COMMENTS
by Readers

Because I believe the President, the Congress, and most scientists are in agreement on the essentials of national science legislation and administration, I venture to suggest that differences relating to the setup of the proposed Foundation and the details of its administration and operation should be settled promptly so that we may get on with the business of producing scientists and fostering research on a civilian basis. The points on which we seem to be in agreement are the following:

Freedom of research and education. It is accepted by most scientists that it would be a mistake to establish a foundation which would attempt or be tempted to select and supervise the particular projects on which scientists shall work. It is agreed generally that, given reasonable provision for accounting for the use of public funds, the institutions and the individuals within institutions selected to carry on research should be granted freedom of choice and action. This is not to say there should be no "request" research, but the emphasis should be on "free" research. The same applies to individuals granted scholarships or fellowships: once it is decided by competent authorities that they have capacity for scientific education or advanced research such as to warrant support, scholars and fellows should be free to pursue their interests in institutions and in directions of their own selection.

Civilian administration. The Army and Navy have been in a position since the war to command support for research not immediately related to military requirements, and have had the guidance of scientists tried and qualified by wartime and other experience. This effort will go forward under the new military setup with Dr. Bush as chairman of the coordinating board for the three Services. Despite the temptation, in view of the controversy over the National Science Bill, to acquiesce in continuation of an arrangement of proved efficiency, I believe none of us is yet willing to default in favor of permanent military administration. Granting the need for military research on weapons and materials, and the necessity for cooperation between military and civilian authorities, it seems to be conceded that civilian rather than military administration of most of the basic research is desirable.

Emphasis on fundamental research in universities and colleges. This proposition does not require argument in *Science.* The point that should be mentioned is that "universities and colleges" does not mean merely the big universities and colleges, nor does it mean institutions located in certain sections of the East, Middle West, and West. I have never met a scientist serving as head of a university or institution, or engaged in research or teaching, who did not say that the hothouse methods employed during the war should be greatly modified, if not abandoned, in the interest of making it possible, as soon as possible, for any college or institution, and for any individual anywhere in the country, to qualify for support. Most of the scientists I know would gladly risk a waste of funds rather than sacrifice the opportunity to build up scientific research and education throughout the country. They know that research capacity and scientific aptitude are not localized phenomena. What they oppose is provision for mandatory, arbitrary distribution of funds without reasonable reference to scientific or educational standards.

Emphasis on training personnel. This point is mentioned only to show it has not been overlooked. For several years the principal object must be to produce scientists and, particularly, teachers of science.

Utilization of both laymen and scientists in the program. There is some misunderstanding about this. It has been assumed by many that the National Science Board, under S. 526 or S. 1850 (the rival legislation), would consist only of scientists, and that the persons appointed would be heads of institutions or departments or other "big-name" men. There is no basis for these assumptions. The bills that have been seriously considered provide for the appointment of qualified laymen as well as scientists on the basis, without reference to politics, of capacity to serve and promote the interests of the Foundation. That qualified laymen should be attracted to this service is not denied, except perhaps by those few who believe that laymen having private interests are incapable of giving disinterested and effective service to a public agency.

Agreeing that it is quality of administration we are looking for, it is generally accepted that we should not insist on filling the board only with those who are able and willing to become full-time officials. Room should be left, and is left in the bills under consideration, for the appointment of present employees of the Government and for recruiting laymen as well as scientists outside the Government.

We cannot dodge the fact that there have been conflicts among us over certain features of the legislation. It is on these points that reasonable concessions should be made:

Appointment and responsibility of the director. It may be that in this respect the bill rejected by the President violates "basic principles which make for responsible government"—but I doubt it. The highly successful National Advisory Committee for Aeronautics is an agency similar in essential respects to the Foundation proposed in the rejected bill. (In the case of NACA there would be more reason for application of the "in-line" principle: NACA is an operating agency, whereas the proposed Science Foundation is precluded from conducting laboratories or pilot plants.) Likewise in the states there are departures from the principle. In New York, for example, the Commissioner of Education is appointed by, and is responsible to, the Board of Regents; I need but mention two recent incumbents—President Stoddard, of the University of Illinois, and his successor, Commissioner Spaulding—to demonstrate that successful administration is not dependent on a theory of organization.

The object is to establish a Foundation which will be vital and imaginative and liberal, not merely efficient in a bureaucratic sense. Nevertheless, those of us who were satisfied with S. 526 should be the first, perhaps, to offer a concession in view of the strong and authoritative view the other way. None of us wants to dilute

or disparage the powers and responsibilities of the President; what is really desired is that the scientists represented on the board shall have a voice in the choice of the principal executive officer of the Foundation. An amendment which would give the President the power to appoint the director after receiving nominations from the board, and which would give him the power to remove the director, would substantially meet the objection to this feature of S. 526.

