letters

NBS and metrication

With the passage by Congress of the Metric Conversion Act of 1975 (Public law 94-168) most physicists probably think that metrication in America is proceeding in accord with the International System of Units (SI). Unfortunately this is not the case. Congress gave the Secretary of Commerce the authority to make the Metric System in the US *different* from the system set up by international treaties and agreements, and *the Secretary, acting on the recommendation of our National Bureau of Standards, has made the Metric System in the US different from the international system.*

The American Association of Physics Teachers had tried for over five years to have the Bureau rescind one of these changes. The international documentation on which SI is based is very clear on the difference between the terms "mass" and "weight," while the Bureau says clearly that "mass" and "weight" are synonymous. As a result of our failing to get the Bureau to adhere to the international definitions of the units of "mass" and "weight," the Council of AAPT took an unprecedented action. *The Council of AAPT voted to censure the National Bureau of Standards.*[1] The AAPT is the second largest member society in the AIP. Only The American Physical Society is larger.

The problem is introduced by the question that physics teachers have encountered in introductory courses. "Is the pound a unit of mass or a unit of weight?" The answer is that in the old British System the word "pound" could refer either to mass (in which case the force or weight unit is the poundal) or to force or weight (in which case the mass unit is the slug). Incalculable educational confusion has resulted from the use of the word "pound" to mean either mass or weight (force). Physics teachers had looked forward to the introduction of SI because in that system the kilogram is the unit of mass, the newton is the unit of force. Thus in the SI there would be two correct and equivalent ways of buying beans. One could ask for a mass of 1 kilogram of beans or ask for a weight of 9.8 newtons of beans. We recognize that there will be enough difficulty getting kilograms into the marketplace, so it is clear that newtons will never make it. Yet we want to measure quantities by weighing and we want to express these quantities in kilograms. There are a couple of possible solutions to this genuine dilemma:

- We could say that "mass" is the property that is being expressed whenever the unit "kilogram" is used. We could note that masses are compared and measured by "weighing" and we would note that "net mass" rather than "net weight" would be the correct way to label packaged goods if the contents were expressed in the "kilograms." The label "net weight: X kg" would probably persist, but its presence would represent no change from the present.
- As an alternative course of action we could redefine the word "weight" to make it synonymous with "mass" so that "net wgt x kg" would be correct. Thus the symbol m could be called either "mass" or "weight."

This would be a proper and fascinating item for debate except for one fact. The issue has already been settled. Even though the appropriate international bodies have adopted the first option, the Bureau of Standards has adopted the second and at the same time the Bureau tells the American people that we are adopting the international system of units!

How did this come about? Somehow, out of complex interactions involving the Bureau and a number of private non-governmental professional groups[2] there emerged the process that our Bureau of Standards calls "concensus standardization," and out of this process has come the recommendation that in the US the word "weight" henceforth should mean "mass." This change was made manifest in several ways:

- From time to time the Federal Register publishes materials relating to metric standards.[3] In "Table 1: SI base and supplimentary units," (of reference 3) the quantity measured in kg is properly identified as "mass" but there is a footnote: " 'weight' is the commonly used term for 'mass'."
- The Bureau publishes an American-

language translation of the official international standards document.[4] In the text (page 16) in which it is stated that the international conference declares that "the word weight denotes a quantity of the same nature as a force," we find that the Bureau has inserted this footnote:

> USA Editor's note: In the USA weight is the commonly used term for mass. Because of the dual use of the term weight as a quantity, this term should be avoided in technical practice. (American National Standards Z210.1)

These two footnotes are the basis for the major change that the Bureau has made in setting up an American Metric System which is different from the SI. Note that in justification of the change, in the second sentence of the second footnote, our highest national authority on standards (NBS) cites the publication of a *private professional group that has no official status*!

▶ In internal documents of our Bureau we find frequent references to the kilogram (or gram) as a unit of weight.

