one must change units of m from gravitational units to absolute units, using

$$W = mg_0 \quad (3)$$

Here, g_0 is a conversion factor and definitely a constant. (It is unfortunate that people associate g_0 with gravity.) One now has

$$d^2y/dt^2 = -g - (g_0\beta\rho/2)V(dy/dt) \quad (4)$$

In similar fashion, one gets

$$d^2x/dt^2 = -(g_0\beta\rho/2)V(dx/dt) \quad (5)$$

The remaining equations in Blum's paper are now easy to correct, as follows. Wherever g is multiplied by β, it should be the conversion factor g_0, and wherever g is divided by V^2, this is the gravitational acceleration $g(y)$. In addition to this, the statements under Blum's Eq. (26) should be modified, and his Eq. (45) should read

$$J(y) = g_0 \int_0^y \rho dy \quad (6)$$

which is easier to evaluate.

As mentioned earlier, these corrections do not invalidate the calculations made in the paper, nor is it this author's purpose to be supercritical of a fine paper. However, this failure to distinguish gravitational acceleration from the conversion factor relating mass in gravitational units to mass in absolute units is a common error and leads to much confusion. It is unfortunate that the word "pound" is allowed to serve the dual role of a force unit as well as a mass unit and that a hybrid system is used continually. It would be better if either the gravitational system of units were adopted consistently and the slug allowed to become a respectable mass unit for all technical work, or the absolute system of units were adopted with stature given to the poundal as a force unit.

Comment on "Use of Ballistic Pendulums With Pulsed Plasma Accelerators"

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IN a recent note,[1] the authors concluded on the basis of only probe and calorimetric measurements that the impulse delivered by a pulsed plasma accelerator could not be determined reliably by a ballistic pendulum. This result is not surprising, for, even based upon the most elementary mechanical considerations, the nature of the momentum transfer from a pulsed plasma accelerator to the pendulum at best can be estimated only within a factor of 2. Indeed, matters are generally worse in that pressure force terms, temporal momentum variations, and ablative contributions from the surface of the pendulum introduce further departures between indicated impulse and the actual impulse. An excellent discussion of thrust of intermittent propulsive devices is presented, for example, in Ref. 2.

The shortcomings in determining reliable, accurate impulse data of a pulsed plasma accelerator by means of a ballistic pendulum have been reported previously.[3,4] In Ref. 4, impulse measurements of a pulsed plasma accelerator as obtained directly on a thrust stand have been compared with the results obtained by using a carefully designed ballistic pendulum. The ballistic pendulum data indicated impulse levels five times larger than measured on a thrust stand that had the entire accelerator system mounted on it. The tendency to obtain a larger impulse with a ballistic pendulum than on a thrust stand apparently has been observed by other investigators also.

A recent conference[5] concerned with the exchange of information on thrust, mass, and power measurements of electric propulsion devices, and attended by those companies actively engaged in the field of electric propulsion, revealed that investigators in the electric propulsion field are using direct measuring thrust stands for performance analysis. None of the attendees reported the use of a ballistic pendulum.

Received by ARS October 25, 1962.

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Comment on "Stresses and Strains in Solid Propellants During Storage"

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AN analysis of the expected deformation in a perforated, horizontal grain of viscoelastic propellant attached to a rigid case has been reported recently by Lianis.[1] However, as noted by Lianis, the calculated displacements were suspiciously large, and long-time creep data were needed for a better evaluation of the expected deformation.

The results of long-time creep compliance tests conducted in this laboratory show, as Lianis suspected, that extrapolation of the relatively short-time compliance data reported by Blatz[2] is not valid but results in an inordinately large predicted displacement.

Creep data for two propellants with different binder systems are shown in Figs. 1 and 2. As the figures indicate, it is possible to fit the data at long times (>50 hr) with a constant creep rate function, but it is not possible to deduce this function from creep tests of only a few hours duration.

For purposes of comparison with Lianis' results, one calculates that for the propellant shown in Fig. 1, in a configuration wherein $R = 20$ cm and $\mu = 2$, the maximum surface radial displacement u is

$$u_{\max} = \{39.0 + [0.045(t)/\text{hr}]\} \times 10^{-3} \text{ cm}$$

Received by ARS October 8, 1962.

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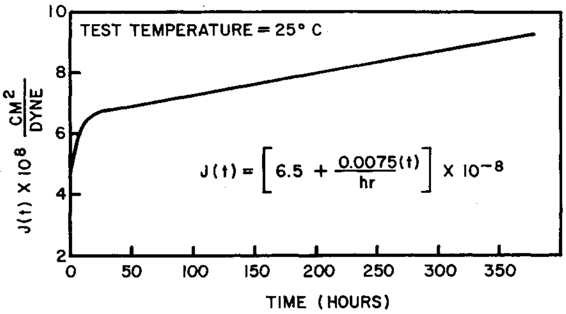

Fig. 1 Creep function of propellant *X*

The density was taken as 1.8 g/cm³, a realistic figure for the propellant shown. After a storage period of 22 days and 9 hr, the maximum radial displacement becomes 6.32×10^{-2} cm, as compared with 1 cm obtained by Lianis from extrapolation of Blatz's data. This result does not lead one to predict failure at relatively short storage times. It may, in fact, be shown that, based upon the data presented in Fig. 1, a storage period of 890 days would be required to obtain a maximum displacement of 1 cm.

It is interesting to note that, although the propellant represented in Fig. 2 is appreciably more compliant in the short-time region than that shown in Fig. 1, a calculation using the same geometric parameter and density, with the

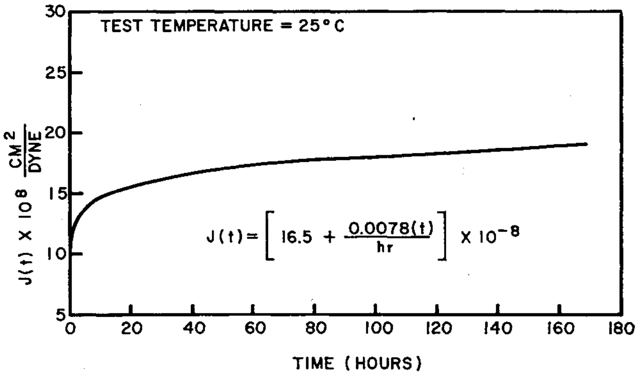

Fig. 2 Creep function of propellant *Y*

creep function

$$J(t) = \{16.5 + [0.0078(t)/\text{hr}\} \times 10^{-8} \text{ cm}^2/\text{dyne}$$

shows that 813 days would be required for a 1-cm displacement. Again, failure would not be expected at short storage times.

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See December 1962 ARS Journal, page 1845, for further details