TUNGSTEN PENDULUM BOB

This 22 lb. sphere is a pendulum bob designed for a millennium clock. The sphere is made of tungsten, which is one of the toughest materials known to exist. Barring a direct hit by a thermonuclear weapon, this artifact should last 10,000 years and then some.

Tungsten was chosen as a material for the bob not only because of its toughness, but also because of a number of other properties that make it desirable as pendulum bob. For one thing, it is one of the densest materials known, far denser than lead and even denser than uranium. This means that a large mass can be squeezed into a small space, which is important in a pendulum because the air drag of the swinging bob is a big part of the energy dissipated. The high density also helps minimize timing variations caused by changes in the barometric pressure. In addition, tungsten has high thermal conductivity, a low coefficient of thermal expansion, a low vapor pressure, and good corrosion resistance, all of which are desirable in a pendulum bob.

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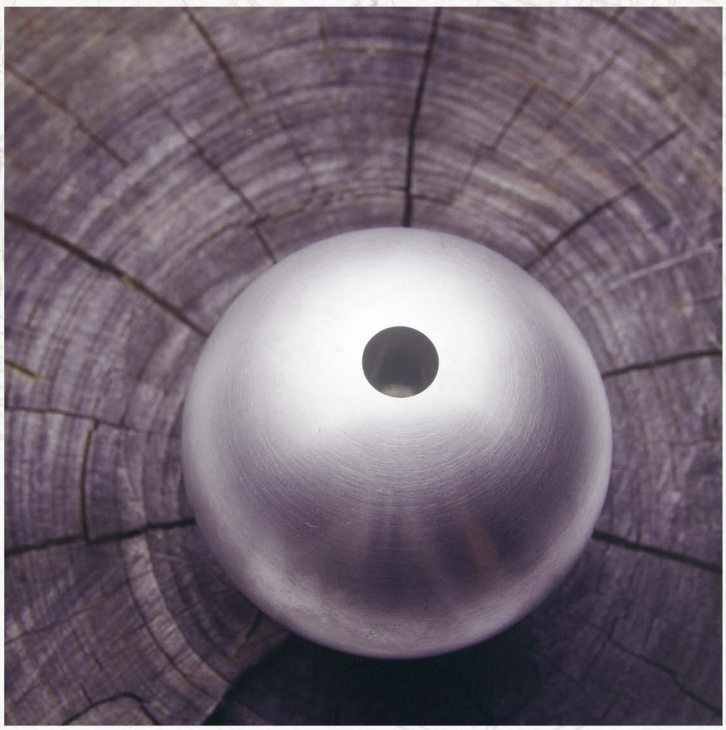
(Tungsten Pendulum Bob continued)

With all of this going for it, you may wonder why you don't see a lot of things made out of tungsten. Although tungsten is not cheap, the main reason it is not commonly used is that it is very difficult to machine or to mold into shape. Tungsten is so hard that it is often used to make tools that cut other metals. It has the highest melting point of any metal (about 3400 degrees C., or about twice that of titanium.) This is the reason it is used in the white-hot filaments of light bulbs. This sphere was cast initially in a custom-made mold by a process known as powder metallurgy. It was then slowly cut into shape with a tool made of tungsten carbide, which is slightly harder than pure tungsten. This takes a long time.

The reason that the shape is a sphere is to minimizes surface. Air drag is roughly proportional to surface area for slowly oscillating bodies. For a quickly moving body, like a car, the flow is turbulent, so it is important to minimize the frontal area and to "streamline" it to get an efficient pattern of vortex shedding. But the flow over a slowly moving body like a pendulum bob is laminar, so it is mostly surface area that matters. You can do slightly better than a sphere, but not much. The traditional lenticular or disk shape of old grandfather clocks has much more drag, a fact which was probably not understood by grandfather clock designers.

Another important aspect of the shape is the bump inside of the hole, on which the bob is intended to hang. This bump is not quite midway in the length of the hole. The placement of the bump is chosen very carefully to compensate for a very subtle thermal expansion effect in which the expansion of the bob causes the inertia of a pendulum to change without changing its length. The position of the bump eliminates this effect for a one-second pendulum (on one side) or a two-second pendulum (on the other). This means that a thoughtful archeologist, digging up this pendulum bob a few tens of millennia from now, should be able to infer that our basic time unit was a multiple of a second.



Care and maintenance of your pendulum bob mostly involves preventing people from dropping it on their toes. With normal handling the bob should gradually develop a brownish surface film of tungsten oxide, which will not interfere with its function. I recommend that you keep your bob away from extended contact with plasma torches, high power laser beams, diamond cutting wheels, and highly corrosive acids, as these may cause unsightly surface blemishes. With proper care, it should outlast your civilization.

--Danny Hillis