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# Materials for Product Design

Eddie Norman, Brian Bullock and Mike Hall  
Loughborough University

The realisation of any product depends on the manipulation of appropriate materials. Materials and manufacturing processes must be selected in relation to the required service performance, the available manufacturing resources and the acceptable cost. Designers need to understand the implications of these choices and be sensitive to the forms their products must take if they are to avoid unnecessary compromises between aesthetic requirements and efficient production. Traditionally it may have been acceptable for designers to hand over 'concept designs' to production engineers to modify as necessary, but a more holistic approach to design development is now expected. The educational experiences of undergraduates on the Design and Technology three year degree programme should enable them to participate fully in a modern integrated approach to product design.

During their first two years the students follow a carefully planned programme of activities which help them develop the necessary knowledge and understanding of materials and processes. Although it is expected that the design practice activities of the students during the second and third years and their subsequent careers will be related to quantity production, they still need to use hand and machine tools in order to make models and prototypes and this can be as important in the early stages of the design process as it is in presenting a product design proposal. A summary of the specific course components related to materials and processing is shown in Table 1 and a brief synopsis of the aims and content of each element is given below.



Figure 1a: Nutcracker

## Year 1: Lectures

### Structure of materials:

The structures of metals, woods and plastics are examined with approximately equal emphasis and there is a brief look at ceramics. The lectures show the relationship between the atomic structures and the natural properties of materials. Acquiring a knowledge of materials and their structure is an essential step towards understanding manufacturing processes

and their effect on material properties. This initial introduction is also the foundation of an awareness of the basis for the use of materials in products.

### Materials processing:

The principles of material removal are covered in relation to hand and machine tools for both wood and metal to complement the practical work undertaken in the manufacturing exercise. There is a general introduction to the techniques associated with quality manufacture such as sand, die and investment casting, forging and presswork and the design implications of each of these processes are considered. Videos are used to show the manufacturing techniques and the lectures concentrate on the physical requirements of each process and their consequences for the 3-D form that can be achieved in the finished component. This allows the student designer to make realistic comparisons between materials and processes to achieve a particular design goal.

Table 1: Principle activities related to materials and processing in Years 1 and 2

	Year 1	Year 2
Lectures		
	Structures of materials (15 hrs)	Properties of materials (15 hrs)
	Materials processing (20 hrs)	
	Safe working practices ( 8 hrs)	
	Design and manufacture ( 4 hrs)	
Practical Activities		
	Manufacturing exercise (39 hrs) (metal/plastics)	Manufacturing exercise (20 hrs) (wood)
	Laboratory investigations (39 hrs)	Laboratory investigations (30 hrs)

