New Light on Pneumatics

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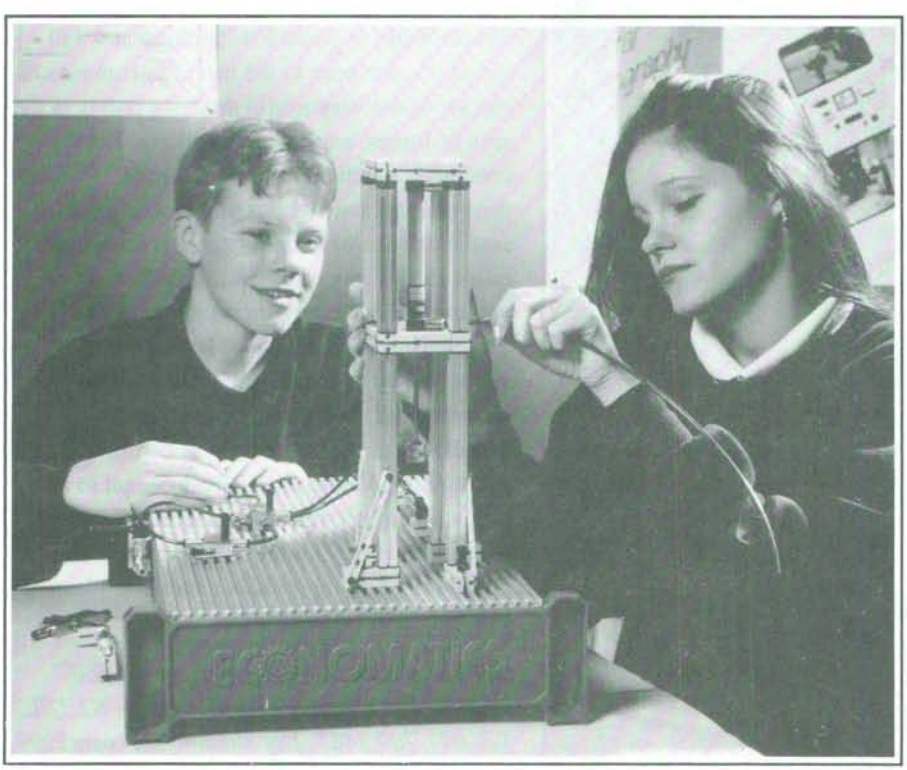
With pneumatics playing an increasingly important role in industry, and the design and technology curriculum in process of revision, now is a good time to re-examine the place of pneumatics in design and technology.

Pneumatics has been rather a shadowy presence in the design and technology curriculum documents published over the last four years, its inclusion or lack of it being something of an indicator of each document's commitment to control technology. The original order makes only a passing reference to pupils knowing that mechanisms can be incorporated within pneumatic systems, whereas the proposals published in December 1992 (the fold-out) at the height of the Blue Peter technology debate go so far as to specify that pupils be taught the use of a detailed list of pneumatic components.

So what really is the place of pneumatics in design and technology? This article sets out to explore this issue by looking at three interlinked areas: the place of pneumatics in control technology in the world outside school, the current use of pneumatics in schools in KS3 and KS4, and, to begin with, the part it has played in the development of the subject of design and technology.



Small-scale industrial pneumatics integrate easily with construction kits like Fischertechnik for prototyping project ideas; they operate at safe low pressures, suitable for the classroom