> "gram: a little more than the weight of a paper clip."[5] "The term 'weight' . . . is considered to be synonymous with mass."[6]

▶ In documents designed for public education the Bureau has repeatedly identified the kilogram as the unit of weight.[7]

▶ Bureau staff members write in the standards documents of private professional groups to advocate use of "weight" to mean "mass." In one of these, Louis Barbrow, who identifies himself as "Coordinator of Metric Activities of the National Bureau of Standards," tells how the mass–weight question received "in-depth attention from the Metric Practice Committee (MPC) of the American National Metric Council."[8] As a result the MPC adopted an explanatory statement that perpetuates the mass–weight confusion. Barbrow then notes:

> The unanimity of the members of the Metric Practice Committee in approving the wording of the above paragraph practically assures that this solution of the mass-weight problem will be incorporated in the primary American metric practice guide that is now being developed.

Thus the coordinator of Metric Activities of our National Bureau of Standards acknowleges that the decision of a committee of a private organization has determined that the treatment of mass and weight in the US will be different from that recommended by international agreements to which the US is a party. The paragraph referred to by Barbrow from a private group is quoted as Appendix 3 of the latest version of the Bureau's own internal guide for metric use.[9] In another recent NBS publication[10] we find

> "the current trend is to discontinue using the term weight in the context of force so that when the term weight is used, as in weights and measures, it is considered to be synonymous with mass."

▶ Writing in scientific journals, and speaking with the authority of our National Bureau of Standards, Bureau officials have advocated and defended this change from the SI.[11]

The extent of the confusion is suggested when one notes that there may be as many as 30 metric style guides available in the US. They are published by individuals and by organizations. Some follow the SI while others follow the recommendations of the Bureau of Standards. It may not be clear to the average reader of these handbooks which system the handbook author has followed. Thus the two systems will be perpetuated and as a result, students for generations to come will ask, "Is the kilogram a unit of mass or a unit of 'weight'?" This confusion follows directly from the Bureau's departure from the international agreements, and hence it is tragically unnecessary. The Bureau's persistent refusal to follow the international definitions of the terms "mass" and "weight" was the sole cause of the AAPT's resolution of *censure*.

The Bureau has responded in several ways. Responding for President Carter and Secretary Kreps, Ernest Ambler wrote to the effect that if AAPT does not agree with the Bureau it is because we don't understand the problem. *We do understand the problem* because we spend a great deal of time in the classrooms and laboratories trying to clarify students' understanding of the terms "mass" and "weight." *It is precisely our understanding of the problem that led to the motion of censure.*

An interesting and representive response was a letter to the editor of the *American Journal of Physics* by Hugh C. Wolfe,[12] who chose to indentify himself as being with the American Institute of Physics. Wolfe says that the AAPT Council's motion of censure:

> incorrectly states that NBS and the Department of Commerce have determined that the metric system to be used in the US shall differ significantly from the internationally approved and recommended SI.

Wolfe then goes on to support the changes the Bureau has made, basing his support on his 54 years of experience. He closes with the recommendation "that gravity force might be a better name than 'weight' for technical use in physics." Then, to be consistent, Wolfe would have to suggest that the

term "weightlessness," which is widely understood by the public, be replaced by the term, "gravity forcelessness." Wolfe indicates that he is a member of the "Metric Practice Committee of the American National Metric Council" where we can imagine that Committee members assume that he is the representative of the physics community in America.

Let us compare Hugh Wolfe's assertion (that AAPT is incorrect) with the facts. To do this we turn to the authoritative document.[4] On page 3 we find the definition of the unit of mass, which is followed by this statement:

> The 3d CGPM (1901), in a declaration intended to end the ambiguity which existed as to the meaning of the word "weight" in popular usage, confirmed that *the kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram* (see the complete declaration, p. 16). [Emphasis is in the original.]

On page 16 we find

> Considering the necessity to put an end to the ambiguity which in current practice still subsists on the meaning of the word *weight*, used sometimes for *mass*, sometimes for *mechanical force*.
>
> THE CONFERENCE DECLARES: . . .
>
> 2) The word *weight* denotes a quantity of the same nature as a *force*; the weight of a body is the product of its mass and the acceleration due to gravity; . . . " [Emphasis is in the original.]

Contrary to what Wolfe says, these quotations make it clear that the Bureau's metric system for the US is not the SI. The Bureau even acknowledges that it has made changes. On the cover of LC1078[3] we find

> This NBS Letter Circular reproduces the Federal Register Notice that interprets and modifies the International System of Units (SI), the Modernized Metric System for the United States. [emphasis added.]

