INVESTIGATION, DEVELOPMENT, AND EVALUATION OF METHODS FOR INTRODUCING SIXTH-FORM SCIENCE STUDENTS TO PHYSICS-BASED APPLIED SCIENCE

BY

G.C. SNEED
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The work begins by presenting evidence to support the need for introducing applied science into the school curriculum and then attempts to categorise the various techniques developed by schools for this purpose.

Consideration is given to the design and development of five purpose built school applied science laboratories, and the success or otherwise of their associated teaching programmes. As only a small number of these laboratories have been built the facilities and conditions existing in typical schools representing the less fortunate majority have been examined, and the reasons which prevented the immediate introduction of applied science activities identified and tabulated.

The work investigates also the possibility of schools utilising facilities offered by science museums as a means of supplementing or complementing their own resources for applied science teaching.

Attitudes towards, and achievements in the field of school applied science teaching and museum education have been studied at first hand in Japan and America, with particular reference to the needs of the high school student.

An account is included also of the development and teaching value of a unique drama production, linking science with the theatre, staged to interest very young children in the fundamentals of applied science.

The thesis ends with a policy description and evaluation of an approach to applied science teaching devised by the Shell School Technology Programme, in an attempt to overcome the problems known to be facing secondary school science teachers wishing to introduce their senior students to technology.
The teaching of applied science in British secondary schools is highly individualistic and many of the approaches developed have arisen through enthusiasts making valiant attempts to overcome the problems of restricted space and limited resources. The nature of these approaches varies from the provision of end of term 'fill in' activities to carefully prepared theoretical/experimental courses.

The educational value of the majority of the approaches is extremely difficult to evaluate as they are unexamined and only one of many influences that contribute to the formulation of any attitude of mind that students may develop towards the world of engineering.

Purpose built applied science laboratories installed in some schools have given their staff and students excellent science based facilities for the subject. In several instances, however, the work undertaken has not achieved outstanding success, over a long period of time, because the pioneer staff involved either retired or accepted new posts, and the appointment of suitable successors proved extremely difficult.

The problem of finding suitable staff is universal and not confined to schools possessing special applied science laboratories.

Young students in Japanese schools do not have the advantage of applied science lessons or special laboratories but nevertheless, are very interested in the world of technology. The reason for their enthusiasm is the high esteem given to technologists by the general public, which in turn is brought about by the widespread appreciation of the fact that mastery of the subject requires a sound knowledge of mathematics and science.
Leading science museums in both America and Japan make a significant contribution to the technological education of young people; particularly in America where they supplement, to varying degrees, the science teaching provided by the schools and frequently form the central point of a local community. The majority of British science museums suffer from serious financial problems and the need to store items of historic interest. If British museum authorities could be encouraged, and financed, to offer services to satisfy the everyday needs of science teachers and their students they would be making an extremely valuable contribution to the technological education of our young people.

The approach to applied science education devised by the 'Shell' School Technology Programme, after a world wide study of the subject, has successfully overcome the major problems of money, space, time and know-how, encountered by practicing science teachers. To date, the method is being used by over 100 British schools and an unknown number in fifteen foreign countries. This approach and associated material which has received the enthusiastic approval of science teachers, science advisers, colleges of education, university education departments and industrialists seems likely to persuade very many schools who, so far, have only contemplated introducing applied science to become actively involved.
ACKNOWLEDGEMENTS

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DEFINITIONS

A PROFESSIONAL ENGINEER+

A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending, managing and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others.

His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications.

His education and training will have been such that he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own Branch. In due time he will be able to give authoritative technical advice, and to assume responsibility for the direction of important tasks in his branch.

+ (This definition has been adopted by the Engineering Societies of Western Europe and the U.S.A. (EUSEC) for the purposes of Conference discussions.)

A TECHNOLOGIST*

A technologist is someone who has studied the fundamental principles of his chosen technology and should be able to use his knowledge and experience to initiate practical developments. He is expected to accept a high degree of responsibility and in many cases to push forward the boundaries of knowledge in his own particular field.
A TECHNICIAN

A technician is someone who is qualified by specialist technical education and practical training to work under the general direction of a technologist.

CRAFTSMEN

Craftsmen are people that represent the skilled labour of manufacturing industry and account for more than a third of its manpower.

* (These definitions have been taken from the White Paper on Technical Education, Cmnd. 9703 H.M.S.O. London 1956.)
AIM

To present evidence that will demonstrate the need for schools to introduce an applied science activity into their programmes to satisfy both an educational and national requirement.
CHAPTER 1

THE NEED FOR INTRODUCING APPLIED SCIENCE INTO A SCHOOL CURRICULUM

1.1 INTRODUCTION

One of the first men to recognise the postwar need for introducing some form of applied science into the upper forms of a grammar school was Mr. A. Sainsbury Hicks, Headmaster of Ealing Grammar School for Boys.

In 1948, Mr. Hicks discovered that very few sixth form boys or girls from the local grammar schools were going to a university to study engineering. Interviews between sixth form science pupils in these schools and their Headmasters, revealed that the majority of these pupils had chosen to read pure science in an attempt to fulfil their ambitions of becoming research scientists. This trend, Mr. Hicks felt, might be due to inadequacies in the scientific education offered in the schools.

At that time the pupil record cards kept by the grammar schools in Ealing, Acton and Southall indicated that nearly all the most able boys were ignoring engineering while the less able were finding employment as craft apprentices. This imbalance was a nationwide phenomenon although at that time it was not widely recognised, nor was the full significance of the problem appreciated.

By the late 1950's it was becoming quite apparent in England that too few adequately qualified candidates were applying to take courses in the technologies, and especially the classical engineering subjects, once they left school. At the same time it was felt by educationalists that boys only considered entering higher technological education if they were unable, intellectually, to pursue a pure science course at the same level.

1.2 STATISTICAL EVIDENCE - THE BIRKBECK STUDY

With the aid of a grant from the Department of Scientific and Industrial Research, Birkbeck College - in 1962 - were able to carry out a study amongst sixth-form science students, in grammar and public schools, to relate the career choice of the boy to:-

(1) The type of school he was attending.
(2) His likely success, based on school estimates in 'A' level examinations. (1) (2)

The survey considered 800 boys from over 40 schools. Of these 3%
study scientific subjects beyond 'A' level. Those boys wishing to study science at post 'A' level standard divided themselves amongst chosen occupations as shown in the table below.

<table>
<thead>
<tr>
<th>%</th>
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<tbody>
<tr>
<td>Biological sciences 12</td>
</tr>
<tr>
<td>Physical sciences 34</td>
</tr>
<tr>
<td>Engineering 37</td>
</tr>
<tr>
<td>Medicine or Dentistry 17</td>
</tr>
</tbody>
</table>

Upon qualifying, the majority of these boys expressed the hope that they would become concerned with 'research' of some kind. Further analysis of the 37% interested in engineering revealed that mechanical and civil were equally popular - approximately 50 each - while the remaining 150 were divided between chemical, electrical and the other branches of engineering. Less than 5% of the entire sample wishing to study science at post 'A' level standard wished to teach.

The important question of the ability of these boys deciding to become scientists, doctors or engineers was investigated based on the schools' prediction of their 'A' level results. The findings of this investigation are shown in the table below.

<table>
<thead>
<tr>
<th>Biological Sciences</th>
<th>Physical Sciences</th>
<th>Medicine</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERCENTAGES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outstanding (Distinctions) 7</td>
<td>20</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Able (3 passes) 47</td>
<td>56</td>
<td>56</td>
<td>58</td>
</tr>
<tr>
<td>Borderline (2 passes) 23</td>
<td>14</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Less able (1 pass or less) 23</td>
<td>10</td>
<td>23</td>
<td>13</td>
</tr>
</tbody>
</table>

This table shows that the majority of the exceptionally talented boys want to study pure science at the university; in fact almost 80% of the best brains opted for pure science. Only one boy in 20 who wants to become an engineer is thought to be outstanding in ability while one boy in 5 wanting to read the physical sciences is considered outstanding.
Both public and grammar schools were amongst the 40 considered in the survey so the results were analysed to try and detect any difference in career choice resulting from the nature of the school. The table below shows the findings of this analysis.

<table>
<thead>
<tr>
<th></th>
<th>Public Schools</th>
<th>Grammar Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Sciences</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>Medicine</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>Engineering</td>
<td>35</td>
<td>39</td>
</tr>
</tbody>
</table>

(These figures are percentages)

It appears from these figures that there is very little difference in the numbers from these schools choosing pure science and engineering.

The final aspect investigated by the survey was whether the tendency of the ablest boys to study science rather than engineering existed in both public and grammar schools. The results of these findings is shown in the table below.

<table>
<thead>
<tr>
<th>Ability</th>
<th>Public School</th>
<th>Grammar School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science</td>
<td>Engineering</td>
</tr>
<tr>
<td>Outstanding</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Able</td>
<td>56</td>
<td>60</td>
</tr>
<tr>
<td>Borderline</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Less Able</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

(These figures are percentages)

It seems that the tendency does exist in both types of school.

The survey decided that there did exist a widespread prejudice amongst the ablest boys against engineering, as a career. It went on to say that this state of affairs had probably existed for some time but that it was comparatively recently that public attention had been drawn to it.

1.3. THE OXFORD UNIVERSITY STUDY

In 1963 the department of education at Oxford University published a report of a study they had carried out amongst grammar and public school boys in regard to recruitment into higher scientific and technological education in England and Wales. (3) The main purpose
of this study was to see if, in fact, the most able boys did take pure science at the university, leaving the applied science to the less able boys and, if so, why?

The study revealed that this assumption was true and examined some factors that could contribute to this particular pattern of recruitment. It was discovered that the early specialisation in English schools caused boys to have to decide between taking an arts course or a science course, in the sixth-form, by the age of 14 or 15; probably before they had had any real experience of the true nature of the studies they would encounter.

Although the division between the arts and science is made at this early age, it was further shown that the final decision about the type of career the boy would follow did not seem to be made until he had entered the sixth-form, and then probably towards the end of the sixth-form course. With this general behaviour pattern in mind, let us examine the factors that influence the boy in his choice of a career. These factors may be summarised as external or internal influences in relation to the school. Let us consider the external influences first.

1.4 EXTERNAL INFLUENCES

PARENTS My personal experience as a master at Ealing Grammar School for Boys showed that over 90% of the senior pupils consulted their parents about their prospective careers; but, on the whole, the parents did not really consider themselves to be sufficiently well informed about the careers open to their sons and, therefore, they preferred to remain non-committal, the ultimate decision being left to the boy himself.

