposed in 1901 by Giorgi and in 1904 by Robertson but received scant attention on account of the artificial prestige of the CGS system. A single universal system of units should be the ultimate goal, and the "definitive units" are chosen with a view to their adoption not only by all scientists but also by the butcher, the baker and the candlestick-maker.

THE PROBLEM OF UNIVERSAL UNITS

The purpose of this paper is to advocate the use of a single system of units meeting these two essential requirements:

(1) Universal applicability for all purposes from the common every day practical needs to the most exacting scientific uses.

(2) Ready transition to the single system involving minimum change and inconvenience.

It is unnecessary here to stress the importance of a common meeting ground for all commercial countries in the matter of units. The existing confusion and waste due to the multiple, redundant units which are still in use is quite generally recognized, and progress is being made towards universal units. It is most important that a proposed universal system of units should not call for radical changes; otherwise, its chance of securing adoption is small. For the proposed system what has been done has been to choose from among the multiplicity of existing units the ones best adapted to form a single, comprehensive and final system for universal use. These units are shown by Table I in the column headed "Definitive Unit"; each unit, with the exception of the (10^5dyne) unit for force, is now in common use. Furthermore, the international prototype meter and kilogram became the fundamental standards of length and mass in the United States in 1893, while eight of the remaining units (or their international electrical equivalents) were legally established by law in 1894. It is believed that the proposed "definitive" system may be advantageously adopted by individuals, and without inconvenience, even in the absence of further legislative or other general adoption.

Even though we recognize the difficulties in the way of securing the universal adoption of any one system of units, it is nevertheless extremely worth while to determine the best system of units for this purpose, and to secure for it the widest possible adoption as rapidly as possible. It is especially important that physicists should show the way by exclusively employing the system adapted for universal use, before custom and legislation have established additional units which can not be absorbed into such a system. This change will directly benefit physicists themselves, for they are now handicapped by the intermingled and varying use of many systems of units, including the CGS electrostatic, the CGS electromagnetic, the practical, the international, the rational, the ampere-turn and the gravitational systems in addition to the metric system. Upon the first four of these systems the British Association Committee on Electrical Standards placed the seal of its approval without, apparently, any serious consideration of the possibility and desirability of a single universal system. The CGS system has served a great purpose. It was a long step towards complete unification, but it was not intended to be and is not adapted to be the single universal system and for that reason it should give place to a truly universal system as soon as possible.

It is important that the subject of units should now be considered from a comprehensive, universal point of view because of possible legislation extending the use of the metric system. Fortunately scientists are in a position, on the basis of a long and essentially successful experience with metric, absolute CGS and other units, to specify the complete system of units which may be confidently fixed as the universal goal. All changes which are introduced should be consistent with and aid in bringing about the ultimate adoption of a universal system of units. Proposals looking toward the adoption of the metric system in the United States and elsewhere should consider the question of units broadly and not merely adopt the meter-liter-gram units because these were the original metric units. As shown by Table I, the kilogram is required for consistent interrelation with the meter, second and watt. Furthermore, the consistent unit of volume is the stere or meter cube, which is almost exactly a kiloliter.

It is important that the proposed universal system of units bear a simple, distinctive name, especially since many of the individual units brought together in the system differ little, if at all, from units which are already associated with one or more existing systems of units. The name proposed is "definitive," and this name is appropriate because these units are the best final selection from among all metric possibilities. Justification for the name does not require proof of absolute finality; it is recognized that with the advance of science some new basis for units superior to the metric basis may be discovered. In that event the definitive units should be superseded. In the meantime, however, every worker in science, engineering, industry, commerce and everyday affairs may confidently turn to the definitive system for his units.

PROPOSED DEFINITIVE UNITS

The proposed units are shown in Table I, together with the conversion factors for reducing several other systems of units to definitive units. The meter and the second are the two units for the space-time framework; the watt and the joule are the units for power and energy, the essential binding links in all physical transformations; the (10^5dyne) and the (kilogram) are the dynamical units for force and mass. The definitive system includes the international prototype meter, the international prototype kilogram, the international mercury ohm, the international farad and the international henry. The definitive watt, however, is the mechanical, not the international, watt, the latter being 340 parts in a million larger. The definitive ampere, volt and coulomb are, consequently, each smaller than the corresponding international unit by 170 parts in a million. These differences are negligible except in refined scientific work.