Ambler has noted[13] that the Bureau has received support "with respect to our basic position" and notes that

> upon occasion, this support manifests itself by an open communication. I would like to refer you to one such letter written by Dr. Hugh C. Wolfe of the American Institute of Physics.

Because he indentified himself as being with the American Institute of Physics, Wolfe's letter is being cited by the Bureau as the expression of the physics community while the Bureau ignores the official request of the AAPT.

Just before the AAPT Council passed its motion of censure, a representative of the Director of the Bureau met with the Executive Board of AAPT. We asked him, in effect, "can't the National Bureau of Standards simply issue a correction to bring US practice into agreement with the international recommendations?" His reply said, in effect, that the National Bureau of Standards does not set standards! A high-school teacher on our Executive Board raised her voice in obvious anguish, "But I have told my students for years that the National Bureau of Standards does set standards, and now you tell us that you don't."

What has been the international reaction to this? Before the AAPT motion of censure, J. Terrien, Directeur Honoraire of the Bureau International des Poids et Mesures in Sèvres, France wrote (28 August 1978)

> I am in full sympathy with your letter dated August 11, 1978 concerning weight; it is a matter of concern for me and for many others. In the preceeding years, I have had correspondence with Louis Barbrow and Ch. H. Page of the NBS, who stated that the popular use of weight as synonym of mass must be acknowledged, or even endorsed, by the physicist. But my plea has been unsuccessful.

Copies of the AAPT's motion of censure of NBS were sent to Paris. They brought this response from a prominent international figure, whom we don't identify because he says that he has to meet with and work with our NBS people when they come to the conferences in Paris:

> I was very happy to receive your letter of February 19, 1979 and to see a copy of the resolution formally adopted by your association. I completely endorse it. The matter you raise is an important one and must be settled: it is unfortunate to encourage the confusion between mass and weight at the present time when the universal adoption of the SI and the reports on space travel (also the efforts of teachers!) were beginning to clarify their distinction in the minds of many people. NBS publications are also a working tool outside the United States so that your action will be, hopefully, beneficial internationally.

The AAPT is not alone in this effort to have mass and weight treated in the US in accord with the international agreements. The National Society of Professional Engineers (NSPE) and the American Society for Engineering Education (ASEE) have taken strong stands in support of the correct use of the terms "mass and "weight." As Chairman of the Metrication Coordinating Committee of the ASEE, Eugene A. Mechtly wrote (16 July 1979)

> In contradiction of these facts, other official NBS publications tell us that

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the kilogram is a unit of weight, in direct violation of the international treaty definitions.

Although the Bureau practices and defends "consensus standarization" we should note that the real effect of "concensus standardization" is the loss of accountability. Bureau people serve on these private committees and when one asks the private groups why they made this mass–weight change they reply that it was because the Bureau wanted it. When one asks the people of our Bureau why this was done, they say it was because these private groups wanted it.

Physicists with whom we have talked about this have usually been unaware of this and have expressed genuine distress when they were informed of what the Bureau has done.

In his initial response to the AAPT's motion of censure Ambler offered to talk. We had talked with Bureau people for five years before the motion to censure, and we have talked for the one year since. Almost a year after the motion of censure, we find the kilogram used as a unit of weight in official publications of the Bureau.[9] Since no real progress could be reported in the first year following the censure, the Council of AAPT (21 January 1980) voted to renew the censure and directed the AAPT Committee on Mertrication to renew its efforts to get the Bureau to follow the international definitions.

It is clear that great damage has been done. We wish to present to the physics community the following recommendations with regard to the US National Bureau of Standards. We must use public and private channels to try to influence the Bureau to

- Accept the clear and widely understood 1901 definitions of mass and weight for use in the US.
- Join with the physics and engineering education communities in a massive effort to undo the widespread educational damage to metrication and to metric education in America that has resulted from the Bureau's actions.
- Make the necessary changes in the Bureau's policy of "concensus standardization" so that it is replaced by an orderly procedure of arriving at standards and definitions, *with full accountability*.