PRESTIGE The sixth-form boys considered in the Oxford Study were asked to list the occupations which they thought were:

1) The highest paid.
2) Those that had the highest prestige or social standing in the eyes of the general public.
3) Those that required the highest intelligence.

Doctors and solicitors were ranked first and second both for prestige and pay, while it was thought that a university lecturer required the highest intelligence. No engineers or technologists appeared in the first six of either prestige, pay, or intelligence rankings. The reason for this, it was suggested, may be the rather lax and inaccurate way in which the title 'engineer' is used to describe various kinds of employment. Many men who could be described accurately as craftsmen,
technicians, toolmakers, etc., seemed to be classed together by their friends and families as engineers; or as working 'in engineering'. In this way boys who are part of such families, or who visit them, tend to think that engineering and overalls are synonymous. If the term were confined to men who had obtained a university degree in the subject, or who were recognised by a professional institution, then perhaps, no difficulty would arise.

HOBBIES AND OUTSIDE ACTIVITIES Although a small percentage of the boys considered in the Oxford Study stated that their hobbies and part-time jobs influenced them in the choice of career, my experience at Ealing showed that such influences had very little effect on our boys once the applied science laboratory had been installed.

1.5 INTERNAL INFLUENCES

The influences to which a boy is exposed at school are created by the curriculum he follows and the people who teach him. These are the so called internal influences, which we will examine now in more detail.

THE CURRICULUM The Oxford Study found that as soon as a boy reached a grammar school at the age of 11 plus, he began to study subjects that were labelled and seemed to fall into little pigeon holes. Probably he found that he was able to do one subject better than another and consequently when the time came, at about the age of 15, to decide whether to enter a scientific or non-scientific course, the decision was based upon whether he had achieved success in a particular group of subjects rather than on the more distant goal of a career and qualification. Boys therefore entered one or other of the sixth-forms and studied a group of subjects that were largely prearranged for them by the school. By the time they were completing their sixth-form studies boys came to the conclusion that, since they were able to obtain higher marks in one subject than another, or one subject seemed easier to master than another, a career in that particular subject should likewise prove to be best for them. In this way many boys embarked upon careers which did not really fully exploit their particular abilities. Although the subject groupings offered in the science-sixth were capable of giving a boy entry to a university for an engineering degree course, boys did not often consider it because the subject 'engineering' was not presented to them at school. They did not feel that they knew enough about the subject, or what would be involved in such a course at the university. Alternatively, the boys wh
had achieved success with the familiar academic subjects at school wished to gain further success by studying them at the university. It seemed that boys had little enthusiasm for delving into the new and virtually unknown subject of engineering. In some cases it had been identified in their minds with craft, as taught in the lower school, and they considered themselves above taking up the career of a craftsman. On the other hand, it was thought some boys had chosen to study technical drawing and metalwork for their advanced studies at school and gained the false impression that university engineering courses would be similar.

CAREERS MASTERS The Oxford Study found that these masters were usually just members of the staff who took the job of advising boys, in addition to their normal work of teaching a subject. My personal experience has shown that in the past many of these masters did not fully understand the nature of engineering themselves and, as a result, pupils who had a definite scientific bias probably were advised to consider doing research in pure science at the university; whilst a boy whose record sheet noted that his academic subjects were not particularly strong, but who had an interest and some ability in craft most likely was advised to consider a career in engineering.

Now that schools are beginning to take a more enlightened view about engineering, and applied science and technology are being discussed and talked about more generally, careers masters are revising their thinking. A boy who specifically asks for advice about engineering probably will, in my experience, be referred to a member of the science staff, especially if the careers master himself is an arts graduate. The boy will be advised also to read the illustrated literature concerning careers in engineering, which is freely circulated to schools by most of the large industrial concerns.

SCIENCE MASTERS The Oxford Study found that many physics and mathematics masters, because they had been to the university and followed a course in pure science themselves were so steeped in pure science that they gave the impression to their pupils that the only really successful outcome to a scientific education was research. The acceptance of this view was aided by the feeling, experienced by many boys, that by taking a pure science course at a university the final decision of a career could be further postponed as it gave an opening for many careers. Unfortunately, boys
did not appear to realise that an engineering degree course also gave an excellent grounding in scientific principles and was therefore no barrier to changing to something else at a later date.

THE IDEA OF RESEARCH The Oxford Study found that boys thought research was likely to give them an exciting career and enable them to be in the forefront of new discoveries. The boys in the survey thought that research was less like ordinary work and was more likely to bring fame and fortune, although fortune was not always the deciding factor.

The Oxford Study found also that the only boys who seemed to have a realistic approach to research were those who had already decided to be applied scientists of some kind. The reasons they offered were either that they lacked the patience to do research or that they could not stand being in a laboratory all day, probably working on a minor problem for months at a time. Other boys favoured applications of science in preference to research, because they thought they were not good enough for research. Most sixth-formers it was found agreed that the best brains went into research and that to be involved was an indication of having reached the top. In fact, to carry out research within a university was considered to be the ultimate goal and to be far superior to carrying out similar work in Industry or in a Government department.
The Institution of Chemical Engineers produced a report in 1964, entitled 'The Choice of Chemical Engineering at University or Technical College'. The sample for this survey was the whole 1963 intake of students into degree courses in chemical engineering in the UK, together with comparative samples of students entering mechanical engineering and chemistry in the same year. As well as analysing in quantitative form the factors that influenced choice of subject the survey went into relevant aspects of students backgrounds.

One significant finding was that the background of students had changed since the Department of Education at Oxford had looked at the problem in 1961 and published its findings in 1963. It was found that higher education was spreading down the social scale and was perhaps likely to offer hope for engineering.

On the vital question of what influence took students into their particular career subject, the main influences were found to be as shown in the following table.

<table>
<thead>
<tr>
<th>Chemical Engineers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry teacher</td>
<td>16</td>
</tr>
<tr>
<td>People already in the profession</td>
<td>14</td>
</tr>
<tr>
<td>Literature from professional institutions</td>
<td>13</td>
</tr>
<tr>
<td>Parents</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical Engineers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents</td>
<td>14</td>
</tr>
<tr>
<td>Pre-college work in related job</td>
<td>12</td>
</tr>
<tr>
<td>Headmaster who does not teach chemistry or physics</td>
<td>10</td>
</tr>
<tr>
<td>People already in the profession</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemists</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry teacher</td>
<td>27</td>
</tr>
<tr>
<td>People already in the profession</td>
<td>10</td>
</tr>
<tr>
<td>Headmaster who does not teach chemistry or physics</td>
<td>8</td>
</tr>
</tbody>
</table>

This survey confirmed the findings of previous investigations that science teachers and school teachers exercise considerable influence on students who finally choose a scientifically based career.
In February 1964 Sir Harold Hartley gave the first Maurice Lubbock Memorial Lecture in the Engineering School at Oxford. During his address Sir Harold stated that "unless the trend among able young people to turn away from engineering stopped, a problem will be created that could rank in severity with the greatest that Britain is facing". Sir Harold went on to explain that the severity of this problem lay in the fact that the national wealth of Britain relied on engineering.

Sir George Pickering also emphasised the national importance of training engineers when he said that "The creation of wealth requires technological and scientific leadership and to this our educational Institutions are the key".

1.8 THE DAINTON REPORT

By 1968 national attention was turned towards what became known as the 'Swing Away from Science'. The Dainton Committee published figures in February 1968 that showed a steady decline in the number of entrants into science and technology faculties between the years 1962 and 1966. In 1962 45.9% of the student population studied science or technology, but only 40.6% were studying the same subjects in 1966.

The findings of this Working Party also confirmed Sir Harold Hartley's fears, expressed in 1964, concerning the threat to national wealth through the shortage of suitably qualified manpower.

Dainton suggested that the cause of the problem may, in part, be attributed to school children being deterred from studying science by

1) the distant relationship between the physical sciences and human affairs
2) the apparent rigour of science
3) the 'materialism' created by the exploitation of science and recommended modifications to the science curriculum so as to humanise it and bring the subject matter up-to-date.

The findings also mentioned the importance of giving every child the opportunity of acquiring some knowledge of technology in order to improve their general education.

1.9 THE SWANN REPORT

In September 1968 the Swann Committee, which had been investigating the flow of qualified manpower into industry, recommended the instigation of school science curriculum reform and the establishing of links between industry and the schools. The aim of this link would
be to give children the chance to learn something about the problems faced by the society in which they live.

Prince Philip perhaps summed up the great need for encouraging boys and girls to take an interest in technology and consider a career in this field during his Graham Clark lecture when he used the phrase 'The engineer is in fact the means by which the people are enabled to enjoy the fruits of science.'

1.10 RECOMMENDATIONS FOR A SCHOOL From the foregoing observations it can be seen that a school should try and help boys and girls to make a reasoned choice for their future career by giving them accurate information and advice at least and, if possible, some first hand experience of the subject in question. Able students should be made to realise that engineering has something to offer them and is not just a career for the less academically gifted.

Engineering must be shown:

a) to demand a high standard of mathematics and physics
b) to offer stimulation and challenge
c) to be just as exciting as pure science.

Although students could be told these facts by outside lecturers or enlightened school teachers, it is far better to provide some means whereby students can experience engineering principles while still at school and so be able to make their own decisions based on facts.

Since traditional grammar schools usually do not have any kind of engineering course available for their fifth or sixth-forms, it seems highly desirable and in fact of paramount importance that schools should develop some kind of applied science activity. Such work could begin in the lower school; but, since boys appear to make their decision about a career as late as possible, it seems that the best approach would be to introduce applied science, both of an academic and experimental nature, into the fifth and sixth-forms.

Once the number of able students in a school embarking on higher courses in engineering increases, the status of an engineer will rise automatically in the students' estimation. This will affect not only members of the upper school, but will create an attitude towards engineering that will permeate the whole school.
CHAPTER 2

A CRITICAL REVIEW OF METHODS DEVELOPED FOR INTRODUCING APPLIED SCIENCE INTO SECONDARY SCHOOLS

AIM
To identify and categorise the various approaches devised and used by secondary schools to introduce their students to applied science.
A CRITICAL REVIEW OF METHODS DEVELOPED FOR INTRODUCING APPLIED SCIENCE INTO SECONDARY SCHOOLS

2.1 AIM

To identify and categorise the various approaches devised and used by secondary schools to introduce their students to applied science.

2.2 INTRODUCTION

By the early 1960's schoolmasters and industrialists were becoming aware of the fact that some schools already were attempting to introduce a new type of course or activity with a view to interesting boys and girls in engineering and to demonstrate its intellectual demands.

In 1964 the Institution of Mechanical Engineers decided to initiate a survey into the extent and scope of the work being undertaken in schools with the hope of producing a document that would clarify the situation and form the basis for any further action.