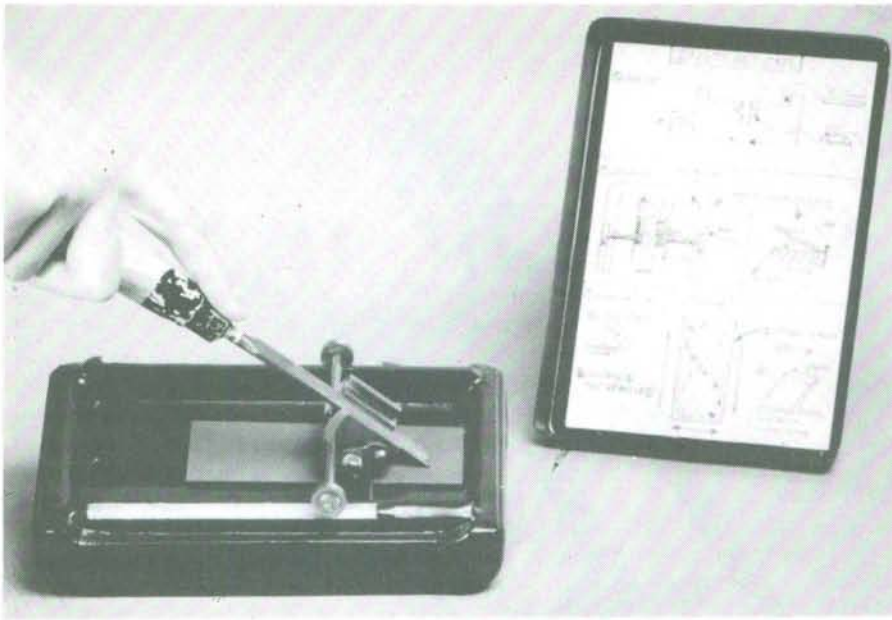
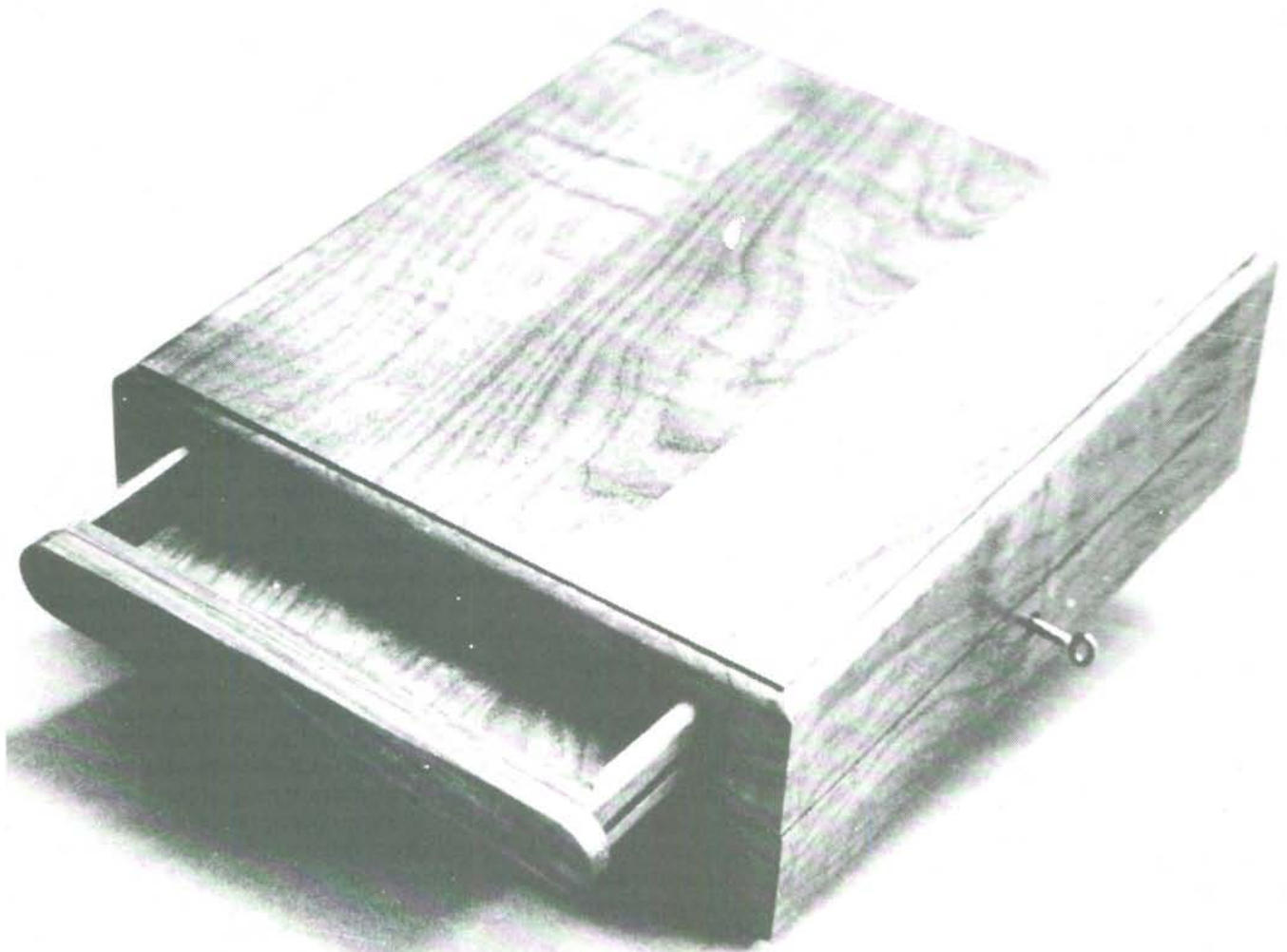


Figure 1b: Honing Guide

**Safe working practices:**

Making models and prototypes requires the use of tools and workshops and safe working systems must exist to prevent accidents occurring. As adults the students have considerable responsibility under the Health and Safety at Work Act for their compliance with safe working practices, but the nature of the hazards and the working systems developed to cope with them need to be carefully explained. These statements are, of course, reinforced in every workshop area to which the students are introduced. Safety issues are equally vital to intending teachers and to students taking up a role in industry.