We feel that it is clear that our Bureau of Standards has made a grievous error. We hope that with the support of the physics community the Bureau will take the necessary bold initiative to correct this error so that the Bureau and the physics and engineering communities can work together to put metrication in the US on the sound scientific basis that is represented by the international documents and agreements.

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References

1. AAPT Announcer **9**, March 1979, page 23
2. American Society for Testing and Materials, (ASTM); American National Standards Institute (ANSI); American National Metric Council (ANMC) and its Metric Practice Committee, and Institute of Electrical and Electronics Engineers (IEEE).
3. See for example NBS publication LC 1078. (November 1977.)
4. NBS Special Publication 330. The current edition in early 1980 is the 1977 edition.
5. National Bureau of Standards Letter Circular 1052, February 1974.
6. National Bureau of Standards Letter Circular 1035, January 1960, amended January 1976, page 9.
7. "What About Metric:" by Louis E. Barbrow, "Coordinator of Metric Activities" of the Institute For Applied Technology of the National Bureau of Standards.
8. Guidelines for Writers of SI Metric Standards and other Documents, American National Metric Council, 1975; page 17.
9. "Guidelines for the Use of the Modernized Metric System" (author not identified) *NBS Dimensions*, December 1979, pages 13–19.
10. NBS Handbook 44, 1–30 (1979).
11. L. E. Barbrow, "SI—What is it—Does Weight Fit?]] AAPT Announcer **4**, May 1974 page 24, Paper E1.
12. H. C. Wolfe, Am J. Phys. **47**, 547 (1979).
13. E. Ambler to Eugene A. Mechtly, 16 August 1979.

Note added in proof The people who have worked with the Bureau to make these objectional changes are continuing their pressure. In a letter dated 14 April 1980, Bruce Barrow, chairman of the IEEE Metric Practice Committee proposed to the Bureau:

> Delete the 1901 mass and weight declaration from NBS 330 (the middle portion of pg. 16) in its entirety. This does *not* require that the CCPM abrogate its 1901 resolution (or declaration). It simply requires that the NBS Translator (presumably in consort with the Canadian and U. K. authorities, at least) determine that the English words *mass* and *weight* are not one-for-one synonyms for the French words *masse* and *poids*, and that the 1901 resolution is not sufficiently important to SI practice to be included in the English edition."

The international documents are the basis for SI. The 1901 statements in those documents are the clear and definitive statements of mass (*m*) and weight (*mg*). The Bureau is being asked to suppress this information.

6/16/80 *A. A. B.*

COMMENT BY HUGH C. WOLFE: I carefully refrained from identifying myself as being with the American Institute of Physics in my letter to the editor of the *American Journal of Physics* because I did not want to give the impression that my views were those of AIP, which has taken no position on this matter. That identification was added by the editor, and I did not see a proof before publication.

It is unfortunate that Bartlett and the AAPT Committee continue to assert that NBS has deviated from Le Systeme International d'Unites, which is designated as SI. There is no existing deviation. In particular, the NBS is always most explicit about the correct use of the newton as the unit of force and the kilogram as the unit of mass. The AAPT's objection is rather to a matter of terminology that is not a part of SI, which is a system of units, to wit the question of whether the word "weight" shall be used to mean a force or a mass. The AAPT is following a resolution of the General Conference of Weights and Measures (1901), which declared that the word "weight" shall mean a force equal to *mg*, whereas NBS has recognized that for most Americans the word "weight" is generally used as a synonym for the less familiar technical word "mass." One may remark that "weights and measures," as used in the name of the General Conference and of our state and national bureaus, refers to the standard masses which are called "weights" and other measurement standards.

It is amusing to consider Bartlett's reference to "the well understood term weightlessness." This term is commonly applied to a body that has the "weight" (in his terminology) *mg* and which is in free fall with the acceleration *g* under the influence of this gravity force. We often think of measuring the gravity force in terms of the opposing force required to prevent free fall and, of course, no such opposing force is present when the body is falling with the acceleration *g*. How many people understand this when they use the term "weightless"?