2.3 THE PAGE REPORT

In the same year the Institution of Mechanical Engineers set up a small panel chaired by Dr. C.G. Williams, then Vice-President of the Institution, that secured money from their James Clayton Fund to finance this survey which was undertaken for them by Mr. G.T. Page, M.A. His findings were published under the title "Engineering Among The Schools" in August 1965. This report showed that a bewildering variety of work had been attempted. Between them, the schools appeared to have covered virtually the full spectrum of possible applied science and engineering activities.

The following paragraphs will try to categorise and outline the various approaches that have been devised.

2.4 APPROACHES USED BY SCHOOLS WITH NO SPECIAL FACILITIES

1. ENLIGHTENED TEACHING

Schools that had no extra money or accommodation for embarking on a separate applied science activity, had no alternative but to make use
of existing facilities. A few did this by means of enlightened teaching in the normal subjects mathematics and physics, supplemented by carefully planned visits to factories.  

In the report several schools made the point that the syllabus was fixed for them by the university, perhaps not ideal, but the way in which they were to teach it was left entirely to them and, therefore, they were able to show their skill by incorporating the interesting applications of science that were revealed during visits to industry.

2. INDUSTRIAL VISITS

Visits to research laboratories were found to create an interest in a particular item, such as a Wind Tunnel, and formed the basis for useful classroom work. Even visits to a local building site were reported to inspire students to cast concrete beams or make model bridges reinforced in various ways, and test them to destruction by loading.

COMMENT By giving some very simple specification, an element of inventiveness and design can be introduced into such work with a small prize, perhaps, being given for the structure that will stand up to the greatest load before breaking.

3. LINKS WITH TECHNICAL COLLEGES OR UNIVERSITIES

a) TECHNICAL COLLEGES

A few schools formed a link with their local technical colleges and together devised part-time courses for the school boys and girls which were held at the college. The duration of these courses, the report states, ranged from one afternoon a week, up to several days in succession during the school holidays.

COMMENT Such courses need careful planning and close co-operation between the staffs concerned if they are to be worthwhile. However, it does provide a means whereby the school can benefit from the know-how and equipment of the college.

b) A UNIVERSITY

An attempt has been made in the Reading area to organise co-operation between the university and a few schools wishing to undertake project work without using their workshops. The first step was to invite a few interested schools to form an 'Engineering Club' based at the university, and then setting the sixth form students the initial phase of the projects
given to the undergraduates studying engineering. This initial phase involved analysing and investigating engineering needs and the study of existing systems and components to determine their suitability for a given purpose'.

The two reasons put forward for involving schools in this kind of work are that 1) no apparatus is needed, and 2) it gives a 'feel' for engineering problems in general.

COMMENT This approach was conceived by Mr. M. Deere while he worked at Harwell and implemented when he joined the staff of Reading University. Mr. Deere recently left this University and so another enthusiast will have to be found to keep the activity alive.

4. INVITING VISITING LECTURERS

Contact between school and industry has been established in some areas by inviting outside lecturers to address the students. The report indicated that suitable lecturers were not easy to find.

One cautionary note sounded by schools inviting outside lecturers was that they did not always want the senior engineers who had reached the top of their profession, but preferred the bright engineers on the way up the tree, as their students aired the view that the senior men belonged to a different world from themselves.

COMMENT If difficulty is experienced in finding suitable lecturers it is often possible to invite old boys from a school, who have reached some standing in a particular engineering field, to return and talk to present students about their experiences and to give some first-hand advice.

SUMMARY

The approaches developed by schools without special facilities for applied science may be summarised as follows;

1) internal, but organised by school staff
2) external, but still organised by school staff
3) external, but conducted by staff from other educational establishments.

COMMENT Schools contemplating these approaches must realise that external activities involve travelling time in addition to the educational activity and may be wasteful with regard to what is achieved
ultimately.

Final evaluation must be left to individual schools who are aware of their own individual circumstances.

2.5 APPROACHES USED BY SCHOOLS POSSESSING SOME FACILITIES

These approaches can be summarised under the following five headings:-

1) A course or activity based on the craft department, organised entirely by the craft master.
2) A course or activity based on the craft department, but run by staff from this department together with staff from the mathematics and science departments.
3) A science based activity organised by a science master.
4) A formal course providing preparation for a written examination.
5) A science based course of an unexamined nature.

The approaches listed under headings 1 and 2 generally encouraged project work.

2.6 PROJECT WORK

The impetus for this approach frequently came from the staff of the metal-work department who had given up using what they considered to be 'fatuous' metal-work syllabuses and examinations. This approach has probably been the one most widely employed by schools and may further be sub-divided into three broad classifications: 10

A. Projects that lead to some form of external examination.
B. Projects leading to some form of internal assessment.
C. The unexamined project.

A. EXTERNALLY EXAMINED PROJECTS

One of the outstanding examples of this category of activity is in Dauntsey's school, Wiltshire. Since 1961 this school has had an examined project attached to its 'A' level physics examination set by the Cambridge Board. A good project can raise a boy's 'A' level mark in physics by as much as one grade. The master responsible for initiating the scheme thought that this bonus would help to make the course worthwhile and also give the work some status in the boy's estimation. 102

Project work at Dauntsey's is started in the lower school with a
course in metal work. The difference between metal work and engineering is clearly explained at this stage. In the following year there are optional engineering periods with group projects, to design and construct something useful for the school. Examples of projects tackled at this stage include an overhead projector and an electronic clock.

A fresh start is made at sixth-form level. The first half term is spent on a short project to give the boys experience and to enable them to think of subjects suitable for their main work. Recent projects have included:

a) Thermal insulating qualities of building materials.
b) Air flow over a wing section, involving the construction of a wind tunnel.
c) Acoustic reverberation of different rooms.

Once the project for the main work has been selected, it must last four terms and is normally taken by all boys studying mathematics and physics at 'A' level. The report on the finished work includes notes on the construction of the apparatus, the performance of the ensuing experiment and any conclusions that can be drawn from the exercise. The report is then submitted to the external examiner for consideration. After giving each report due thought, the examiner visits the school and gives each boy a half-hour oral examination.

OBSERVATION As the know-how in all fields is unlikely to be possessed by the master, the students have to make enquiries outside the school. This type of work is thought, by the schools that provide it, to develop interests in topics not covered, or too modern to be, in the usual school text books. It is also thought it will help able boys and girls to see the challenge of engineering and encourage them to take engineering at the university.

COMMENT The success of this type of work depends to a great extent on the master in charge. He must vet very carefully the choice of a project submitted by a student, so that the subject chosen will extend the boy or girl but not present any insuperable problem, and also be within his or her scope, visualisation and constructive skills. It is also necessary that the laboratory in which this work is done should be well equipped.
B. INTERNALLY ASSESSED PROJECTS

A good example of this category of work originated at Danum Grammar School, Doncaster.

Sixth formers are encouraged to undertake a project on which they are allowed to spend one afternoon each week throughout the two year period of their 'A' level course. These students are expected to work in the library, laboratory or workshop according to their needs, and to visit Firms and Universities whenever serious difficulties arise.14

A typical project would involve the design and construction of an uncommon piece of apparatus which is then used in the science laboratory to explore a scientific problem. Recent examples have included an electronic timing device and a photoelectric alcoholometer.

The final pieces of work are internally assessed and might qualify the student responsible for a prize on speech day.

OBSERVATION The Headmaster of Danum Grammar School, Mr. E. Semper, believes that this approach enables students to see the inter-relationships that exist in science and so enlivens the process of learning.

COMMENT This approach is probably very good while the number of students involved is small. If the student numbers reached 20 or 30 it would be difficult to keep track of each individual as the technique could easily be abused by those merely interested in a 'free afternoon'.

C. UNEXAMINED PROJECTS

A good example of an activity that encourages unexamined projects is the scheme developed in the Technical Activities Centre at Sevenoaks School.15,16,38

Pupils meet the centre compulsorily at the 13-plus stage, when they have a double period each week. At the lower-sixth level, one of the options is three periods a week in the centre; up to twenty boys can take advantage of this offer. However, the main activity takes place after school, on a voluntary basis, and is held each weekday evening until 6p.m., and is available to boarders at the weekend. This
out-of-school part of the activity is organised within the framework of a club called VISTA (Voluntary and Independent Scientific and Technical Activities) to which boys become eligible after entering the upper fourth. During the club periods the master in charge is available for supervision and advice, but a limited amount of work is also permitted outside club periods if it does not require supervision. Membership of this club is limited to 80 boys, but only about 20 of these avail themselves of the facilities on any one evening.

The Centre also acts as a venue for discussing testing or developing anything that is new in the boys own world of science and models, many of the ideas for which come from the journals or magazines displayed in the reading room. The activities undertaken are never considered to give any kind of vocational training; in fact they are looked upon as a new dimension within a liberal education.

Before a boy may tackle a project, certain courses have to be taken and passed. In this way no boy begins without sufficient knowledge to carry it through. These courses include such things as introductory mechanics, engines, model boats, electronics, etc. As an example: suppose a boy wishes to make a radio-controlled boat. Before being allowed to construct it he would have to study the elementary principles involved by following both the course on model boats and on electronics. Once he has passed the relevant course, tested by a few oral questions, he is permitted to tackle an open-ended project in his own way. The simplest project may be little more than a model, while the most sophisticated make a high demand on scientific principles. Examples of this type of project are an air cushioned monorail and a radio-controlled hydrofoil boat. The master in charge considers the Centre to be a medium for creative thinking. He also feels that it introduces boys to topics for which there is very little room in the normal syllabus and develops qualities which are all important in technology and science, but that do not always show up in examination results. These qualities, he thinks, are initiative, enterprise, endurance, originality and inventiveness.

A CRITICISM AND REPLY One criticism made against the Centre is that the trial and error amateurism that so often marks the boys private technical efforts at home is being given a degree of official sanction that would reduce their accuracy in class-work. The Centre's reply is
that it discourages the happy-go-lucky approach (one of the reasons why they compel boys to spend some time on the necessary theoretical groundwork before they start a project) but believes a certain amount of inspired amateurism can be of great value when entering an unknown field of investigation.

2.7 SCIENCE BASED ACTIVITIES

A number of schools provide science based applied science activities that are neither projects nor formal courses. Such activities may give boys and girls the chance to operate a radio club or view films describing industrial techniques and processes.

One of the most publicised science based activities is the satellite tracking work carried out at Kettering Grammar School. This is an extra-curricula programme in which all students are encouraged to take an interest; but only selected students participate.