Figure 2: Wood machining exercise



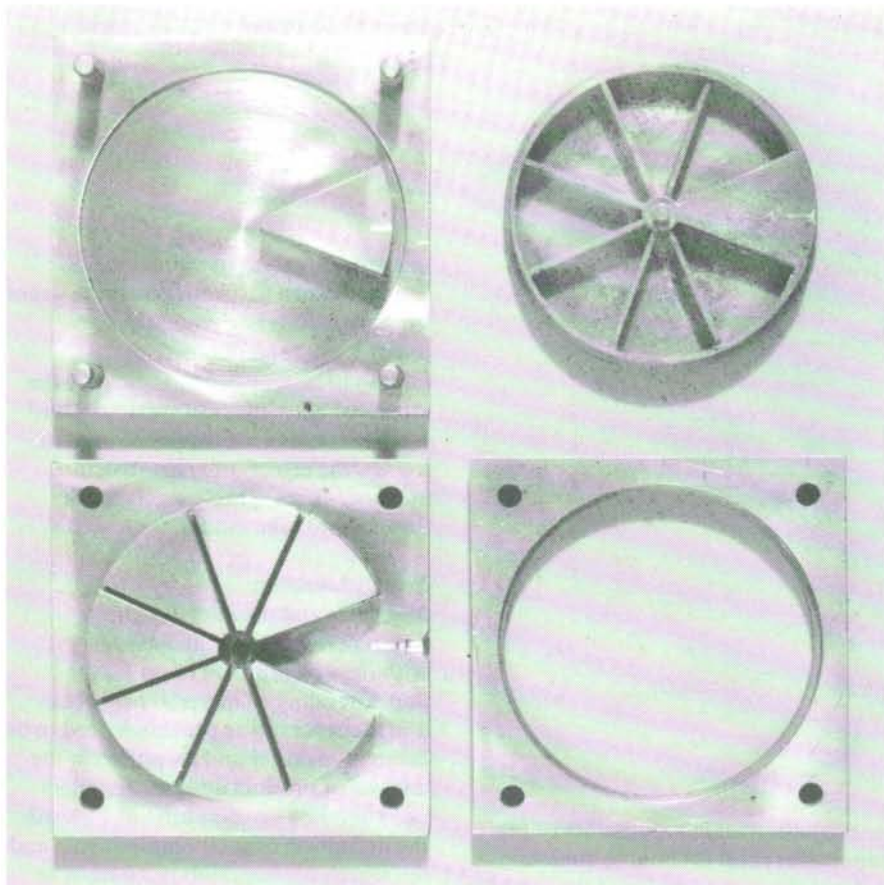


Figure 3a: Injection mould tool

Figure 3b: Furniture Design

**Fig.3**  
**Materials and processing knowledge and understanding associated with Year 2 Design Practice**

**Injection mould tool**

- machining and the design of mould tools
- the mechanical properties of plastics e.g. strength and stiffness
- the working properties of plastics e.g. thermoplasticity, shrinkage, in relation to machine capabilities.

**Furniture design brief**

- one-off and quantity manufacturing techniques in wood
- joint design and adhesives
- finishing methods

**GRP moulded product**

- product design in relation to shell structures.
- designing and making moulds
- structural properties of fibre reinforcements
- control of chemical setting resins and additives.