HUGH C. WOLFE
Metric Practice Adisory Group of the
American National Metric Council
5/12/80 *Washington D.C.*

COMMENT FROM NBS: Albert Bartlett's letter represents part of his presentation at the Metric Symposium at the APS/AAPT Annual Meeting in Chicago (23 January 1980). I was the first speaker and presented a paper entitled; "SI: Prognosis for the Future."[1] Bartlett's talk, "Educational Problems and Progress in Metrication," was to a significant extent concerned with NBS's position concerning the use of the term "weight." I responded orally at the Symposium to Bartlett and in fact have been in communication with him and other members of the scientific and technical community in an effort to present the distinction between NBS's statutory role with regard to the SI system and its advisory role in the area of metric conversion. Failure to acknowledge this distinction is at the heart of the disagreement between the American Association of Physics Teachers, as represented by Bartlett, and the NBS.

The International System of Units (SI), the modernized form of the metric system approved by the General Conference on Weights and Measures (CGPM), of which the US is a member, is the same in the US as in the rest of the world. The Metric Conversion Act of 1975 (Public Law 94-168), whose primary purpose was to establish a US Metric Board to "coordinate the voluntary conversion to the Metric system," did indeed define the "metric system of measurements" to be the International System of Units as established by the General Conference on Weights and Measures in 1960 and interpreted or modified for the United States by the Secretary of Commerce. Periodically, the Department of Commerce publishes a revised Federal Register Notice taking into account changes in SI approved by CGPM. The last such notice appeared 26 October 1977.[2] It summarizes the official French language publication, "Le Système International d'Unités (SI)."[3] An English translation is available.[4] The only difference in units between the French and English documents is the status of the hectare (10 000 m^2), which is commonly used in the US and, therefore, appears in a table entitled, "Units in Use with the International System," rather than in a table "Units in Use for a Limited Time." This distinction hardly warrants the charge contained in the first paragraph of Bartlett's letter.

The second paragraph contains the essence of the misunderstanding. SI is a system of *units* and not *quantities*. SI states very explicitly that the unit of mass is the kilogram and the unit of force is the newton. The controversy is concerned with the proper use of the word "weight." This has clearly bothered scientists for a long time and resulted in a 1901 CGPM declaration:

"Taking into account the decision of the CIPM of the 15 October 1887, according to which the kilogram has been defined as a unit of mass;

"Taking into account the decision contained in the sanction of the prototypes of the Metric System, unanimously accepted by the CGPM on the 26 September 1889;

"Considering the necessity to put an end to the ambiguity which in current practice still subsists on the meaning of the word *weight*, used sometimes for mass, sometimes for *mechanical force*:

The Conference declares:

1 The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram;

2 The word weight denotes a quantity of the same nature as a *force*; the weight of a body is the product of its mass and the acceleration due to gravity; in particular, the standard weight of a body is the product of its mass and the standard acceleration due to gravity."[5]

This declaration makes two important statements; it defines the kilogram as the unit of mass, and it defines one meaning of weight. This declaration discourages the use of the unit kilogram as a unit of force—a proposition that has met with reasonable success. It could not define "weight" as having *only* the meaning specified. Usage alone does that. The Webster's 3rd New International Dictionary (page 2593) lists more than a column's worth of definitions of "weight" and "weigh." This multiple use of the word "weight" is not a problem unique to the US but is well-nigh universal in the Western countries, including those that have been on the metric system far longer than we. It is not correct to state that there is "an international definition of mass and weight" if this statement is taken to mean that there is only one definition acceptable in the English language, and any action based on this conclusion such as the censure of NBS by the Council of AAPT is based on a false premise.

The use of the unit "pound" as a unit of both mass and force does indeed cause confusion, and proper SI usage eliminates that problem. The ambiguity in the meaning of weight causes fewer problems, which can be reduced by recommending, for example, that the term "weight" not be used for technical audiences. This was the essence of a recent West German proposal to the Consultative Committee for Units (one of the international technical advisory committees reporting to the Comité International des Poids et Mesures). Another, which is clearly favored by the AAPT, is to agree to restrict the use of "weight" to mean the force due to gravity ($W = mg$). For this proposal to be successful, however, requires the agreement of the English-speaking peoples, generally, an agreement which is not likely to be reached in the foreseeable future. Furthermore, attempts to reach such agreement are outside the responsibilities of NBS.

Bartlett should add to his two possible solutions an alternative that corresponds to the real-life situation: The word "weight" sometimes means mass and sometimes force. Depending upon its meaning, the correct SI unit is the kilogram or the newton.