Control Technology

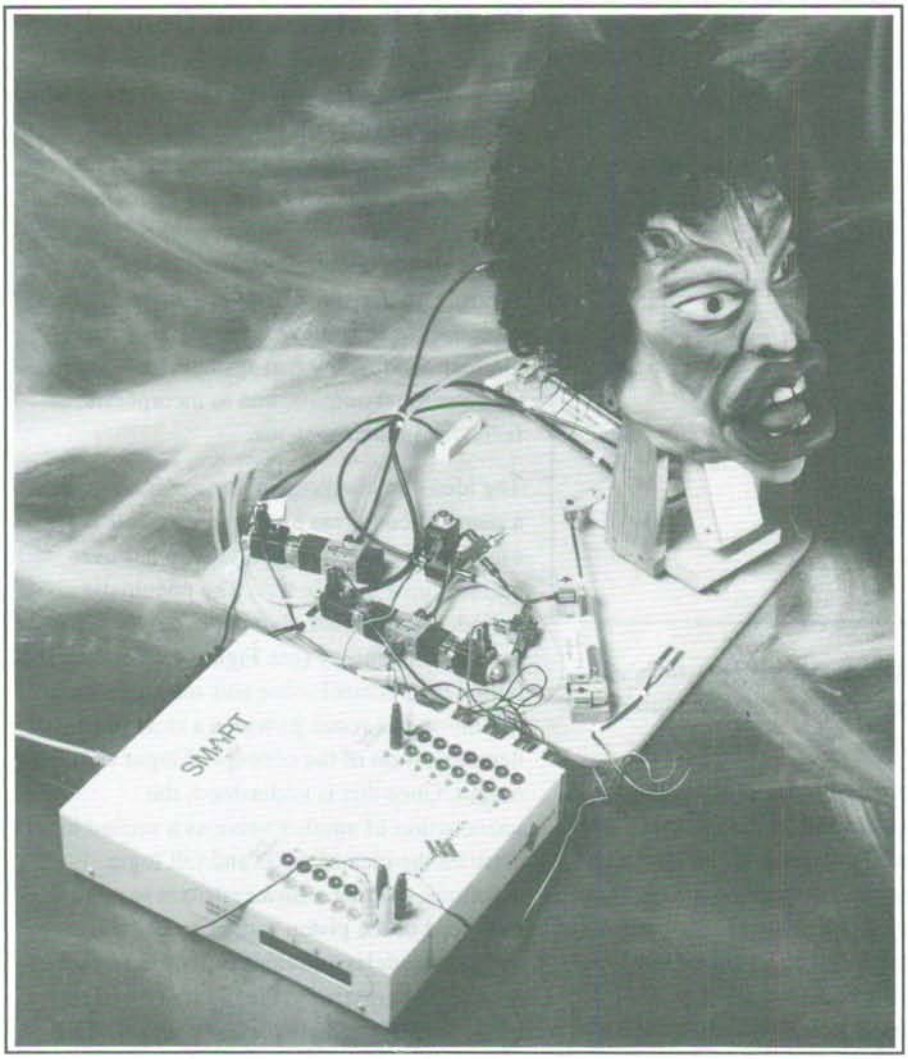
A significant factor in the development from craft subjects into CDT was the Schools Council Project Technology scheme which was published in the Control Technology books in 1974. It is interesting now to see how this first attempt to frame a whole field of scientific and engineering activity into a school subject, dealt with pneumatics. Alongside sections on structures and electronics was a central section on the control of movement: electrical switching to control the source of rotary movement — an electric motor, and valves to control the source of linear movement — a pneumatic cylinder. Both were presented as being of equal importance.

The growth of control technology led to a second Schools Council project, Modular Courses in Technology, in the early eighties. This created the model of GCSE technology as a general core with a choice of specialist modules. In this rather fragmented approach, pupils experienced pneumatics only if it was one of the modules chosen by their school. It is worth comparing this model with a parallel development, the Scottish Standard Grade Technological Studies syllabus, which has pneumatics as one of its core subjects; the others being mechanisms, electronics and technology in manufacture with the emphasis on integration of all four.

Another interesting comparison is that between the uncertain place of pneumatics in the orders for England and Wales, and the more positive view taken in the equivalent order for Northern Ireland in which pupils both at KS3 and KS4 are to be taught to use pneumatic cylinders and valves in circuits to achieve desired effects. It would appear that curriculum developers in Scotland and Northern Ireland have a vision of technology that embraces more of the nature of control technology as it exists outside schools.

The World Outside School

In the world of control technology outside school, the design engineer has a choice of three basic types of actuator — electrical, pneumatic and hydraulic — to provide force and movement. Each has its strengths and weaknesses and each is appropriate for particular purposes. It is likely that all three would be accompanied by an electronic control system that is either hard wired or programmable.



This animated head, made as part of an NCET project in control technology, shows how pneumatics can be integrated with computer control in a design and make project

Over the last ten years, major advances in pneumatics technology have meant that it is increasingly favoured over electrical and hydraulic systems. New designs of valves and cylinders have brought greater efficiency; electronic control has increased accuracy and speed of response; and miniaturisation has meant that a pneumatic system now occupies a quarter of the space it would have needed ten years ago.