The work began in 1957 with a group of enthusiasts taking a general interest in the idea of satellite tracking. Some years later the construction of equipment capable of receiving radio signals from satellites was undertaken, at a cost of £50, using the surplus market as the source of supply.

Boys in the school maintain a continual radio watch throughout the weekends and holidays as well as within normal school hours. In 1966 the group were the first to disclose the location of a third Russian launch site somewhere south of Archangel.

COMMENT This particular example is highly specialised and may be of great value to the boys actually involved, but the programme seems unlikely either to help the vast majority of students at the school to see the relevance of examination science to the outside world, or to give them an insight into the many branches of engineering that might provide them with a career.

2.8 PREPARATION FOR A WRITTEN EXAMINATION

This fourth main approach is orientated around some form of established examination, the idea being that schools think the students will work better if they are aiming to achieve some kind of tangible result at the end.
The examinations chosen by the schools were not usually recognised by a university as being qualifications for embarking on a university engineering degree course as they were, in most cases, either of a geometrical or mechanical drawing nature. Some syllabuses having more scientific content are published by the AEB, JMB, and the Oxford and Cambridge boards. These syllabuses are examined at 'A' level by means of papers whose titles are shown in the table below.

<table>
<thead>
<tr>
<th>Examining Board</th>
<th>Name of Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEB</td>
<td>Engineering Science</td>
</tr>
<tr>
<td>JMB</td>
<td>Engineering Science</td>
</tr>
<tr>
<td>Oxford</td>
<td>Engineering</td>
</tr>
<tr>
<td>Cambridge</td>
<td>Elements of Engineering Design</td>
</tr>
</tbody>
</table>

The AEB and JMB syllabuses may be regarded as alternatives to physics while those published by the Oxford and Cambridge Boards, complementary to physics. These latter two do not purport to provide basic entry qualifications for a university engineering degree course and may be more suitable for use with non-university bound students, or as an extra 'A' level for students already taking mathematics and physics.

The AEB syllabus is regarded by approximately half of the universities as acceptable for students seeking entry to their science or engineering departments while the JMB syllabus is now accepted by all university physics and engineering departments and most medical departments, as a suitable entry qualification.\textsuperscript{18}

The JMB course in engineering science, first examined in 1969, is perhaps the most highly developed in that both the practical work and the written examinations are significantly different from previous examinations in this field. All candidates are required to submit reports for assessment on three experimental investigations and a project. Each investigation occupies approximately 10 hours of laboratory time while the project is expected to take 50 hours.

A typical investigation could involve the tensile properties of a new polymer with the student being expected to 1) decide what to measure, 2) to determine the information, 3) obtain the observations and then make an appraisal of his approach and findings.
The project is expected to make a heavier demand on the students' conceptual ability than the investigation and could take the form of designing and building a small engine test-bed.

This new approach to practical work is balanced by a similar development in the theory. The final written examination consists of two 3 hour papers. Paper 1 is broken down into 3 one-hour sections entitled, 'Knowledge', 'Engineering Comprehension' and 'Project Design', with paper 2 covering engineering analysis. The comprehension test presents the candidate with an engineering article of approximately 1,000 words and seeks to determine his understanding of the text, diagrams and mathematical analysis, while the project design exercise requires the candidate to plan the early stages of an investigation of the type mentioned above.

OBSERVATION One of the immediate difficulties facing the few schools who have attempted to teach the new JMB syllabus is the lack of text books which consider the wider implications of the subject. In order to solve this problem the Engineering Science Development Unit has been set up by the Schools' Council and Loughborough University of Technology.

COMMENT Schools will require a lot of help in setting up the prescribed practical work and a considerable amount of inservice teacher training will be needed before the average science teacher will feel competent to prepare candidates for this examination.

2.9 AN UNEXAMINED COURSE

This approach offers some form of theoretical/experimental course with formal instruction being provided by a member of the staff. The work may be undertaken either in school time or after school as a compulsory or voluntary activity, but is never examined either internally or externally.

One of the best known examples of this approach has been developed at Ealing Grammar School. Their voluntary course was devised so that sixth-form boys studying science could experience some of the rigours and disciplines of engineering while still at school, so giving them a better chance to reach the correct decision regarding the nature of their future university course. Full details of the Ealing scheme are given in the next chapter. (Page 29)
Such courses, if not carefully constructed, can overemphasise an individual teacher's personal interests and may not necessarily provide a balanced introduction to applied science for the participating students.

2.10 APPLIED SCIENCE IN THE LOWER SCHOOL

Although many of the approaches to applied science teaching outlined in this chapter have been developed for use with the sixth-form, some of them have extended down into the lower school. In the main, however, schools find that their most able boys, while in the lower school, are unable to spare much time for applied science as they are too busy taking 'O' level courses. For this reason the majority of lower school applied science activities are offered to the less academically gifted boys. This state of affairs has aroused concern in the minds of several schoolmasters on two counts: first they feel that the most able boys will automatically associate applied science with 'second class minds' and secondly, still have to decide upon the nature of their sixth-form course without any first hand ideas about the true demands of engineering.

At first sight these seem justifiable reasons for concern, but schools with a thriving sixth-form activity in applied science have found that these difficulties have not materialised. Three schools* have arranged their staff teaching time so that the masters responsible for the sixth-form applied science activity take at least one, and perhaps two, forms in the lower school for physics or mathematics. In this way the natural enthusiasm of these masters for applied science soon permeates to the younger boys who become quite excited about engineering long before they reach the sixth-form. Such schools have also, either working models displayed in the building - made by boys engaged in the project approach - or a laboratory containing exciting apparatus such as a heat engine or hydraulic bench. Even a short visit once a term to such a laboratory has been found to instill in these younger boys a strong interest to learn about applied science, whenever they have the opportunity.

2.10.1 SOME APPROACHES ADOPTED

Unfortunately very few schools are in possession of special laboratories and those without have developed their own ideas of applied science for the lower school, which generally has been based on Dauntsey's, Ealing, Sevenoaks.
on the craft department. The efforts made by schools to interest the younger boys in engineering may be summarised under the following five headings:

1) Timetabling metal work and technical drawing for the first two years only and then allowing the boys to carry on with these subjects on a voluntary basis, or in conjunction with some form of project work.

2) Taking formal metal work and technical drawing courses to 'O' level - perhaps continuing to 'A' level in some cases - even though the staff do not really approve of the syllabus.

3) Developing their own programme of studies based on the workshops but relevant to science teaching. Wallingford Grammar has encouraged the making of scientific models, or models that illustrate some simple engineering principle. The design and sketching for these models being carried out in the technical drawing periods in the hope that a close and realistic link will develop between the workshop and the drawing office.

The idea of producing an object for a fixed price and within specified limits of accuracy has been tried in a number of schools, such as Oundle, in an endeavour to try and introduce an Industrial atmosphere to an otherwise routine exercise.

4) Writing their own 'O' level syllabus and then attempting to have it recognised by an examining board.

One example of this approach originated in Danum Grammar School, Doncaster, when they wrote an Applications of Physics paper and had it accepted for an 'O' level examination by the Cambridge Local Syndicate Examining Board. This syllabus was taught as a course running parallel to the usual 'O' level physics. The Headmaster, Mr. Semper, felt that boys derived the greatest benefit from this syllabus by acquiring a good background knowledge in readiness for embarking on an 'A' level physics course.

COMMENT This syllabus still exists but had to be dropped from Mr. Semper's own school when reorganisation, associated with comprehensive education, reached his school a year or so ago.
Preparing children for a CSE Engineering Science examination. The syllabus for such an examination frequently overlaps the corresponding physics syllabus; the only significant difference in those offered by the Southampton Board, for example, is that candidates are required to undertake a small project as part of their assessment for the engineering science examination. One such project involved building a simple telescope.

COMMENT Some teachers I have spoken to are not very happy about the examination as they feel that insufficient distinction is made between pure science and engineering.

SUMMARY Many of the applied science activities provided for pupils below the sixth-form are based on the craft department and attempt to provide the most realistic outlook towards the world of engineering, that is possible in the prevailing circumstances. The few relevant 'O' level science based examinations are not widely used and many of the newer ones are written for pupils working at CSE level.

2.11 THE DILEMMA OF SCHOOLS TRYING TO START AN APPLIED SCIENCE ACTIVITY

With these widely different applied science activities now working in England, schools wishing to start some sort of applied science scheme for themselves tend to look at those that have been set up already. Then they try and decide which one to emulate, or at least upon which one to base their own ideas. These beginners must decide first whether they want their activity to begin in the lower school or in the sixth-form. At first sight it might seem better to begin in the lower school, so that the students can make a reasoned choice between the arts and sciences at sixth-form level; however, in practice, the most able boys in the lower school are often unable to spare time for a new subject owing to the high demands already being made upon them by preparation for the 'O' level examination. If then the applied science is to begin in the sixth-form, it may be thought that it would have little or no influence in the lower school. It has been found, however, that there can be a moulding of a lower school boy's attitude towards applied science if imposing apparatus is in evidence.

2.12 PROVISION OF HELP

In order to help schools willing to develop applied science schemes,
the Schools Council - in 1966 - decided to sponsor a small pilot project to examine in detail the teaching of applied science in certain schools and then to make a recommendation for a major development project in this part of the curriculum, if one appeared to be required.

The plan involved five regional groups, with twelve schools in each; most of them schools where interesting work in applied science had been developed. In addition, there were a few schools in each group where this type of work had not yet been started.²¹

The principal aim of the pilot project, which lasted one year, was to analyse the experiences of these selected schools in terms of curricular content, staff, accommodation, expense, etc.

The pilot project report entitled 'Technology and the Schools'²² published in 1968 confirmed the existence of many different approaches to the introduction of applied science into the schools. It further revealed that 50% of the experienced schools had their applied science activity based on the technical or handicraft department, and that in only 25% of the schools were the science staff responsible for the initiative.

The report also pointed out that two of the major difficulties that prevented schools from beginning applied science were the lack of suitable teachers and inadequate school accommodation for project work.

A recommendation was made for the preparation of new teaching material by small teams of teachers working under local Development Leaders.

On the basis of this report a major three year curriculum development project was established in 1967 entitled Schools Council Project Technology. During this period twenty nine regional groups of schools were formed with each group containing schools in the following three categories:-²⁴,¹¹⁵

a) Trial Schools - those in which new material could be tested.
b) Consultative Schools - those already having experience.
c) Associate Schools - those with no experience but who wished to begin an applied science activity.

1,000 Associate schools were found and Project Technology made
every effort to help the teachers and children in them to 'become aware of the technological forces in society', by organising conferences, arranging local committees to interchange ideas, and distributing printed material containing suggestions and sources of help.

The Schools Council recently agreed to extend Project Technology for a further two years, until September 1972, by which time £274,000 will have been spent on this programme.