The definitive units are so simple and convenient that it is surprising that they were not adopted originally in place of the CGS units; as far as I know no extended use has ever been made of them as a comprehensive system. The system was proposed, however, in 1901 by Giorgi under the name of the "absolute practical" system, and in 1904 by Robertson as the "complete practical" system. The solid advantages which they pointed out were almost ignored due to conservatism and the artificial prestige of the CGS system. Emde recommended the adop-

TABLE I

FACTORS FOR CONVERSION INTO DEFINITIVE UNITS[1]

Quantity	Symbol and Definitive Unit[2]	Value of Unit in Terms of Definitive Unit[3]					
		International Unit	Practical Unit	CGS Electromagnetic Unit	CGS Electrostatic Unit	Gaussian-Heaviside-Lorentz Unit	Mechanical Metric K-M-S Gravitational Unit
Length	s Meter	1	10^7	0.01	0.01	0.01	1
Time	t Second	1	1	1	1	1	1
Power	P Watt	1.00034	1	10^{-7}	10^{-7}	10^{-7}	0.1019716^{-1}
Energy	W Joule	1.00034	1	10^{-7}	10^{-7}	10^{-7}	0.1019716^{-1}
Force	F (10^5 dyne)			10^{-5}	10^{-5}	10^{-5}	0.1019716^{-1}
Mass	M (Kilogram)	10^{-3}		10^{-3}	10^{-3}	10^{-3}	1
Resistance	R Ohm	1	1.00052^{-1}	$1.00052^{-1}\ 10^{-9}$	$1.1130^{-1}\ 10^{12}$	1.1290×10^{13}	
Current	I Ampere	1.00017	1.00026	1.00026×10	$2.9974^{-1}\ 10^{-9}$	$1.0626^{-1}\ 10^{-10}$	
Potential	V Volt	1.00017	1.00026^{-1}	$1.00026^{-1}\ 10^{-8}$	2.9974×10^2	1.0626×10^3	
Electricity	Q Coulomb	1.00017	1.00026	1.00026×10	$2.9974^{-1}\ 10^{-9}$	$1.0626^{-1}\ 10^{-10}$	
Capacity	C Farad	1	1.00052	1.00052×10^9	1.1130×10^{-12}	$1.1290^{-1}\ 10^{-13}$	
Inductance	L Henry	1	1.00052^{-1}	$1.00052^{-1}\ 10^{-9}$	$1.1130^{-1}\ 10^{12}$	1.1290×10^{13}	
Magnetomotive force	F (Amp.-turn)			1.25631^{-1}		2.82168	
Magnetic flux	ø (Weber)			$1.00026^{-1}\ 10^{-8}$		$2.82168^{-1}\ 10^{-7}$	
Magnetic pole	m (Weber)			1.25631×10^{-7}		$2.82168^{-1}\ 10^{-7}$	
Reluctance	$\mathcal{R}$ (Amp.-turn/weber)			$1.25598^{-1}\ 10^8$		$1.25598^{-1}\ 10^8$	

[1] A numerical magnitude based upon any unit is transformed to the corresponding definitive unit by multiplying by the tabulated value of the original unit. A literal relation, $f(A, B, C \cdots) = 0$, transformed to $f(A/a, B/b, C/c \cdots) = 0$, holds for definitive units, a, b, c being the tabulated values of the original units for A, B, C respectively.

[2] The definitive units are connected by the ten, simple, fundamental energy relations:

$$W = Pt = Fs = \frac{1}{2}Ms^2 = RI^2t = VIt = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}LI^2 = \frac{1}{2}F\phi = \frac{1}{2}\mathcal{R}\phi^2.$$

[3] Based upon the experimental constants: velocity of light $= v = 299.82 \times 10^6$ meter/sec.; acceleration due to gravity $= g = 9.80665 = 0.1019716^{-1}$ meter/sec.^{2}; international ohm $= r = 1.00052$ "practical" ohm; international ampere $= a = 0.99991$ "practical" ampere. Therefore, $a^2r = 1.00034 = 1.00017^2$; $v^2r^{-1} = 1.1130^{-1}\ 10^{-17} = 2.9974^2\ 10^{16}$; $4\pi v^2 r^{-1} = 1.1290 \times 10^{18} = 1.0626^2 \times 10^{18}$; $r/4\pi = 12.5598^{-1} = 0.282168^2$; $4\pi r^{-1/2} = 12.5631$; $r = 1.00026^2$, from which follow the tabulated values.

