Sonic boon

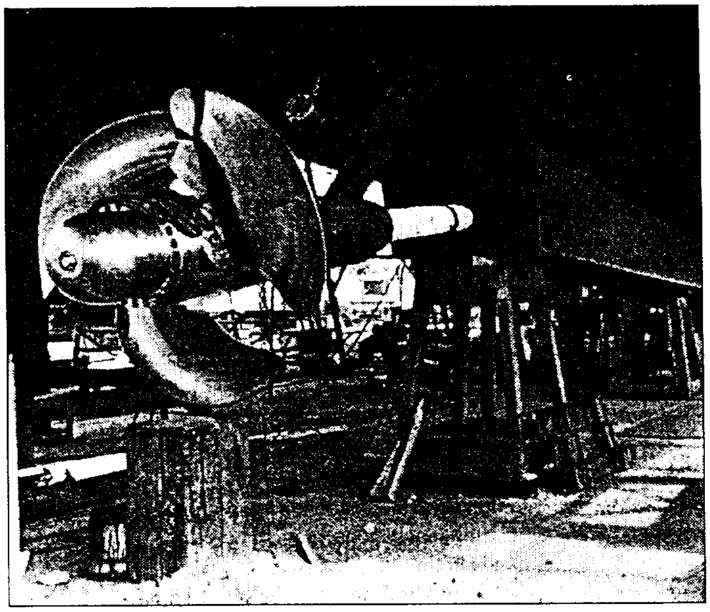
The Economist
OCTOBER 5TH–11TH 1991

WHEN sound travels through water, strange things can happen. The waves of pressure rapidly stretch and compress the liquid as they pass, alternately creating and destroying tiny bubbles of gas. And as anyone who has used a bicycle pump will have noticed, compressing a gas heats it up. Intense sound can carry this to extremes: the pressure in the bubbles may rise to several thousand atmospheres, and the temperature can reach 5,000°C—about as hot as the surface of the sun.

Acoustic cavitation—as the phenomenon is called—was first noticed by the British Admiralty. In 1895 the rulers of the Queen's navy were perturbed to find that the propellors of their latest destroyer, HMS Daring, were eroding away for no apparent reason. The explanation was provided by Lord Rayleigh, a physicist. He showed how the bubbles produced by Daring's powerful propellors could generate the extreme temperatures and pressures which were destroying them.

Lord Rayleigh's discovery, suitably toned down, is the basis of some useful technology. Ultrasonic scrubbing has been employed for some time for the relatively mundane task of cleaning things. Now more sophisticated uses are coming on stream. The sonic bubbles offer a simple way of doing chemistry at high temperatures and high pressures—sonochemistry.

One promising application of sonochemistry is for the making of organometallic complexes. Organic molecules—those with skeletons built of carbon atoms—can be made to react with metals like lithium and zinc to produce useful drugs. But at the sort of temperatures needed to promote these reactions, such metals are tricky to handle. However, if the metal is dispersed in a liquid containing the relevant organic molecules, the high-temperature reactions can be confined within the tiny bubbles.



Beware of boiling bubbles

Another medical application is the creation of microscopic protein spheres filled with air. These can be produced by beaming ultrasound through water which has had the protein dissolved in it. Microspheres seem to pass through the bloodstream without risk and they can be used to improve the quality of images taken with ultrasonic scanners. Molecular Biosystems, a Californian company, is seeking approval for this application of the microspheres. More speculative research is also being carried out. If microspheres incorporating haemoglobin (the red blood-pigment which carries oxygen) could be made, it would be a big step towards the manufacture of artificial blood.

The latest sonochemical breakthrough, reported in a recent issue of *Nature*, has been to make glassy metals. Normally, metals are crystalline—their atoms are arranged very regularly. Glasses, in contrast, have their atoms jumbled up as though they were liquids. Glass is made by cooling something too fast for it to crystallise. For window glass, hours will do. But metals so much want to form crystals that they have to be cooled very quickly indeed. Kenneth Suslick and his group at the University of Illinois have worked out how to do this using cavitation. Because the bubbles heat up and cool down so rapidly, anything heated by them will also cool extremely fast. Since the temperatures reached inside the bubbles are enough to melt most metals, it is possible to cool minute drops of liquid metal so rapidly that, instead of crystallising, they become glassy.

Glassy metals have interesting magnetic properties which have made them popular for applications such as computer disks and tape-recorder heads. At the moment they have to be made by dropping molten metal on to a plate cooled by liquid nitrogen. This is technically awkward and relatively costly. Using ultrasound should be much cheaper. Indeed, it is the relative simplicity of their method that proponents of sonochemistry are keen to point out. No high-powered lasers or gas flames are required. The sort of ultrasound equipment that can be found in most school laboratories is enough to produce a chemical storm in a teacup.