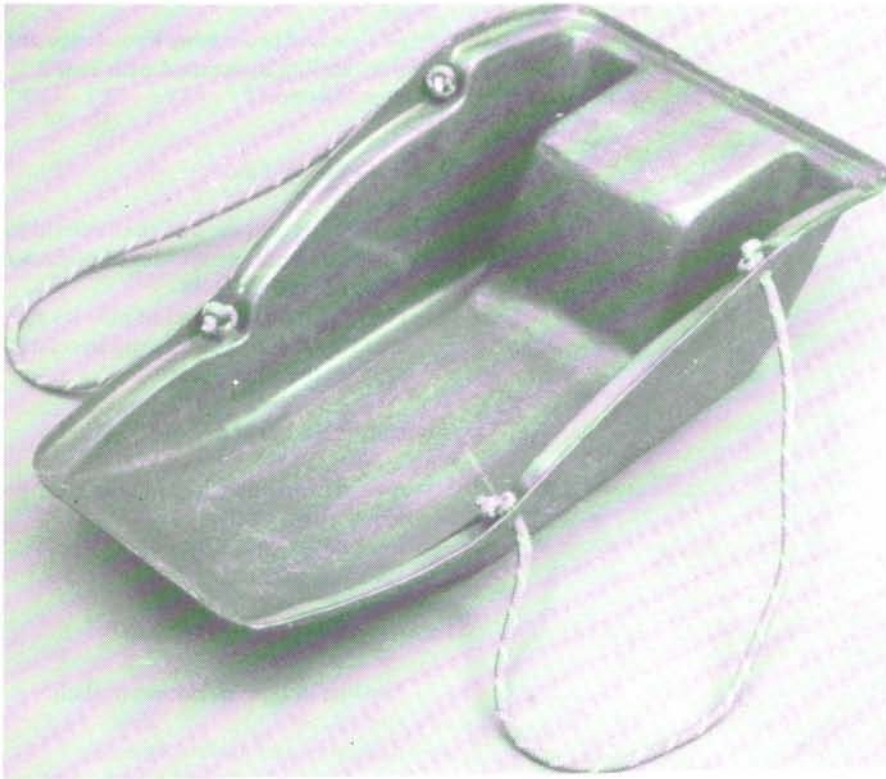


Figure 3c: GRP brief

**Design and manufacture:**

By the third term students have acquired more awareness of the implications of their design decisions on the manufacturing process. These lectures develop and explore this link to help prepare then for Design Practice in Years 2 and 3.

**Year 1: Practical Activities.**

**Manufacturing exercise (Metal/plastic)**

The majority of students beginning the Design and Technology course have taken an 'A' level in a Design-related subject. For most students this has involved them in processing wood and plastics, but few have experience of working in metal. The development of metal processing skills therefore forms the central feature of the Year 1 manufacturing exercise through controlled project work. Students are introduced to good machine shop practice and planning procedures through some preliminary exercises and then they plan and carry out the manufacture of a product. Detailed planning sheets are drawn up for all components partly to increase efficiency, but equally as a deliberate linking step towards programming NC and computer controlled machinery. The project is completed by asking the students to use the information from the lecture programme to redesign the 'one-off' product to be suitable for small batch or quantity manufacture. Fig. 1 shows examples of work done by first year undergraduates in the last two years

— the design and manufacture of (a) nutcrackers and (b) honing guides.

It can be seen from Fig. 1 that plastics play an integral part in this programme. Following a series of lectures on a wide variety of commercial processes and demonstrations of handworking plastics, students undertake a related design project that involves them in mouldmaking, moulding and finishing procedures. This is an opportunity to develop their understanding of the properties of plastics in relation to visual characteristics, moulding and structural strength and hence to synthesise design, manufacturing and performance requirements.

**Laboratory investigations:**

Being able to select and manipulate materials successfully depends on an understanding of the origins of their properties and how these are influenced by the manufacturing process e.g. what makes a material strong or weak?, soft

or hard?, resistant to corrosion?. Students learn to investigate these issues for both metals and woods by macroscopic and microscopic examination. For metals issues like the effects of alloying, heat treatment and work hardening are explored, and for woods, the effects of grain structure, moisture content and defects (both natural and man made).

**Year 2: Lectures:**

**Materials and product design:**

The experiences in Year 1 associated with the development of an understanding of material properties and manufacturing processes need to be brought together and amplified in the context of product design. Designers need to take a positive attitude towards the definition of their requirements and the search for materials or composite structures which will satisfy their specifications. Exploring the area of knowledge associated with materials and their processing makes it less likely that there will be a simple acceptance of what is readily available or easily acquired with the consequential constraints on the product and its form.