tion of Giorgi's proposal but only as a temporary transition system. The absolute CGS units have continued to be regarded as the fundamental, complete system of units; to be extensively supplemented in practice, nevertheless, by the intermingled use of metric, practical, rational, international and ampere-turn units. No uniformity of practice has prevailed, the units from different systems being combined by different authors in different ways.

A consistent system employed to a very limited extent in electrical engineering satisfies the connecting relations of the definitive units but makes use of the centimeter-(10^7dyne)-(10^4kilogram) in place of the meter-(10^5dyne)-(kilogram). For a universal system, however, the meter is to be preferred to the centimeter and the kilogram to the (10^4kilogram). The meter and the kilogram are the units now in actual use in commerce and practical life in metric countries; the centimeter is recognized as a basic unit by scientists but not to the extent of influencing the nomenclature; 10,000 kilograms as an everyday unit of mass is much too large since it lies far beyond ordinary sense experience. No other possible combination of metric multiples is to be preferred, but it may be noted that the combination of the dekameter-(10^4dyne)-(10 gram) has the attractive feature of making weight and mass numerically equal to each other within 2 per cent.

ADVANTAGES OF DEFINITIVE UNITS

The proposed definitive units combine, to a remarkable degree, the best features of all existing systems of units. The following may be specially noted:

1. Definitive units are independent of place and time. They are absolute in this and every other respect and the peers of the CGS unit for the most refined scientific work.
2. Readily visualized magnitudes of convenient size for everyday needs characterize the definitive units of the more important quantities. The meter and kilogram are the common metric units of length and mass. The definitive unit of force (10^5dyne), which is approximately the force of gravity on 0.1 kilogram, is a force which is directly apprehended, whereas the dyne, the CGS unit, corresponds more nearly to the proverbially negligible weight of a feather.
3. Convenient names are already in common international use for most definitive units or their practical equivalents. Eventually a few new names should be adopted so that no basic definitive unit will be encumbered with a numerical prefix as in (10^5dyne), (kilogram) and (centare). Names are quite secondary to the adoption of the universal system. Apparently the adoption of definitive units would be hindered rather than helped by the simultaneous consideration of new names for units, if we are to judge by the discussion elicited by Giorgi and Robertson twenty years ago.

TABLE II

PHYSICAL CONSTANTS IN TERMS OF DEFINITIVE UNITS

	Numeric	*Unit*
Radius of positive electron	1 micro^{3}	meter
Diameter of negative electron	3.8 micro$^{2.5}$	"
Wave length shortest γ-ray	5.7 micro^{2}	"
Wave length cadmium red No. 1	643.84696 micro$^{1.5}$	"
Earth to sun	0.1495 mega^{2}	"
Light year	9.4614 mega$^{2.5}$	"
Parsec	30.838 mega$^{2.5}$	"
Radius curvature of space (Silberstein)	1 mega^{4}	"
Mean solar year	31.556926 mega	second
Velocity of light in free space	299.82 mega	(m./sec.)
Capacity of meter cube of free space	8.8572 micro^{2}	farad
Inductance of meter cube of free space	1.25598 micro	henry
Iterative impedance of free space	376.57	ohm
Resistance of one kilogram of mercury in a column one meter long	12.7898 milli	"
Force betwen two kilogram point masses separated one meter	66.58 micro^{2}	(10^5 dyne)
Force between two coulomb point charges separated one meter	8.9845 mega$^{1.5}$	"
Force between two weber point poles separated one meter	63.359 kilo	"
Charge of negative electron	0.1593 micro^{3}	coulomb
Mass of negative electron	0.89 micro^{5}	kilogram
Mass of sun	2.0 mega^{5}	"