A statement that his first solution was adopted by international bodies is based upon an incorrect understanding of the jurisdiction of the Treaty Organization involved. An appropriate statement would be: "The International bodies that operate by treaty and agreement to establish an international system of units have come to an agreement that the kilogram is the unit of mass and the newton is the unit of force," and further, "It is recommended that for scientific purposes, the word 'weight' be restricted to mean a quantity of the nature of a force."

The enumerated items listed next in the article demonstrate a confusion between metric practice and the metric system of units. The latter is the prime responsibility of the General Conference on Weights and Measures and in the US, through delegation, of the NBS. On the other hand, metric practice and the use of the metric system is by tradition a result of the consensus standards process more characteristic of engineering and professional societies than of scientific or research societies. Through the consensus process, which takes into account comments of all interested parties, a standard is developed that describes an accepted set of definitions, requirements, test methods, or performance characteristics. A related procedure exists on the international level. For example, the International Organization for Standardization Technical Committee 12, (ISO/TC12), Quantities, Units, Symbols, Conversion Factors and Conversion Tables, developed ISO Standard 31, which contains accepted definitions for the quantities of physics and chemistry. The term "weight" is defined in ISO 31/III-1978(E) as a force, with the unit newton. A remark states that "in common parlance, the word weight is often used to mean mass." The word "weight" does not appear in the Standard ISO 1000 (1973), whose title is "SI units and recommendations for the use of their multiples and of certain other units." The meaning of the word "weight" is a problem also at the international level, and methods of handling the problem are analogous to those recommended for use in the US by NBS.

Furthermore, neither the resulting "consensus standardization" nor NBS recommends "that in the US 'weight' ... should mean mass" as Bartlett alleges. Rather NBS recognizes that in common speech "weight" often (some reputable scientists and engineers would say invariably) does mean "mass" and that it is important to recognize that fact in recommending procedures for the use of SI. Bartlett's observation that NBS has prepared a footnote to the Federal Register Notice which states " 'weight' is the commonly used term for 'mass' " is a recognition of usage which we have included for the benefit of the reader. It is consistent with international practice.

He cites a footnote in the NBS-produced English-language version of the SI booklet on the use of the term "weight" as a basis for the charge that NBS recommends a US version of the metric system different from SI. The use of quantities is advisory within the scope of SI. International agreement in the use of "weight" does not exist. To illustrate, the official West German representative to the Consultative Committee for Units, at its meeting in Sevres, on 28–30 May 1980, introduced a resolution that states, "Recognizing that ambiguity exists in current practice in the meaning of the word 'weight,' used sometimes for mass, sometimes for force of gravity, the CGPM recommends (a) that the word 'weight' not be used in scientific terminology, and (b) that the words 'mass' and 'force of gravity' (or 'weight/force') be used for these quantities." After much discussion, the resolution was tabled, but it demonstrates that this problem and possible solutions are not unique to this side of the Atlantic.

A reference to the American National Standard Z210.1 is given in the footnote in the NBS document. It might have been desirable to include in explanation that the wording, endorsed by the NBS editors, came from Z210.1. The next edition, now being prepared, will include a statement of that nature to elucidate the distinction between NBS's responsibility for SI and its citing the American National Standard for recommendations of metric practice.

Bartlett confuses the issue by glossing over the distinction between NBS's authoritative role dealing with the physical standards of measurement and its advisory role (together with many other organizations) in the preparation of engineering standards.

To cite another example; British Standard PD 5686: 1978, "The Use of SI Units" states:

"Units of weight. There is no explicit SI unit of 'weight' but the word is in very common use; ambiguity as to its meaning has long been a source of confusion. 'Weight' is used in the sense of mass in the Weights and Measures Acts of 1963 and 1976 and in common parlance. *When used with this meaning the SI unit is the kilogram.* Strictly with this meaning, the 'weight' of a body is equal to its apparent mass.

"In the past, 'weight' has also been used with a particular scientific meaning, that of gravitational or downward force, the 'weight' of a body being the product of its mass and the acceleration of free fall at the location of the body on the earth's surface. *When used with this meaning the SI unit is the newton.*"

Certain documents such as Bartlett's references 5, 6 and 7, which were directed primarily to the general public, might be construed as not recognizing the dual nature of the meaning of "weight." NBS intends that any republication of these documents shall contain more precise statements concerning mass and weight.