Between late 1971 and early 1973 Project Technology expects to contribute a wide range and variety of teaching material that has been identified as meeting a real need in the schools. This new material has been evaluated in the trial schools, re-edited by Project Technology and submitted to a number of leading publishers. Typical titles in the series of guides, expected to be published, are 'Introducing Fluidics' and 'Design with Plastics'.

2.13 EVALUATION

With such a complex pattern of approaches how can one school measure the success of itself or another? One yard stick is the number of students leaving the school to proceed to a university course in engineering. Unfortunately many of the schools embarking on applied science courses are themselves new, or else the courses have run for such a short time, it is difficult to produce any really definite conclusions.

Whatever evaluation technique is used it is important to try and estimate the separate value of the approach and the teacher. Even the most modest approach can achieve success when used by a dynamic and knowledgable teacher and fail miserably when taken over by 'more ordinary' members of the teaching profession.

2.14 SUMMARY

The approaches and techniques developed by schools have arisen through Headmasters and individual teachers attempting to implement their own ideas, with regard to applied science, either by using the facilities available - however limited, or by breaking new ground.

In some schools applied science activities have grown out of existing metalwork or technical drawing courses, while in others the new work has been carefully devised to fulfil a particular educational
Whether the resulting activity is craft based, science based, examined or unexamined depends very largely on the organising enthusiast's own interests, ability and educational views.

2.15 CONCLUSION

Schools must realise that there is no declared 'right way' of introducing applied science into the curriculum.

Assessing the merits of the numerous approaches that have been devised must be very difficult for teachers sitting on the side lines waiting to enter the arena of applied science teaching resulting, perhaps, in them remaining sitting. Unfortunately each prospective teacher in the field has to weigh his or her own skills with the money and facilities available in their school, and then choose the approach which is most satisfactory for them.

Even with the help of the new teaching material being produced by development units such as Project Technology it seems that many years will pass before an individual teacher's enthusiasm ceases to be the governing factor for introducing and maintaining an applied science activity in a school.

Unless a school creates small teams of masters or mistresses who are competent to organise applied science such individualistic work will probably fail to survive the inevitable changes of staff.
AIM

To describe the research and preparation that went into the development of what became the first applied science laboratory and course, presented in an English grammar school.

Evidence will also be offered to show that this new scheme fulfilled its stated purpose.
3.1 INTRODUCTION

The idea of introducing some form of applied science course into the sixth-form science department of a grammar school first occurred to the Headmaster of Ealing Grammar School for Boys, Mr. A. Sainsbury Hicks, as long ago as 1948. The reasons for suggesting the introduction of such a revolutionary kind of course derived from following the early careers of boys who had passed through the sixth-form at the school and then had proceeded to a university.

The Headmaster had noticed immediately upon his appointment to the school in 1946 that a large number of the boys wanted to read pure science at the university. Upon following their careers he discovered that most of the boys who studied physics, chemistry, or indeed mathematics, filled posts when they left the university which led them into Industry. The boys found too that very often, despite their pure science training, the nature of their employment made them become applied scientists of some kind. For this reason many of them had to reorientate the whole of their science two or three years after leaving university, to make them effective people working in factory production.

3.2 INFLUENCE OF THE ENVIRONMENT

Ealing Grammar School is situated in the county of Middlesex and the Headmaster was aware of the fact that, at that time, the highest figure for juvenile employment in Middlesex was in component factories. Therefore, it seemed reasonable to him that a grammar school which was placed in an environment of employment that was weighted heavily towards 'engineering' should take notice, in some measure, of this conditioning factor. By referring to the list of school leavers, the Headmaster found that over half of the boys who left Ealing at the age of 16 went into 'engineering' either as craft or student apprentices, mostly the latter. Of the student apprentices, an appreciable number would have stayed at school, he thought, and would have proceeded to a university to read for an engineering degree, if there had been provision
for them in the school. This provision, he felt, also would have an immediate appeal for the very able boys who might not be attracted by a pure science course in the sixth-form when there was no prospect of getting to grips with subjects that obviously were of a professional kind. Appendix 1.

These were the two factors that really made the Headmaster think that it would be a profitable thing for boys to be exposed to some kind of pre-conditioning course, relating to engineering, whether they were planning to become engineers or not.

3.3 FIRST STEPS TOWARDS CREATING A COURSE

I joined the School in 1954 as an assistant physics master and was immediately captivated by the idea of an applied science course and became associated with the Headmaster in the early stages of its development. It was in the same year that Mr. Hicks made a successful approach to the local education officer for permission to develop such a course.

3.4 THE AIMS OF THE PROPOSED COURSE

The Headmaster and I decided that the proposed course should fulfil the following requirements:-

1. Encourage more of the academically able boys to consider becoming professional engineers.

2. Demonstrate that a career in engineering can be exciting and intellectually rewarding.

3. Help boys of only average ability to realise that engineering, as practised by professional engineers, is not closely related to a school craft department.

3.5 THE PROBLEM OF INSUFFICIENT LABORATORY SPACE

At the same time as plans were being made to introduce some form of engineering course into the school it was becoming apparent that additional science laboratories were needed urgently to cope with the large number of boys that were entering the sixth form to study science.

As two of the existing three school laboratories were on the ground
floor and the third one was on the second floor, the science staff
favoured the building of a new science block in order to keep all
the laboratories in close proximity.

3.6 THE FIRST MEMORANDUM TO THE MINISTRY (1955)

Following the successful approach to the Local Education Officer,
the Local Education Committee asked the Headmaster to prepare a
memorandum that could be submitted to the Ministry of Education.

The gist of this memorandum was that the school was established
in 1913 to provide secondary education up to sixth-form level and had
been enlarged only once, in 1936. The extensions at that time provided
a gymnasium, a library, two additional classrooms, and a stage addition
to the existing assembly hall. During the years since the war the
sixth-form numbers had risen from 18 in 1946 to 88 in 1955, the students
being evenly divided between the arts and economics on one hand and
science on the other. The laboratory provision for school science teaching
for the whole school was the same then as when the school was opened,
namely, one chemistry laboratory, one physics laboratory, and one
elementary laboratory. However, in spite of this, during the three-year
period (1953-1955) the science department turned out 10 State scholars
and three Open scholars, all devoted to pure science. The existing school
premises were at that time over 5,000 sq. ft. of teaching space short
of that required under the building regulations for a three-form entry
grammar school. The proposed extension would consist of two main
blocks, one to house a gymnasium and the other a three-storey engineering
and science block. In the engineering block it was proposed to establish
a laboratory in which boys could receive some pre-exposure to engineering
thinking as an extension of their mathematics and their physics, even if
they were not considering becoming engineers. However, if they embarked
on their sixth-form pure science course with the intention of eventually
becoming engineers, it might be a very good thing for them to find out
what is entailed, because they might discover, before it was too late,
that engineering was not what they thought it was at top level and,
therefore, it was not the sort of thing to which they could devote their
lives. Furthermore, boys who were setting out on their advanced level
course to become pure scientists might find applied science in an
engineering laboratory, of the type we proposed more attractive. Thus
we would be filtering into a much under-provided profession top level
brains.
As a result of this memorandum, the scheme was accepted in principle and early in 1956 the County Architect was instructed to prepare plans for the extension of the school. (Page 43)

3.7 ADVICE FROM UNIVERSITIES AND INDUSTRY

Before the Ministry of Education would finally agree to an engineering course being provided at the school they required details of the equipment to be installed and an outline of the material to be taught.

As the Headmaster believed that it would have been unwise to base the content of the proposed course on his personal whim or my particular engineering interest, we decided to consult organisations directly concerned with engineers and engineering education.

Advice was sought from, and given by, many industrialists and engineering departments but direct assistance was provided by Dr. C. G. Williams ('Shell' Research Ltd), Professor Saunders (now Sir Owen Saunders) and Professor Christopherson, (Heads of the department of Mechanical Engineering at Imperial College, London), Professor Pope and his staff (Mechanical Engineering Department, University of Nottingham) and Professor H. Wright-Baker, (Head of the Mechanical Engineering Department, Manchester College of Technology).

3.8 THE SECOND MEMORANDUM TO THE MINISTRY (1957)

After spending more than one year collecting information and receiving advice it was possible to write a second memorandum to the Ministry of Education confirming our philosophy and giving an outline of the apparatus and subject matter to be used.

PHILOSOPHY The consensus of opinion obtained from industrialists and professors of engineering was that the proposed course should give potential engineers the benefit of some engineering studies and so arouse their curiosity about engineering principles.

We were strongly advised not to specialise in any one field of engineering but to devise a course that emphasised the intellectual problems and would integrate with the existing school science programme.
Everybody consulted was anxious that we should not produce ingenious mechanics, however skilled with their hands, but present the cultural possibilities of applied science in the hope that a larger number of able students would consider becoming professional engineers.

A LABORATORY Professor Wright-Baker and Professor Pope thought it was essential to teach the proposed new course in a special applied science laboratory in order to give engineering, in the eyes of the boys, the same status as the other school science subjects.

Professor Wright-Baker suggested that this laboratory should be called 'The Experimental Methods Laboratory' and contain equipment that students could use to obtain data for interpretation.

SUBJECT MATTER So that the course would not concentrate on any particular field of engineering Professor Pope suggested that the subject matter presented should give a suitable background to all the specialist branches of engineering. This, he thought, could be achieved by offering elementary hydraulics, heat engines, strength of materials and electronics. Experimental work together with relevant theory, would form a four prong attack in a two year course for sixth form boys studying science.

APPARATUS As the existing commercial equipment for teaching hydraulics and heat engines was too large and expensive for use in schools, the University of Nottingham offered to lend us some working drawings of a special hydraulics bench they had designed, so that we could arrange to have a similar unit made for ourselves. The University offered also drawings of apparatus for demonstrating some static and dynamic applications of applied mathematics.

In case we should experience difficulty in placing an order with a local metal-fabricating company, Professor Pope had persuaded a Nottingham firm - Tecquipment Ltd. - to undertake the work on our behalf.

Dr. C.G. Williams was willing to involve Shell Petroleum Ltd. in helping us to build a miniature engine test bed that would enable all the normal tests and measurements associated with full size equipment to be made.

FINANCE The Local Education Authority agreed to finance the building of one of each of the units shown on the drawings offered by the
University of Nottingham, while Shell Petroleum Ltd. offered a grant from their education fund to assist with the building of the miniature engine test bed and to buy any additional pieces of the Nottingham apparatus that we felt would be of assistance.