**Year 2: Practical Activities:**

**Manufacturing exercise: (Wood)**

Wood machining necessitates close adherence to a safe working system and this is promoted by the knowledge of the properties of wood gained in Year 1. The objectives of the manufacturing exercise in Year 2 is to teach students good practice in machining wood and to enable them to appreciate the techniques used for wood processing in industry. The Department only has simple machines but the operating principles

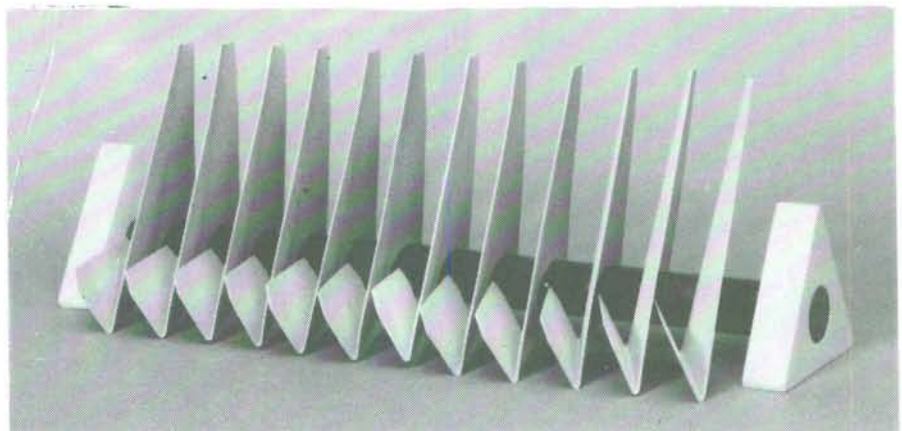


Figure 4: Cassette Rack

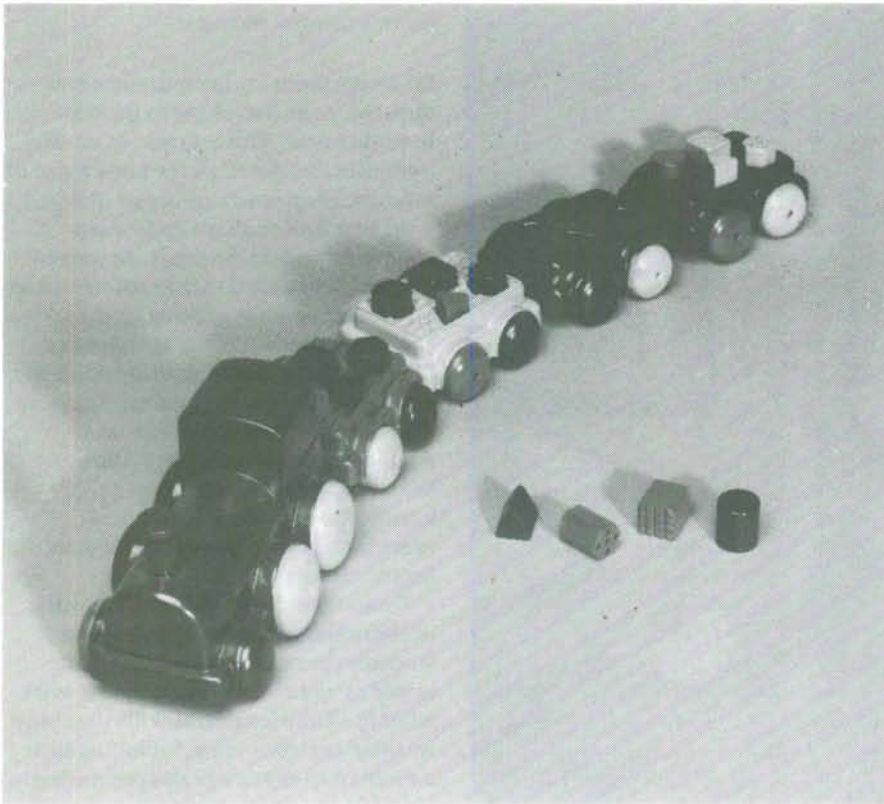


Figure 5: Toy Train

are the same as those found in more complex industrial equipment. Figure 2 shows an example of the kind of exercise all students complete.

**Laboratory investigations:**

These investigations are designed to support the lecture programme on 'Materials and Product Design'. The effects and design implications of processes like welding and brazing metals and the use of adhesives with woods, plastics and combinations of materials need to be explored. The protection of metals and woods from damaging environments and the relationship of these finishing techniques to aesthetic issues is another important topic.