Bartlett refers to Handbook 44, and official publication of the National Conference on Weights and Measures, which describes the NCWM recommended use of the term "weight." This is a usage jointly arrived at by the State officials responsible for weights and measures administration in fifty States. It is reviewed for technical accuracy by NBS scientists. The recommendation appearing on page 1-24 of Handbook 44 might be clearer if worded slightly differently, for example: "When the term weight is used for the purposes of weights and measures, as described in this handbook, it is considered synonymous with mass." Can anyone who has ever purchased packaged goods (net weight = 453 g) question that proposition?

Bartlett's reference 11 is a talk presented by Louis Barbrow of NBS to the AAPT in 1974. A footnote states that the position advocated by Barbrow was his own and not that of NBS, contrary to the statement in the manuscript.

NBS is convinced that the cause of the AAPI's resolution of censure was a misunderstanding by the AAPT Board concerning the International System of Units and the role NBS plays in participating in the definition of SI. NBS has always and unequivocably stated that the SI unit for the quantity "mass" is the kilogram. The handling of the term "weight" has *not* been settled by international agreement, contrary to Bartlett's statement; this is evidenced by the different attempts to handle the question both internationally and at the national level. Textbook authors have a responsibility for representing the situation accurately, much as NBS has attempted to do. To digress on this subject, the answer to Bartlett's question, "Is the kilogram a unit of mass or a unit of weight?", is simple. The kilogram is the SI unit of mass. In common parlance, the term weight is often used to mean mass. Under those circumstances, the kilogram is used as the unit of weight.

With respect to LC 1078, I have already discussed the minor change with regard to the "hectare" between this circular and the official SI booklet. The fact that the Metric Conversion Act of 1975 authorizes the Secretary of Commerce to interpret and modify SI for use in the US does not mean that modifications, however small, would be made without consultation with the affected sectors of society. This has happened in the case of the hectare. The statement on the cover page is a paraphrase of the Metric Conversion Act. Major modifications in SI have not been made for US use.

Bartlett has cited two individuals from foreign countries, (one unnamed). One has given his personal opinion concerning actions of individual staff members of NBS and the other endorsed the AAPT resolution. In my discussion above, I have quoted from the official West German proposal, which recognizes the continuing ambiguity in the use of the term "weight" and proposes a resolution for handling this problem. Thus, there are indeed views other than those quoted by Bartlett about the term "weight."

His letter refers to organizations whose positions on the use of weight and mass are in accord with that of the AAPT. However, other professional organizations of significant size of membership have positions on the use of weight rather different from those of the AAPT. These include the American Society of Mechanical Engineering and the Institute of Electrical and Electronics Engineers. The National Council of Teachers of Mathematics through its annual sponsorship of National Metric Week and its interaction with students in their formative years is no doubt as influential as any in getting succeeding generations of students to "think metric." In an official publication of NCTM "GOING METRIC: Guidelines for the Mathematics Teacher"[6] the ambiguity of the meaning of weight is recognized with the conclusion that for the purposes of that book, "the use of the term *weight* will be synonymous with *mass*. If the *force of gravity* is implied, it will be so stated and the term *weight* will not be used in this way."

At the request of the NBS Director, the AAPT Metrication Committee and other interested organizations have been asked to comment on official NBS documents describing the metric system and metric practice. Bartlett's

reference 9, "NBS Guidelines for Use of the Modernized Metric System," is one such document. A revised appendix to this document has been distributed for comment. Despite what NBS or anyone else might say, the dual use of the term "weight" will probably persist in everyday life. Therefore, when the term is used under ordinary circumstances, it is important to differentiate between mass and force, and to use SI units properly for the quantity intended.

In response to the specific recommendations of the letter:

▶ NBS certainly accepts the 1901 CGPM declaration of the description of weight as a quantity of the same nature as force. We also recognize there are other definitions and that one cannot ignore these in dealing with the public.