The majority of automated manufacturing processes, especially in industries such as plastics, furniture, food and clothing make extensive use of pneumatics because it is clean, safe, lightweight and cost-effective. A pneumatic system compares favourably with electrical and hydraulic equivalents when it comes to maintenance, durability and cost of manufacture. The automotive industry is making increasing use of pneumatics, not only in manufacturing processes, but in on-board systems such as suspension and central locking. The new clutchless car makes use of a pneumatic gear selection system. In the fast developing world of theme park thrill rides, pneumatic systems are used to fix safety harnesses in place and to fire the passenger vehicle at high speed into the looping ride.

The growth of the pneumatics industry is indicated by the fact that in excess of £80m are now spent annually on pneumatic components in the UK, compared with some £50m ten years ago. In the same period, the hydraulics industry has suffered something like a twenty-five per cent reduction.

Classroom Experience

Talking to teachers about their reasons for including pneumatics in their design and technology work, three ideas emerge:

i) It has to be included if pupils are to be given a complete and balanced experience of control technology as it exists in the world outside school.

ii) It opens up the range of possible design and make projects for pupils, and generates new project ideas.

iii) It makes an ideal vehicle for teaching ideas about systems and control.

In the words of one teacher: 'For me, systems and control work should be built around pneumatics because of its immediacy and simplicity, and the way it motivates pupils. In half an hour they can learn something, use it and get a real sense of achievement'. This is true across the full ability range. For the teacher, trouble-shooting is much simpler than with, say, electronics. There are fewer possibilities for error, you can see what is happening, and altering a circuit is simply a matter of reconnecting pipes to push fittings, rather than desoldering components.

School-Industry Links

One of the purposes of school-industry links is to give pupils awareness and understanding of industry. Where this involves factory visits teachers find that, for pupils who are familiar with pneumatics, the array of modern machinery is far less intimidating and often serves to stimulate project ideas such as pneumatically-operated pick and place devices or systems for moving material on and off conveyors. Pneumatics is particularly useful in projects that involve pupils' own small scale manufacture. Chip making and can crushing for recycling are popular projects; more enterprising ones include printing tickets for

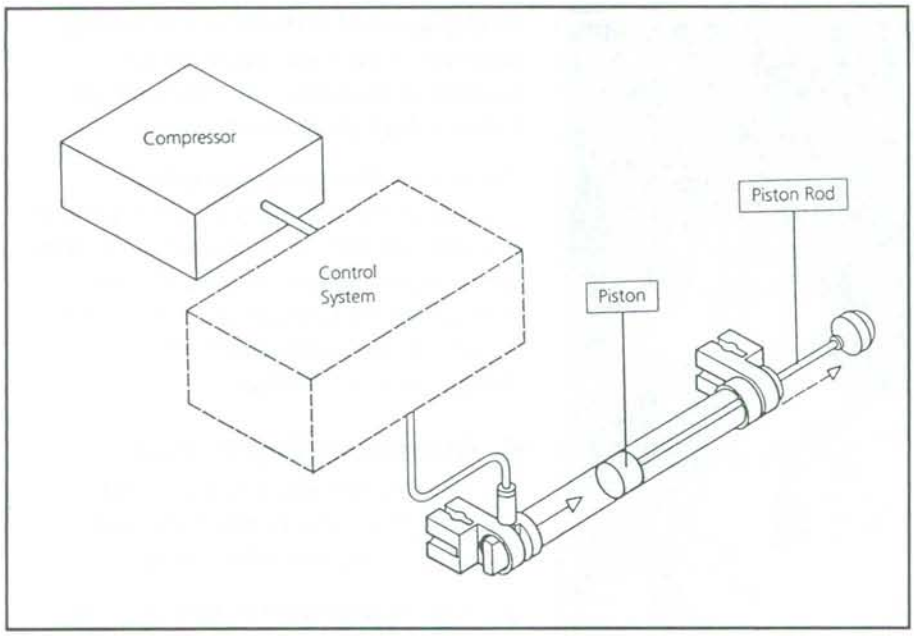


Fig. 1:
When compressed air is released into a cylinder, the piston rod moves, providing linear force and movement

local events and manufacturing plastic belts using pneumatics to stamp holes and insert rivets for buckles.

The use of pneumatics in the areas of leisure and animation is also reflected in school projects. One pupil's advertisement for a tyre company featured an animated arm pumping up an inflating tyre. At another school, a group of pupils have produced an animated version of the *Three Little Pigs* complete with pneumatically-operated collapsing house and a wolf who huffs and puffs by means of a pneumatic cylinder.