The brief synopses given above describe elements of the degree programme specifically thought of as 'Materials', but there are many other areas where an understanding of materials is developed and the student's knowledge of materials is used. The modelling activities associated with Core Design in Year 1 develop and extend the knowledge of the 'one-off' processing of wood which the students bring from their 'A' level studies. Design Practice in Year 2 is normally organised around three key themes — the design and manufacture of an injection moulded product, a furniture design brief and a general product design exercise often related to GRP moulding. Clearly each of these areas involves a considerable materials component and some of these are indicated in Fig. 3 with photographs showing typical student projects.

These Design Practice experiences of course develop much more in students than just knowledge and understanding associated with materials and their processing. All three projects fundamentally concern the manipulation of 3-D forms and their realisation, and consequently graphical and 3-D modelling techniques are the key elements but an understanding of materials selection and manipulation is also necessary. In the injection moulding exercise the students work in pairs — each making half the tool — so

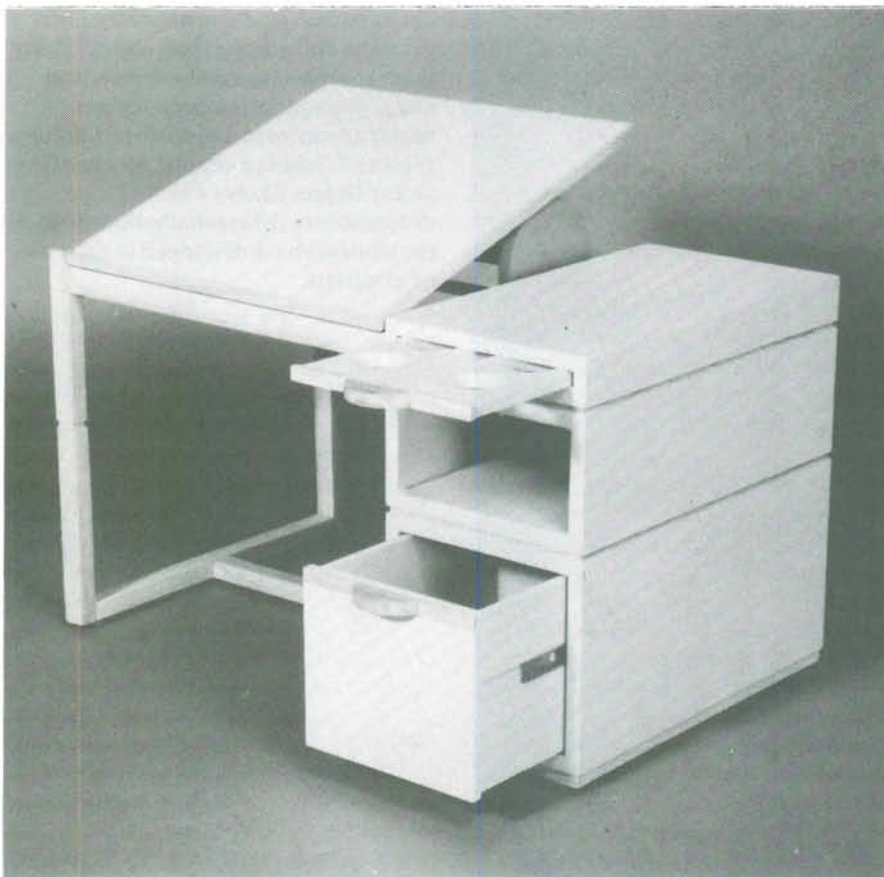


Figure 6: Child's Desk