Status of the board. It has been said that the board described in S. 526 would consist "essentially of private citizens" who would meet only occasionally, and it is suggested that their service would be casual and perfunctory. There is no basis for this view. All of our experience demonstrates that if strong appointments are made, the members will be conscientious to the point of sacrifice—as much so, at least, as the members of any full-time commission now serving in Washington. One of the principal reasons for specifying a part-time board was to obviate the drag which, after the formative period, affects full-time commissions; to save as much as possible of the amateur spirit in the direction of the Foundation; and to attract men and women, scientists and laymen, who might be unable to devote full time to Foundation service. It is hoped the critics of S. 526 will make a concession on this point.

It has been too little stressed, I think, that in making this provision for Federal grants to institutions and individuals we shall be better satisfied if ultimate responsibility is placed on the shoulders of a selected group of our fellow citizens rather than in the hands of a full-time official. Without reflecting unfavorably on the present administration of taxpayers' money for scientific research and education, it should be borne in mind that we are proposing a vast extension of Federal assistance which, I submit, should be subject to direction and check beyond that required for the ordinary business of Government. Related to this is the belief held by many that, to minimize if not avoid political interference and criticism, the President and the Director of the Foundation should be protected against pressure for grants; an authoritative board appointed by the President should be responsible for policies and grants.

Other details. Though the President is critical of other features of S. 526, the Congress and the scientists do not seem to be involved in any serious disagreement. The provision for the interdepartmental committee should be amended to place the direction of its activities directly under the President's authority. The provisions for special commissions (except perhaps the provision for a commission on cancer research, which might serve a useful purpose in establishing a clearing and coordinating agency) seem unnecessary and should be eliminated. (BETHUEL M. WEBSTER, *15 Broad Street, New York City.*)

Work done in compression, $pdv = dW$, say, has as its counterpart a change in potential, $vdp = dW_0$; similarly for a change in thermal energy, $dQ = TdS$, and its counterpart, $SdT = dQ_0$. It is proposed to regard this dQ_0 as potential thermal energy analogous to work potential vdp and so clarify and simplify the thermodynamics of deformation.

In a previous paper (*Science*, October 4, 1946, p. 317) it was shown that the Second Law in a very simple and useful form may be directly derived from the Gibbs thermodynamic potential, $U - TS + pv$, for any body in which that potential is uniform. When energy dU (either thermal or mechanical) is added or removed,

$$dU - TdS + pdv = 0 \quad (1)$$

by the First Law; hence

$$SdT = vdp, \quad (2)$$

the Second Law.

In other words, as the internal energy of a body is changed, whether by heat or by mechanical work, the thermal and mechanical potential energies change always by equal amounts. The "free" energies, TdS and pdv, are not equal in general, but $SdT = vdp$ ($dQ_0 = dW_0$) for every reversible process.

Free and potential energies are related through the physical properties of a body. For example, $pdv/vdp = p\beta$, where β is the compressibility defined by $dv = v\beta dp$. Similarly, $TdS/SdT = \alpha T$, where α is the thermal coefficient of expansion given by $dv = v\alpha dT$.

$$\frac{pdv}{vdp} \equiv \frac{d \log v}{d \log p} = \frac{dW}{dW_0} = \frac{dW}{dQ_0} = p\beta, \quad (3)$$

$$\frac{TdS}{SdT} \equiv \frac{d \log S}{d \log T} = \frac{dQ}{dQ_0} = \frac{dQ}{dW_0} = T\alpha, \quad (4)$$

$$\frac{Tdp}{pdT} = \frac{TdS}{SdT} = \frac{dQ}{dW} = \frac{T\alpha}{p\beta}. \quad (5)$$

These sets of fundamental relations permit many kinds of transformations between variables, but adiabatic coefficients must not be confused with isothermal.

In the writer's proposed general law of deformation (see *J. Franklin Inst.*, May 1921 and December 1946),

$$\frac{dy}{y} = n\frac{dt}{t} + m\frac{dp}{p} + r\frac{dT}{T}, \quad (6)$$

the parameters n, m, r are ratios of fractional increments similar to those in (3), (4), and (5) above. If y in (6) is volume, then $m = p\beta$ and $r = T\alpha$. Hence, by (6), m is simply the ratio of the increments of free and potential mechanical energy, dW/dW_0, and r is dQ/dQ_0. The creep factor involved in n of (6) is time t times a constant having the dimension reciprocal time.

The relations discussed above are, of course, exact only in the differential form given. Some of them hold in integral form over a surprisingly wide range, but in such cases the physical processes involved must remain constant. And in the differential form (6) there is no difficulty with fractional dimensions, since the parameters are simply dimensionless ratios of fractional increments, each of which is dimensionless.

Since the increments of thermal and work potential are always equal, whether due to added heat or work, it follows that the total potentials remain equal over very wide ranges.

In deriving his radiation formula, Planck found the probability of P packets of radiation, each of energy $h\nu$, being associated with N resonating particles having an average energy E_0, introducing the assumption $Ph\nu = N E_0$, or radiation density equals mechanical energy density. Fitting this assumption to the Second Law (2) involves some interesting physical relations.

For gases, $T\alpha$ and $p\beta$ are unity; hence, in a gas all four forms of energy are present in equal amounts. For most solids and liquids these products are very small, and correspondingly large potentials are to be dealt with. (P. G. NUTTING, *3216 Oliver Street, N.W., Washington, D. C.*)