KS3 Systems and Control

Projects such as these tend to be done in KS4, but pneumatics is also used extensively in KS3 and is highly relevant to the latest draft proposals for design and technology in that it makes tangible many of the key elements of systems and control specified at this level; i.e. pupils should be taught to use devices that control and transmit energy; to interconnect mechanisms to achieve different kinds of movement; to know that systems have inputs, processes and outputs; and to incorporate feedback in their systems.

The idea of a compressor as a device that uses a pump to compress air into a reservoir is easily explained to any pupil who has ever pumped up a bicycle tyre. The pneumatic cylinder is an eminently simple device for transmitting energy (see Figure 1). Pressing the button on a control valve and seeing a piston rod move as a result provides a clear practical demonstration of the concept of input and output. Once this is understood, the introduction of another valve as a second input clarifies the idea of AND and OR logic functions. Adding a flow restrictor to control the speed of the piston rod, or a reservoir to give a time delay provides further examples of process. Alternatively, the input of a system could be the linear movement provided by a cylinder, the process a series of linkages or other mechanisms, and the output a movement or number of movements on, for example, an animated face.

In pneumatic systems, the need for feedback in the form of proof of position is easily understood. In the system shown in Figure 2, cylinder A pushes a container under a hopper and cylinder B tips the hopper so that its contents pour into the container. It is clearly important that a feedback loop is built into the system so that cylinder B will not tip until there is proof that cylinder A has pushed the container into position. Proof of position can be achieved using just pneumatic components, but this kind of control of cylinders in conjunction with sensors provides a natural progression into integrating pneumatics with electronic or computer control systems, which is what schools tend to do in KS4.

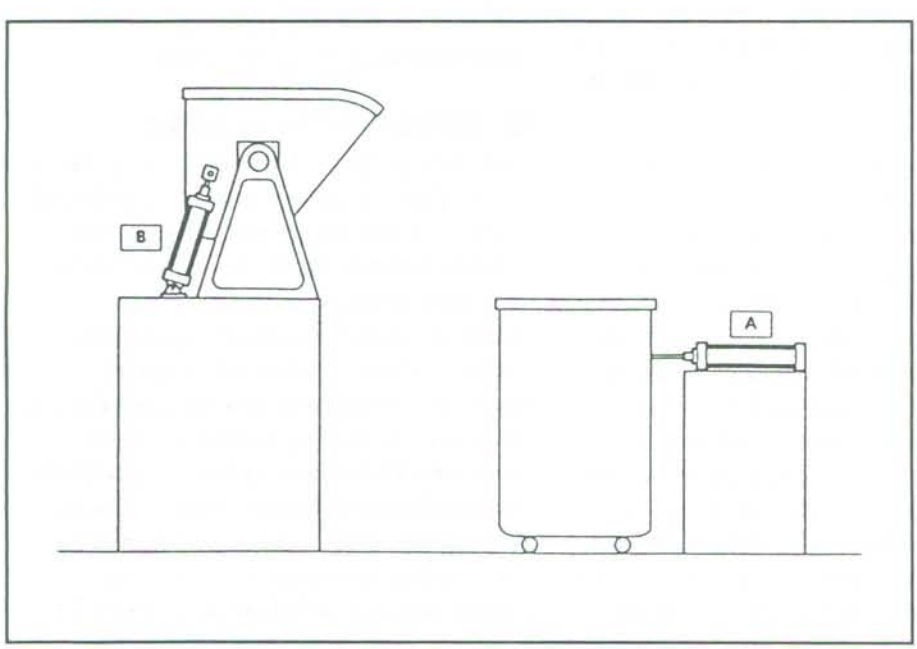


Fig. 2: The need for proof of position feedback

Equipping for Pneumatics

Equipping to teach pneumatics need not be either costly or complicated. A pneumatics workstation comprises a number of basic components, a firm base to fix them to, and a source of compressed air. As a beginning, this could be a small mobile compressor which would supply one or two workstations used for teacher demonstrating and practical work by groups of pupils as part of a circus of systems and control activities. Schools equipping for pneumatics with whole classes would look to provide five to ten workstations supplied by a large fixed compressor with an airline installed around the workshop, preferably inside service trunking alongside the low voltage electricity supply. This obviously represents a substantial investment but has the advantage that, once set up, the resource lasts for years with no additional cost other than the occasional coil of pipe.

Whatever the future of pneumatics in design and technology curriculum orders and syllabuses, two points are clear. The increasing number of teachers who use pneumatics find it to be an excellent way to teach systems and control, and any coverage of modern control technology without it is simply incomplete.

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