▶ I do not see that widespread educational damage has occurred to metrication or to metric education. Whatever uncertainty might have been engendered by misinterpreting the 1901 CGPM resolution can easily be remedied by reference to the American National Metric Council Handbook on Metric Education,[7] which is based on the American National Standard for Metric Practice.

▶ The Bureau does publish a handbook on the SI, SP330,[4] which is a translation of the official French document. Metrication or metric practice is a subject for the voluntary standardization process, both here and internationally, and the American National Standard Z210.1 provides a handbook on metric usage. It is reviewed by NBS for technical accuracy and consistency with the official SI booklet.

In summary:

▶ There is a basic disagreement concerning the status of the quantity weight. The NBS point of view is that definitions of quantities are not part of SI. The AAPT, as expressed in the letter, feels the opposite.

▶ NBS plays a definitive role in interpreting SI for the US. Procedures for the use of SI, or metric practice, are primarily carried out through the voluntary standardization process. AAPT seems to feel that an authoritative procedure is required for the latter. We disagree on both practical and legal grounds.

▶ NBS gives guidance on recommended practice dealing with the use of SI units. It suggests that care be taken to be responsive to the audience addressed. AAPT believes the national standards laboratory must be definitive in its guidance in spite of obvious ambiguity in practice. NBS believes it has an obligation to recognize what is actually being practiced as well as to lead the technical community.

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▶ In some official publications intended primarily for the general public, clarification of the meaning of the word "weight" would have been desirable. We agree and have taken steps to bring this about.

▶ AAPT has requested that a clear communication path be established with NBS to provide input on matters dealing with metric practice. Such a channel has been set up.

▶ AAPT feels that the past NBS actions have done widespread educational damage to metrication and metric education in the US. We, and other professional societies, find such a charge to be without substance. We are however, very concerned with the comfort given to professional gainsayers on the value of introducing metric practice when poorly substantiated statements emanate from an important segment of the scientific community.

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6. W. W. Leffin, "Going Metric; Guidelines for the Mathematics Teacher, Grades K-8," #66, National Council of Teachers of Mathematics, (Reston) (1975).
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Long life for the oblate

F. P. Boynton's comment (September, page 98) on L. S. Finegold's discussion (June, page 78) of J. S. Garrow's longevity parameter, W/H^2, only scratches the surface of strategies towards long life. W/H^2 (kg/m^2) can be analyzed microscopically in the spheroidal model of human physiognomy. From the volume of a spheroid, $V = (4/3)\pi a^2 b$, assuming a density of water, it is trivial to show that for prolate people of girth G, $G^2/H < 0.5$ is required for greater longevity. This suggests that conventional decrease of the girth and increased length (Boynton's option) are required in the proper proportion to extend one's life span. Alternatively, for the oblate solution, H drops out of the equation. In this case, $W/H^2 = 170$ G and $G < 0.15$ m should improve longevity. Thus, a new strategy, previously ignored by medical science, should be investigated by all physicists seeking the fountain of youth.

Note added in proof: Early in fetal development, the unborn child most nearly resembles the oblate spheroidal condition. Such individuals have long been known to have greater life expectancies than physicists.

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Risks from solar energy

The September guest comment "Future energy alternatives in perspective" by Harvey Brooks (page 9) was an excellent addition to PHYSICS TODAY. He brought out many valid points that would be beneficial to the general public. I would like to comment on the health risks of solar energy mentioned in his discussion concerning uncertainty and risk. As a strong advocate of solar energy I am concerned with the consensus that solar energy can somehow solve a portion of the energy-supply problem without any harmful side effects. The numerous materials used in the construction of solar energy systems can, and under certain conditions do, exhibit thermal decomposition, mechanical breakdown resulting in particulate emission and outgassing. Unfortunately, the question as to whether or not toxic substances or gases are generated has not been studied in detail.

It is my recommendation that a research program to study these phenomena be initiated. The objectives of a possible research program would be to determine whether such products are present in the fluid medium, identify them, and then determine their concentration within the system. From previous research in environmental toxicology the toxicity of these products could be ascertained. The confirmation that toxic products are generated would indicate that system-design modifications should be completed prior to the extensive implementation of solar technology.

It would be disastrous to discover at a future date that toxic products were generated by such systems and we failed to identify these products and reduce their environmental effects.

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