approach need cause no loss of accuracy. His fellow student, Hong-Chia Lin, is looking at the case where the grid is formed from many individual blocks, simple in themselves, but needing to exchange information across boundaries. This latter project is part of a joint exercise with the French organisations ONERA and Avions Marcel Dassault.

Design of the numerical algorithms is still far from being universally agreed. The weeding-out by natural selection of less successful methods is more than balanced by the generation of new and untested ideas. One of last year's MSc students, Steven Rham, tried to design a compressible flow code having the unusual feature that flow variables are stored on the edges, rather than at the corners or on the centre of each computing cell. This generates a mathematical problem in which there are twice as many unknowns as equations, so that some supplementary conditions are required and Steven's thesis work consisted of analysing and experimenting with these. He has now accepted employment in the CFD code development team at RAE Farnborough.

Also radically different from any scheme in current use are those that have been, for many years, a personal (unfunded) hobby-horse of the first author. The schemes attempt to put to practical use the somewhat ambiguous mathematics of multidimensional wave propagation. A firm theory of such methods is only slowly emerging, but one report has been written following a visit to colleagues at the University of Heidelberg, and another is being jointly prepared with members of the von Karman Institute. Interest is now being shown in many quarters; maybe these ideas have a future. Valuable contributions to this line of research were also made by Dr Bernd Einfeldt, who visited CoA for one year under the NATO Visiting Fellowship Scheme. Bernd also collaborated on the important question of how the code can be guaranteed to give physically realistic results (e.g. positive pressure and density) under absolutely any circumstances. The international flavour of CFD was well maintained here with a co-author from the University of Uppsala. Those who met Bernd during his stay will be interested to know that he has secured an attractive position at the Konrad-Zuse Zentrum für Informationstechnik in Berlin.

A student who recently gained her PhD here is Smadar Karni, from Israel. Her problem was one of the subtlest and least understood in CFD, although it sounds very simple. In calculating the flow past an aircraft, the simplest assumption to make about the atmosphere is that it is uniform and unbounded. However, there is no such thing as infinity in a computer. Instead, one sets a computational boundary at some large nominal distance, and attempts to ensure that nothing is happening there. This turns out to be amazingly difficult, and sorting out events on the boundary consumes much of the time taken by an aeronautical calculation. Smadar was able to contribute an original idea that reduced the cost of the calculation by nearly 50%. She will be staying on as a Research Officer to work on the detonation problem.

Hypersonic aerodynamics has become fashionable again recently (in some countries at least), and CFD has much to offer in a field where experiment is difficult and costly. Another of last year's MSc students, Martin Clark, tackled the ambitious project of a three-dimensional flow at Mach 15 past a "waverider" shape. Although there was not time to attempt any actual design work, this certainly qualified as a successful feasibility study. A PhD student, Alan Dawes, is developing a so-called random choice method for the accurate calculation of non-equilibrium hypersonic flows. His work has the interesting feature that the mesh will adapt itself to following the streamlines of the flow. Many of the methods used for hypersonic calculations aim at the clearest possible resolution of these strongly discontinuous flows. The quest for high resolution seems to cause slow convergence of the methods and another PhD project in this area, conducted by Creigh McNeil, aims to explore and hopefully cure this problem.

A short project was recently conducted by Dubravka Vasilic-Melling on a topic having some local Bedfordshire interest. If radioactive waste is buried in sealed containers which may (perhaps after many centuries) develop leaks, one needs to know how far the radioactivity will be carried by groundwater, and by how much it will decay. Another feasibility study showed that numerical techniques developed for very different purposes may usefully contribute to these studies.

The random-choice method mentioned above has been a long-standing interest of the second author, who has contributed much to its development. Indeed, the Second International Conference on Random-Choice Methods was held at Cranfield in 1987. He has also devised a new technique called the weighted-average-flux method for wave propagation problems. Recently, he has become interested together with Research Officer Jack Pike, in the topic of two-phase flow, specifically the flows comprising the mixture of product gases and solid remnants that result from propellant ignition in guns and rockets. Even the basic mathematics of such flows is only poorly understood. However, progress is being made, and Figure 2 shows results for flow within a circular tube filled to 57% with a granular propellant material. The long horizontal axis is along this tube, which is the combustion chamber of the gun, and the short axis represents radial distance. The stick has been ignited from the far end, and, in the space around it, pressure waves have travelled forward and outward. Some reflection from the forward end, where the shot is located, have occurred. The quantities plotted refer to the gaseous phase between the granules.

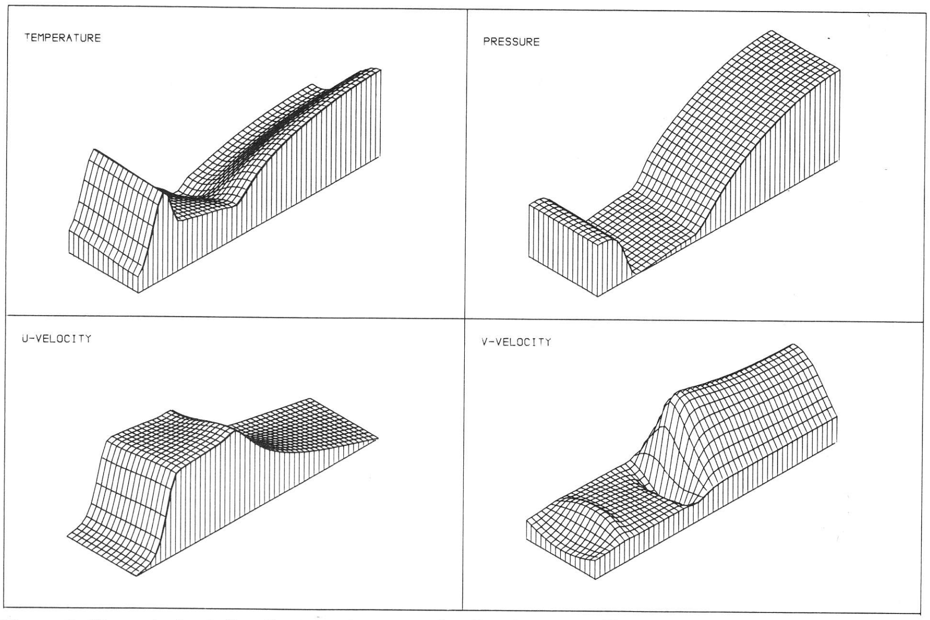

Figure 2. Numerical solution for two-phase reactive flow in a propellant bed.

What of the future? The work described above is very varied, but certain research themes have emerged which should continue strongly. Plans have been drawn up for a specialist MSc course in CFD, to begin in October 1990, and will shortly be submitted to the Engineering Faculty Board. The course may be run in conjunction with the School of Mechanical Engineering. It will offer core material on the fluid mechanics, numerical analysis, and computer science that underpin all of CFD, but will also offer optional modules on various applications. Uniquely, there will be a module on experimental methods, that should ensure nobody loses touch with physical reality.

If you take every fourth letter from the name of Cranfield, you get CFD. We are not yet suggesting that every fourth student at Cranfield will be studying CFD, but we're growing towards it.