4. A complete, coherent system of definitive units is obtained by so extending Table I as to avoid useless coefficients, in essentially the same way as for CGS units. The complete table would include units for area (centare), volume (stere = 1.000027^{-1} kiloliter), velocity (meter/second), electric force (volt/meter), temperature, entropy, etc.
5. The entire range of each quantity encountered throughout all nature is conveniently referred to the single corresponding definitive unit by the use of numerical prefixes. These prefixes are to be regarded as a part of the numeric and not as creating an independent basic unit. Arithmetical notation supplies different methods of expressing these prefixes, and further developments are doubtless possible. Table II illustrates the use of powers of mega and micro prefixes to cover the entire range of nature in categories of a million; the known range of lengths extends over only seven of these categories. As far as I have looked into the matter twelve of these categories suffice for any one of the quantities of physics, as known to-day.
6. The minimum changes in commerce, in legislation and in scientific instruments are called for by

definitive units since the largest possible number of international units are retained.

7. Conversion of existing results into definitive units is made simple by the use of Table I. The table may be extended so as to include English units and the algebraical as well as the arithmetical relations between units. A grounding in the definitive units is sufficient for every one; familiarity with the CGS units or with the historical rôle which they played as progenitors of definitive units is not essential. Results expressed in the older units are readily reduced to definitive units by the mechanical use of the table.
8. Definitive units do not artificially exalt any four units as being preeminently the basic primary units for all purposes. Any choice may be made which will simplify a particular problem under discussion. Among the first twelve units of Table I, four dimensionally independent units may be chosen in 299 different ways.
9. The ten fundamental relations of Table I, Footnote 2, hold also for Heaviside's units. Since the only present use for Heaviside's units is to obtain these relations and others based upon them, his specific units may be abolished, thereby materially simplifying the connection between theoretical electromagnetism and practical measurements.
10. Complete, homogeneous, physical equations (which are best adapted for theoretical physics) are naturally employed with definitive units, since no dimensional constant of nature has by advance agreement any specific numerical value such as unity or 4π. Some of the more important dimensional constants, expressed in definitive units, are included in Table II. The choice of units need introduce no changes in the use of convenient ratios, such as permeability and dielectric constant.

CONCLUSIONS

The definitive system of units makes it perfectly feasible to employ a single system much more generally than has ever been the case in the past; the natural ultimate goal is the universal use of these units for all purposes. In the attempt to extend the application of metric units in the United States the meter-stere-kilogram, rather than the meter-liter-gram, should form the basis for legislation, in order to give definitive units their proper legalized status and to secure to the full the advantages of a comprehensive system consistently interrelated with the legalized international electrical units. The gradual discarding of CGS and other redundant units would inevitably follow. Even in the absence of official recognition of definitive units, individuals may advantageously employ the system. This would cause confusion neither to authors nor readers, since these units, in the main, have already acquired vital existence through world-wide, daily use under familiar, well-established names.

GEORGE A. CAMPBELL
DEPARTMENT OF DEVELOPMENT AND RESEARCH,
AMERICAN TELEPHONE & TELEGRAPH COMPANY,
NEW YORK, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

ASSOCIATED ORGANIZATIONS

A VERY large proportion of the American organizations devoted to the advancement of the sciences and of science in general are officially associated with the American Association for the Advancement of Science (see SCIENCE for February 6, page 166). This feature of the organization of the association is very important and it is continually becoming more so. For the general cooperation of American men and women of science and of American friends of scientific advance the association furnishes convenient arrangements, which are being continually improved, and this is also and specially true with respect to the cooperation of the many special scientific societies of America, in the work of emphasizing the broad unity of science in general and furthering its advancement and its appreciation by the public.

It will be recalled that associated organizations are of two kinds, those that are simply *associated* and those that are *associated* and *affiliated.* Simply associated societies have the general official approval of the association and the latter aids their work wherever possible. Affiliated societies have the same relation to the association and they also have representation in the association council and generally in the respective section committees, thus being in a way constituent units in the larger organization. Furthermore, members of each affiliated society who are not already enrolled in the association have the privilege of becoming so enrolled without paying the usual five-dollar entrance fee, if they join before the second October 1st following the affiliation of the society or before the second October 1st following their election to the society. Official association and affiliation are arranged by application to and election by the association council. No financial or other serious obligations are attached to the arrangements of association and of affiliation but affiliated organizations are generally expected to supply the association annually with lists of their new members, whom the association invites to join it under the special conditions just mentioned. A list of all associated organizations, of both kinds, is published