The outcome of this memorandum was a meeting at Ealing Grammar School between the Headmaster and representatives from the Ministry of Education which resulted in the full acceptance of the course and the promise of money to build a new science block at the school containing a completely new type of laboratory to be known as 'The Experimental Methods Laboratory'.

3.9 CONFERENCE AND EXHIBITION OF THE NEW EQUIPMENT

Towards the end of 1958 Mr. Hicks was encouraged by HMI's to convene a conference of education administrators, headmasters, inspectors, and science masters to view the special apparatus and hear Professor Pope give a lecture entitled 'Sixth-form Science and Technology Development'. This conference, held at Ealing Grammar School in October 1958, was opened by Dr. C. G. Williams and was attended by people who had assisted in the development of our scheme and representatives from all types of secondary schools.

In the course of his address Professor Pope emphasised that an engineer not only needs an understanding of the basic principles equal to that demanded by pure science, but also requires, if anything, a greater understanding and greater aptitude for the experimental method and experimental technique. He pointed out also that there is a world of difference between being able to apply a theoretical principle to answer an examination question and having such confidence in the principle that, later in life, you will risk your professional reputation by applying it to an actual design. Professor Pope made it clear that, although an experimental approach demanded more time from both students and teachers than normal classroom instruction, it was well worthwhile, as the future of this country rested in the sixth-forms of today.

The hydraulic bench exhibited at this conference was the prototype of a completely new design that did not require any mains water services or complicated installation and superseded the one shown on the drawing that we were first offered. The whole unit stood on the floor and had its own 50 gallon water supply that was lifted from the supply tank to the
experimental apparatus on the bench top by an electric pump. Fig 1.

The miniature engine test bed is shown in Fig 2.

This conference aroused a good deal of interest, but also produced its fair share of criticism. Although everybody was not entirely in sympathy with our scheme, they seemed to be glad that somebody had taken a positive step.

3.10 OFFERING THE COURSE

In September 1960 the school was in the unique position of being able to offer the boys in the science sixth-form a pre-university engineering degree course. The immediate decision that had to be made was where to fit this new course into the school programme. Since all the periods on a science sixth-former's personal time-table were filled by his academic subjects, games and general studies, it was quite clear that the engineering course could only be included within the normal teaching hours at the expense of some other profitable activity. As the whole idea of the scheme was to augment the boy's scientific outlook without reducing the number of periods normally devoted to his academic subjects, it was decided to present engineering as a voluntary course to be held after school from four until five thirty p.m. on two evenings a week. The nature and purpose of the new course was fully explained to the entire science sixth-form. It was made quite clear that the content would be treated seriously, but as a non-examination subject and would involve the boys in both theoretical and practical work. The lower sixth were given the chance to learn something about hydraulics, thermodynamics, and strength of materials, while the upper-sixth were offered the opportunity to become acquainted with electronics. After the introductory talk, the boys were left a completely free choice to enrol for these courses if they wished, the only condition of entry being that they must keep up their attendance throughout the year.

With this free choice 50% of the boys, which amounted to 24, elected to attend. The 1 1/2 hours devoted to the work each week was divided into a half-hour teaching period, followed by an hour of practical work. However, in the first few meetings of the year it was necessary to increase the length of the teaching period so that sufficient theory could be covered to reach a standard at which the experiments would be beneficial. It was our practice only to allow the boys to tackle experiments on the hydraulic bench and with the miniature engine test-bed when they understood the principles involved, which took several weeks. Fortunately, however,
Fig. 1. The hydraulic bench designed by Dr. Markland especially for use in the applied science course at Ealing Grammar School.
Fig. 2. The first miniature engine test bed. This unit enabled several interesting experiments to be carried out by the boys attending the applied science course at Ealing Grammar School.
the static and dynamic experiments could, in conjunction with a carefully prepared work sheet, be given to an intelligent sixth-former without a great deal of previous preparation. When an experiment had been completed, the boys were only expected to write a very short account of their procedure, the emphasis being on the presentation of results and graphs. In this way the drudgery of 'writing-up' was reduced to a minimum.

3.11 STAFFING THE COURSE

Advanced work of the kind described, especially on a voluntary basis, can only be undertaken successfully with enthusiasm and co-operation from the staff concerned. Very fortunately, all the masters in the physics department were interested in the Experimental Methods Laboratory and were pleased to offer their services to assist with its smooth running. In this way it was possible to have two masters present at each practical session. By way of compensating for the private time sacrificed, when assisting in the Experimental Methods Laboratory, the members of the physics department were given an additional free period each week during the normal teaching day.

3.12 EFFECT OF THE COURSE ON THE BOYS

This applied science course ran on a voluntary basis for five years and the percentage of boys in the science sixth who elected to attend rose steadily each year. At the end of 1965 one boy gained an Open Scholarship to Oxford University in Engineering. In 1966 the percentage rose to 75 which meant that a total of 57 boys attended, made up of 32 from the lower sixth and 25 from the upper sixth.

During 1966 the policy of the school changed and the timetable for 1967 was arranged so that each student only took three subjects at 'A' level as compared with four in the previous years. The extra time gained meant that the applied science course could be offered within the normal teaching day, but still be on a voluntary basis. This policy change did not increase the numbers attending by any significant amount.

The number of boys whose decision, by their own admission, to study for an engineering degree as a direct result of interest stimulated by the applied science course is shown in the table below. All the boys have been awarded an engineering degree, and five of them have achieved first class honours, including one boy who also gained a gold medal from the University of Leeds.
### 3.13 CONCLUSION

These results suggest that the course is successfully achieving its aim of proving to the able sixth form boy that a career in engineering can be worthwhile, interesting and rewarding. On the other hand at least three or four pupils each year have told me that the course has prevented them from embarking on an engineering degree course, which perhaps was not suitable for their particular abilities, by correcting misconceptions about the subject before a decision was made.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF BOYS ENTERING UNIVERSITY ENGINEERING DEPARTMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>0</td>
</tr>
<tr>
<td>1960</td>
<td>1 <strong>&lt;--- APPLIED SCIENCE INTRODUCED</strong></td>
</tr>
<tr>
<td>1961</td>
<td>6</td>
</tr>
<tr>
<td>1962</td>
<td>4</td>
</tr>
<tr>
<td>1963</td>
<td>7</td>
</tr>
<tr>
<td>1964</td>
<td>5</td>
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<td>1965</td>
<td>12</td>
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<tr>
<td>1966</td>
<td>15</td>
</tr>
<tr>
<td>1967</td>
<td>20</td>
</tr>
<tr>
<td>1968</td>
<td>20</td>
</tr>
<tr>
<td>1969</td>
<td>18</td>
</tr>
</tbody>
</table>
The University of Warwick has recently offered combined first year courses for students interested in Physics/Engineering Sciences and Mathematics/Engineering Sciences. The aim of these courses is to give the students a better chance of selecting their field for specialised study.

The table below shows the number of students choosing the separate disciplines at the end of their first year.25

<table>
<thead>
<tr>
<th>PHYSICS/ENGINEERING SCIENCES</th>
<th>2nd YEAR CHOICE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHYSICS</td>
</tr>
<tr>
<td>SESSION</td>
<td>NUMBER OF STUDENTS ENTERING THE COURSE</td>
</tr>
<tr>
<td></td>
<td>1968/69</td>
</tr>
<tr>
<td></td>
<td>83*</td>
</tr>
<tr>
<td>1968/69</td>
<td>27</td>
</tr>
<tr>
<td>1969/70</td>
<td>24</td>
</tr>
</tbody>
</table>

+ 8 students withdrew from the university and 1 transferred to Economics before the end of the year.

* 11 students withdrew from the university and 2 transferred to other courses before the end of the year.

<table>
<thead>
<tr>
<th>MATHEMATICS/ENGINEERING SCIENCES</th>
<th>2nd YEAR CHOICE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>MATHEMATICS</td>
</tr>
<tr>
<td>SESSION</td>
<td>NUMBER OF STUDENTS ENTERING THE COURSE</td>
</tr>
<tr>
<td></td>
<td>1968/69</td>
</tr>
<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td>1968/69</td>
<td>2</td>
</tr>
<tr>
<td>1969/70</td>
<td>7</td>
</tr>
</tbody>
</table>

* 3 students transferred to other courses before the end of the year.

DEDUCTION. The figures suggest that a high percentage of students find they enjoy the rigours of engineering when they have the chance to meet the subject at first hand.
CHAPTER 4

AN INVESTIGATION INTO THE DESIGN OF PURPOSE BUILT SCHOOL APPLIED SCIENCE LABORATORIES

AIM

To study five schools that were pioneers in the field of introducing teaching facilities for applied science, making special reference to the laboratories they established and the factors that influenced the designs.
4.1 AIM

To study five schools that were pioneers in the field of introducing teaching facilities for applied science, making special reference to the laboratories they established and the factors that influenced the designs.

4.2 EALING GRAMMAR SCHOOL

In 1954 the Headmaster of this school made a successful start towards initiating what became the first applied science laboratory in an English Grammar School. (Page 32)

At the same time, the school's science department was desperately in need of additional laboratory accommodation so the development of the new applied science laboratory became interwoven with a proposed extension to the school building, needed to accommodate the increasing number of pupils entering the school.

4.2.1 ACQUIRING LAND

As the school was on a very small site which offered strict limitations to expansion, (playground area only 2,000 square yards) planning permission had to be obtained to use part of the parkland, adjacent on two sides, before the building of the much needed extension, including an applied science laboratory, could be considered. It was hoped also to increase the playground area by incorporating the garden of a vacant house which was adjacent on a third side. This latter idea presented serious difficulties because the house was classified as being of aesthetic value.

4.2.2 SITING THE APPLIED SCIENCE LABORATORY

At the beginning of 1956 the Middlesex Schools Sub-Committee approved in principle the recommendation for the building of a two storey extension at Ealing Grammar School containing the accommodation listed overleaf.
The Applied Science Laboratory was initially positioned on the first floor of this building and separated from the advanced physics laboratory by a preparation room. As no suitable candidate applied for the position of 'engineering laboratory steward', advertised before the applied science laboratory was built, the then senior science master of the school decided to ask for the applied science laboratory to be placed on the second floor and have the general science laboratory moved from the second floor to the first floor. This arrangement he believed would enable the existing laboratory technician to service two laboratories with the minimum of movement around the building.

4.2.3 APPARATUS TO BE INSTALLED

After the Headmaster and I had consulted members of university engineering departments* and decided that the subject matter to be taught in the proposed course should be, strength of materials, hydraulics, heat engines and electronics it soon became apparent that the only portable apparatus would be that associated with the materials and electronics sections. This meant that provision had to be made, within the laboratory, for a hydraulics bench and for mounting a small internal combustion engine.