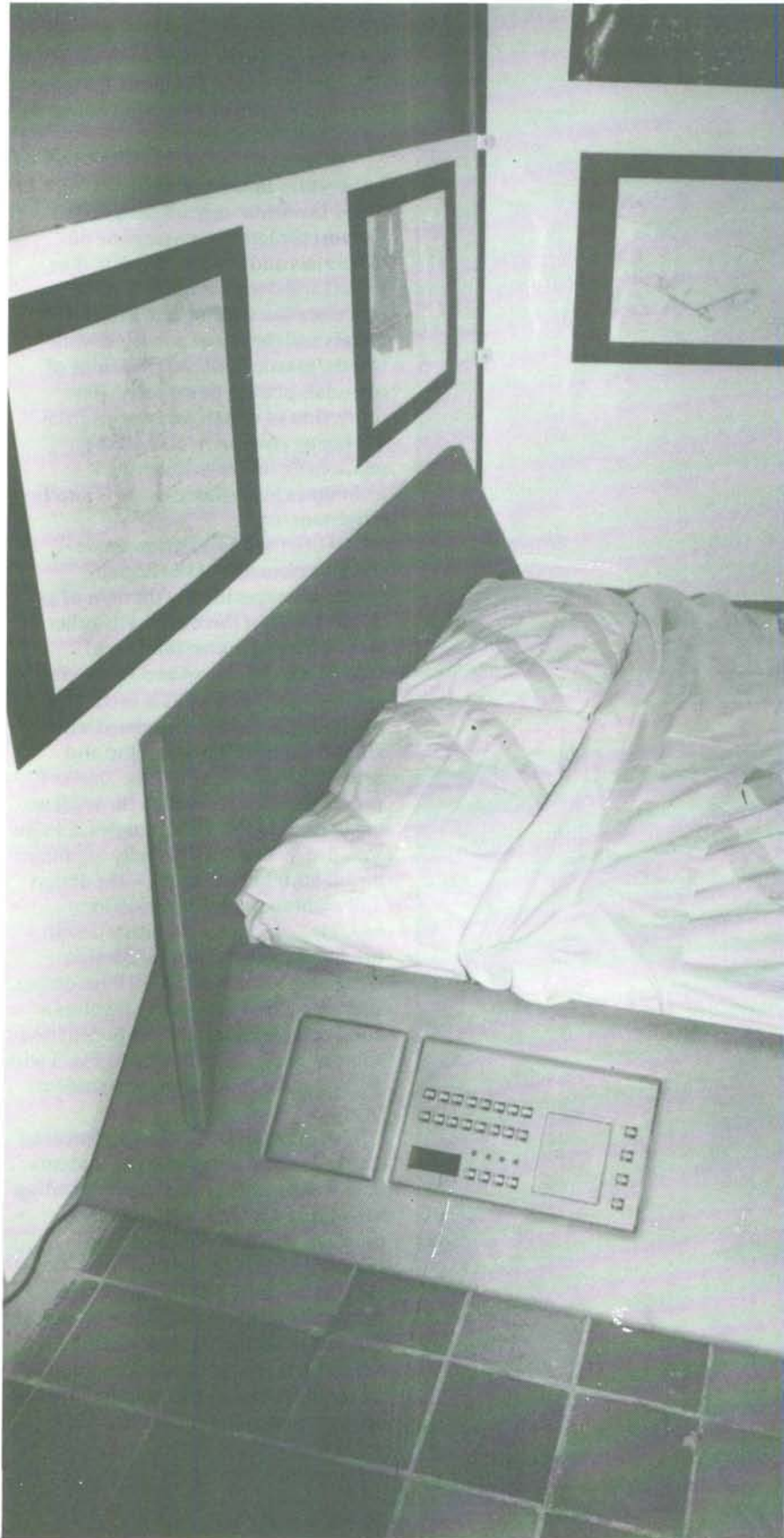


Figure 7: Concrete Water Bed

the importance of fixing datums and dimensions and working to them is brought home. This exercise, of course, both uses and develops the knowledge of machine shop practices begun in Year 1.

In Year 2 all students also take a course in Product Analysis. As part of this activity students are asked to look at all the components making up a consumer product, such as an iron or toaster, from a manufacturing point of view. As with Design Practice other aspects are central to the Product Analysis exercise e.g. ergonomics, function, aesthetics etc., but the knowledge of materials and their processing is a key pre-requisite to its thorough completion.

Design practice dominates the work of the undergraduates in Year 3 and students select their own major and minor projects. They bring to this work all of the knowledge and skills they have learnt in previous years, including their awareness of materials and processing. Loughborough graduates of course take the attitudes and abilities they have acquired into teaching or professional practices and among these should be an open approach to materials selection and a willingness to search for and utilise advances in materials technology. Figures 4-7 show examples of work from recent Degree Shows which demonstrates the sympathetic approach the students have developed in their use of materials.