4.2.4 THE FIRST PLAN

The first floor-plan of the proposed applied science laboratory is shown in Figure 1.

The fixed hydraulic bench was to be 26 ft.long, 2 ft. 9ins.width and 3 ft.high with a finished surface of clay tiles. Such a bench allowed sufficient space for four complete student fluid units. Each unit was designed to have an individual water supply pipe, and a drain-port in the bench top. This latter pipe would enable water to be piped from the apparatus on top of the bench to a balance under it and thence

* See page 33.
Half round Channel

Hydraulic Bench
Grano or Clay Tile

4½" Wall under

Blackboard

Rest of Cupboards - tops form bench

Floor: Grano
Walls: F.F. Brick

Shelf for Models

fig.1

Engineering Laboratory Plan

1/4" =
The water supply for the apparatus was to come from a 40 gallon tank mounted at a height of 9ft. 6ins. above the outlets. This tank would be able to supply each bench with 10 gallons of water. To ensure an undisturbed flow of water each bench was designed to have its own ¾in. pipe from the tank terminating with a valve and short extension. The final connection with the experimental apparatus was to be by means of a flexible tube.

The experimental apparatus intended to be used on the bench was going to need a total water supply of 22gpm with the 'The impact of a jet on a vane' experiment requiring the water to be delivered at a pressure of 10p.s.i. It was hoped to supply this water, at the appropriate pressure by making a direct connection to the water main. The Metropolitan Water Board was approached by the Architect's department with regard to this connection but the reply was a most emphatic refusal; the alternative, therefore, was to introduce into the supply line from the tank some type of booster that would create the pressure required.

Shortly after the Metropolitan Water Board had refused permission for a direct connection to be made into their main, we realised that the miniature apparatus designed for these experiments would fail to achieve its purpose if it was accompanied by extensive pipework connected to a large supply tank and a pump.

It was for this reason that Professor Pope and Dr. Markland, from the University of Nottingham, designed and built a hydraulic bench with a self-contained water supply.

4.2.5 A PORTABLE HYDRAULIC BENCH

In March, 1958, the prototype bench was completed and proved to be extremely successful. (Page 37, Fig. 1)

One of its great advantages over the 'built-in' type of bench was its ability to be positioned in the laboratory, as required, and moved when necessary. The only external connection needed was to a 15 amp mains electrical supply. The water reservoir could be filled from any tap by means of a length of hose and emptied likewise, or, at worst by half an hours work with a bucket. The whole bench represented a great advance in the design of apparatus for teaching applied science.

4.2.6 THE SECOND PLAN

As a result of the development of the portable hydraulics bench the Architect responsible for the design of the proposed applied science laboratory was asked to delete the built-in benches and associated
pipework from their drawings. It was hoped that the considerable reduction in overall cost would offset the annoyance caused by this late change in the plan. For the guidance of the Architect, Dr. Markland prepared a list of alterations concerning cupboards, electrical supplies and cooling water for the proposed miniature engine test-bed.

At approximately the same time as the change in the design of the hydraulics bench occurred the Architect, with Professor Pope's advice, decided to modify the dimensions of the central wooden bench to 18' x 6' x 3' and provide electrical and gas services from the three roof beams situated over the bench.

In order to make it possible to support experimental equipment above the central bench Professor Pope recommended the fixing of a steel beam, 4" x 3" RSJ., to the underside of one of the concrete roof beams; each experiment being secured to the beam by a caliper fixing.

These alterations were duly incorporated into the proposed plan and a set of modified drawings prepared by the Architect. A copy of these drawings was sent to Dr. Markland who was invited to make any comments that he thought necessary. After Dr. Markland had looked at the drawings and suggested a few minor alterations, the Architect compiled the final drawings of the proposed Applied Science Laboratory. (Fig 2).

4.2.7 FINANCE

Tenders were invited for building the proposed science and craft extension block together with making some internal alterations to the existing school building. These alterations included converting the gymnasium into specialised teaching rooms for history and geography, and modifying two form rooms that would house the music and art departments when the school occupied the new extension.

At the end of August 1958 the Headmaster was informed that work based on a 21 month contract was to begin at a total cost of £81,118.

4.2.8 SUMMARY

Great care was taken to ensure that the new applied science laboratory did not over emphasise the personal interests of either the Headmaster or the head of department, but provided a course that offered a balanced introduction to engineering science.

The general layout of the laboratory and the nature of the equipment to be installed was influenced considerably by advice from Professor Pope of the University of Nottingham and by the Metropolitan Water Board refusing to allow a direct connection to their main for
Engineering Lab, Ealing County Boy's Grammar School
Ealing Green

Engineering Laboratory
2nd Floor

20'6" wall bench 2'9" high

Fig. 2
of miniature hydraulic teaching equipment being designed.

The position of the laboratory within the building was not given any serious thought and was finally decided by the inability to obtain a suitable technician to service it and the need to use as economically as possible the existing laboratory steward.

4.2.9 EVALUATION

A table showing the effect that this new laboratory and associated work has on the number of boys choosing a career in engineering is given on page 40. The figures suggest that the approach and facilities succeeded in offering a wider career choice and encouraging more students to embark on a career in the world of engineering.

The first head of department ran this laboratory for seven years but when he left great difficulty was experienced in finding a successor. The Headmaster said in 1971 that the laboratory had become 'more ordinary' and would not have such a strong influence on the boys as in previous years.

4.2.10 CONCLUSION

The design and siting of this laboratory have proved satisfactory and enabled a science based applied science activity to be devised and presented in such a way that students became sufficiently excited and absorbed to consider a career in the field of engineering.

4.3 THE MIDDLESEX POLICY ON APPLIED SCIENCE

By July, 1956, the Education Committee of the Middlesex County Council had become very interested in the possibilities of initiating within the grammar schools, further developments in the field of science and technology by adding applied science to the curricula.

The Committee, who were prepared to give special financial backing to this scheme, decided to incorporate into a few selected schools, where extensions were being planned, the necessary facilities for the teaching of applied science.

4.4 HENDON GRAMMAR SCHOOL

At the end of 1956 Mr. Lewis, the master in charge of the craft department at Hendon, was asked to formulate and state his approach to applied science and to sketch the kind of workshops or laboratories that he envisaged as being necessary for his proposed course.
Mr. Lewis did not especially consult any university engineering departments concerning methods of educating future engineers, as had occurred at Ealing Grammar School, although two professors from Kings College, London, did take some interest in his scheme.

* Professor J. Greig
Professor L. J. Kastner

4.4.1 POLICY

Mr. Lewis was firmly convinced that the core of an applied science course was in the drawing office and the metal-work shop, and designed his new department around this concept. He was quite determined that the work studied in the new course should in no way repeat or overlap the work studied in the physics department, although he considered a few experiments concerning the properties of materials to be desirable. 26

4.4.2 THE FLOOR PLAN

The layout of the proposed technical studies department submitted to the Middlesex County Council by Hendon Grammar School, incorporated the five rooms listed below:-

(1) A metal-work room.
(2) A wood-work room.
(3) A machine shop.
(4) A drawing office.
(5) An engineering science laboratory.

After some discussion with the County Architect and the science advisor a few modifications were made to the original layout and plans were prepared to build an extension to the school which incorporated this proposed Technical Studies Department, together with a new assembly hall and dining room. The final arrangement of the suggested rooms is shown on the accompanying floor plan. (Figure 3.)

This extension was erected on part of the school playing field and joined to the existing structure by means of a corridor.

4.4.3 EQUIPMENT INSTALLED

ENGINEERING SCIENCE LABORATORY. Small commercially made apparatus provided standard student experimental work for the topics of friction, torsion, moments of inertia and beam bending. All the apparatus was either screwed to the wall or stored on the bench tops.

Power for the simple electronic apparatus, stored in cupboards, was obtained from commercial power packs connected to the one mains voltage socket, or dry batteries.
drills, a shaping machine and a buffing wheel.

COMBINED METALWORK ROOM AND WOODWORKING AREA. The usual assortment of hand tools, stored in bench racks, together with a muffle furnace and facilities for mixing and moulding various alloys. Welding equipment was available.

DRAWING OFFICE. Sixteen large drawing boards standing on the floor and four smaller ones fastened to the walls.

4.4.4. USE OF THE TECHNICAL STUDIES DEPARTMENT.

The Headmaster decided that Technical Studies should be compulsory for two-thirds of the boys in the 2nd and 3rd forms and then become optional for the same two-thirds when they entered the 4th and 5th forms. The remaining one third contains a high percentage of 'low ability' boys who are encouraged to use the facilities in preparation for the 'O' level technical drawing and woodwork examinations.

The head of the department considers these two examination courses provide a suitable introduction for their sixth form engineering course. This sixth form course is centred around an 'A' level Engineering Drawing syllabus and forms part of "a much wider course of basic Engineering much of which is not examined." The Technical Studies department is available to boys and girls in the sixth form as part of their general education.

4.4.5 SOME OBSERVATIONS ON THE DESIGN

The floor plan of the department clearly reflects the educational ideas of the master in charge. One good feature of the design is the glass partition between the metalwork room and the machine shop which enables one master to supervise senior boys working in either section. The idea of a glass partition separating two areas of a craft department originated at Ealing Grammar School and had to be sanctioned by several Middlesex Sub-Committees, interested in school safety regulations, before finally being approved.

The Engineering Science Laboratory is far too small as it only permits six students to work at any given time. The provision of only one mains voltage socket has proved inadequate.

The positioning of woodworking and metalworking facilities in the same area has also proved unsatisfactory as it is very easy to
In the view of the Headmaster, Mr. E.W. Maynard Potts (retired Easter 1971), the department has "not been used as often as I had hoped. My disappointment is that science and mathematics staff rarely illustrate their lessons by reference to the materials in the engineering rooms". This is partly due to the fact that the science and mathematics staff are without industrial experience and partly because of "separation of science and technical staff." 27

The school obtains its highest 'A' level grades in Latin and Engineering Drawing.

Social studies attract the greatest number of students leaving for university courses with pure science second and technology third.

Although the present arrangement is not as satisfactory as was hoped the Headmaster is reluctant to consider any form of Engineering Science examination as he believes that 16 years of age is too young for boys and girls to decide between pure and applied science. The Headmaster regrets also that the technical experience gained in his school, by prospective engineers, is ignored by the universities.

4.4.7 CONCLUSION

This applied science facility was designed primarily to teach practical skills and technical drawing. There is no numerical evidence to show the effect, if any, of the new facility on the pupil's understanding and appreciation of engineering, but the Headmaster believes that the new department would have met much more success if there had been a closer link between the staffs of the science and technical departments.

4.5 EDMONTON GRAMMAR SCHOOL

At the end of 1956 Dr. Gurr, the County Education Officer, agreed that this school's two existing science laboratories were insufficient and proposed an extension in the form of a science block incorporating five extra laboratories.

It seemed quite clear to the Headmaster, Mr. R.L. Hudson, that the school should have two physics laboratories, two chemistry laboratories and two biology laboratories, but some discussion arose regarding the nature of the seventh laboratory. A decision had to be made between
4.5.1 THE POSSIBILITY OF A FULL SIZE ENGINEERING LABORATORY

Mr. Hudson, who had read both natural sciences and mechanical sciences at Cambridge, would have liked a full engineering laboratory but had to reject the idea on the grounds of cost.

The whole of the proposed extension was budgeted at £118,000 (but eventually cost considerably more) and Mr. Hudson believed that it would have cost at least £40,000, which was too expensive, to equip the full engineering laboratory.

4.5.2 POLICY

Having, reluctantly, shelved the idea of a full engineering laboratory the Headmaster decided in 1957, to devote the seventh laboratory to applied science.

Mr. Hudson felt that it was necessary to take account of the fact that there was no 'A' level engineering examination set by the London University Examination Board; the Board that provided the external examinations in his School. This meant that he could not offer engineering as a specific subject in the sixth-form so he decided that the laboratory should be used to give members of the science-sixth, taking the 'A' level physics course, the opportunity of using apparatus of an engineering nature during the course. It was hoped that this provision for the students would give them a realistic outlook towards engineering and an appreciation of its close association with physics.

4.5.3 EQUIPMENT TO BE INSTALLED

Having decided upon a policy for the use of the laboratory, Mr. Hudson's next task was the consideration of details concerning the equipment to be installed. In 1958-9 there was hardly any suitable equipment available for use in a school applied science laboratory and the idea of employing a skilled mechanic to look after large equipment was, he thought, unlikely to be regarded favourably by the education authorities.

It was for these two reasons that Mr. Hudson did not install full size steam apparatus.

Initially, he had visualised a steam boiler, a reciprocating engine and a turbine, but he decided eventually to send his boys to the Enfield College of Technology for their practical work on steam engines.
£4,500 and a considerable portion of this money was utilised for the purchase of several reasonably sized pieces of apparatus for teaching engineering mechanics.

As far as the apparatus was concerned, Mr. Hudson believed in the precept 'the bigger, the better'.

Some of the experimental equipment was to be mounted on the walls and other items were to be suspended from a girder mounted in the ceiling.

The range of experiments provided, included many of the standard ones carried out with wires, rods and springs. Mr. Hudson had also suggested an Izod machine but this had to be rejected as the local science advisor considered it to be unsafe.

4.5.4 FLOOR PLAN SHOWING THE FINAL DESIGN

With a working scheme in mind the architect was able to prepare drawings for the laboratory which enabled the builders to begin work in 1960, and complete the whole science extension by 1963.

The applied science laboratory was located on the ground floor of this extension and provided with concrete sections at each end so that heavy equipment could be installed if desired at a later date.

A small workshop was provided in an adjoining room at one end of the laboratory as the Headmaster considered it to be impractical to borrow the tools used in the existing craft department situated some distance away.

A floor plan of the laboratory is given in Fig. 4.

The school was very fortunate in having sufficient open space within its boundary to permit this extension to be built on the existing playground area.

4.5.5 ADDITIONAL EQUIPMENT

While the laboratory was being built the Headmaster spent a considerable amount of time searching for two identical D.C. motors that could be coupled together to form a motor generator set. He eventually had a unit custom built with all the connections leading to external terminals.

The biggest motor that he could afford was a 2½ K W unit which made a complete test rig weighing 8 cwt., and which, without any permanent fixing, could quite conveniently be stood on the concrete base already provided.

An engine test-bed was specially built for the school, at a considerable cost, by a local firm using the drawings lent to them by the Shell Petroleum Company. These drawings were, in fact, prepared
which they presented to Ealing Grammar School.

As Mr. C.T. Crellin, the first master to take charge of this laboratory, had a strong interest in electronics and had gained considerable experience in this subject during the war, a fairly large quantity of electronic apparatus was also purchased.

The spacious cupboard adjacent to the workshop was especially provided to store this apparatus. A low voltage supply unit was installed and this enabled D.C. and A.C. outlets to be permanent equipment on the side bench; similar supplies were made available, by means of pillar mounted sockets, to the four portable tables which stood on the wooden part of the floor.

4.5.6 SUMMARY

The Headmaster had to reject his original plan to install a full engineering laboratory, through excessive cost, and content himself with an applied science laboratory sited on the ground floor because concrete ramps to support heavy equipment were specified.

As the University of London, the school's examining board, did not provide a syllabus and examination for 'A' level engineering the apparatus installed in the applied science laboratory was selected by the personal interests of the Headmaster and the first master to take charge of the laboratory. The only external influence was a visit to Ealing Grammar School which provided the stimulus for including a miniature engine test-bed.

4.5.7 EVALUATION

Table 1 compares the number of school leavers electing to study pure science and engineering at a university both before and after the opening of the applied science laboratory.

The Headmaster, Mr. Hudson, is convinced that the sudden interest shown in engineering around 1964 was due to a combination of the new facilities and the enthusiasm and excellent instruction given by Mr. Crellin, the master in charge of the laboratory. At that time Mr. Hudson felt that the new laboratory was fulfilling its purpose and was pleased to report that the students throughout the school were benefiting from its presence.

Unfortunately Mr. Crellin left the school in 1965 to become a UNO advisor and since that time the Headmaster says "we have had a succession of short-stay not-very-good people taking charge of the applied science laboratory". These staff changes have to some extent caused the fluctuation of interest but there is no clear cut reason
<table>
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<th>LEAVERS TAKING PURE SCIENCE.</th>
<th>LEAVERS TAKING APPLIED SCIENCE OR ENGINEERING.</th>
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Mr. Hudson points out that the school became comprehensive in 1967 but so far he says "the entry has only reached the fourth forms but the general disturbance has had its effect on our sixth form and fewer leavers have been going to the university in latter years." 30

Although the school introduced Engineering Science for CSE in 1970 and has just started a similar course for GCE 'O' level, Mr. Hudson is very worried about the future of the applied science laboratory as the present master is leaving for Africa in July 1971 and no replacement has been recruited by June 1971.30

4.5.8 CONCLUSION

The combination of good science based facilities and an enthusiastic teacher enable more reality to be given to conventional school science topics so that students become sufficiently excited and absorbed to consider a career in that field, based on first hand experience.

4.6 ASHFORD (MIDDLESEX) COUNTY SCHOOL

In 1956 Ashford Grammar School was scheduled for an extension to the existing school building and Dr. Gurr approached Mr. D. Atkinson, the Headmaster, to see if he would be willing to introduce applied science into the curriculum. Mr. Atkinson agreed to experiment with this new aspect of sixth-form study and was asked by Dr. Gurr to submit his requirements concerning laboratories and equipment.

4.6.1 POLICY

Mr. Atkinson and his science staff gave the problem considerable thought and put forward a scheme that would fulfill the following educational aims.31

1. To provide a better general education.
2. To indicate to prospective university and technical college entrants the various branches of engineering and the manner in which they serve the community.

The proposed applied science course was to be included within the normal timetable as a compulsory subject for boys in the first year sixth form who were taking physics, and as an optional subject when they reached the second year sixth form. Nine periods a week would be devoted to physics, seven for the study of conventional 'A' level physics and the remaining two periods to be spent in the applied science laboratory for the study of the applied aspect of this subject. The
Physics paper at 'A' level, an examination which has since been discontinued.

4.6.2 PROPOSED LABORATORY ACCOMMODATION

The Headmaster decided that three new laboratories, listed below, were required for the proposed work in applied science; each laboratory being devoted to a particular aspect of the subject.

(1) A Mechanics Laboratory.
(2) An Electrical Laboratory.
(3) An Engine Test House.

4.6.3 SITING THE PROPOSED LABORATORIES

The proposed extension to the school made possible the consideration of some slight re-organisation within the existing building and the Headmaster decided that the physics laboratory should be linked with an adjacent classroom to form the new mechanics laboratory, thus providing a useful addition to the physics department.

The science staff realised that an engine test-bed would be noisy and so it was planned to build a separate test house outside the school building to prevent any disturbance of the neighbouring classes. Once the position of the mechanics laboratory and engine test house had been fixed there was only one remaining laboratory, the electrical laboratory, to be incorporated into the proposed extension.

As a result of these considerations the proposed applied science department was spread over a wide area of the school; however, the Headmaster did not think that this mattered very much as different groups of boys would be working in them at any given time.

4.6.4 EQUIPPING THE NEW LABORATORIES

When the problem of equipping these laboratories arose the Headmaster realised that he, like many other people at that time, was a novice in this sphere; for this reason he left a great deal of empty space on the architect's drawings so that when the nature of the apparatus was finally decided the floor space allowed would be adequate. Miniature teaching equipment, of the type installed at Ealing Grammar School, was not considered because the idea did not occur to the Headmaster or to his staff.

4.6.5 FLOOR PLANS

The floor plans of the three applied science laboratories are
THE MECHANICS LABORATORY. Initially this laboratory was only furnished with a fixed side bench, three movable tables for the students and one for the teacher. Since then a small rig for carrying out hydraulic experiments with a notch and orifice has been permanently installed which needed direct connections to the water main and drainage system.

THE ELECTRICAL LABORATORY. This laboratory has a large area of open floor space at the back of the room which is used to house six small trolleys carrying electrical machines for investigations into the characteristics of series and compound wound motors. These units were designed by the Architect's Department of the County of Middlesex to operate from a 200 volt D.C supply obtained from suitable sockets in the side bench nearest the window.

The adjoining preparation room contains the source of the laboratory voltage supplies. A three phase transformer connected to the industrial mains has its 220 volt output fed into a rectifier and then distributed to the laboratory bench sockets. This transformer together with the motor generator and control panel were installed because the school was at one time intended to be used in the evenings by the local Technical College.

THE ENGINE TEST HOUSE. The test house is a brick built structure fitted with electrical heating to keep the atmosphere warm and so prevent the machinery from rusting. The water supply for the dynamometer and cooling system of the engine comes from a large tank mounted on the roof and filled from the mains by means of a ball valve; after use this water is directed to waste.

The original idea of an 'observation room', provided as a safety factor for the students, has not been used. All controls for the engine were to have been connected to a master control panel in this room and all dials mounted directly on to the test unit and positioned so that they could easily be seen and their readings recorded through the observation window. The staff felt that with a small group of closely supervised senior boys, accidents were unlikely to happen and that the boys would enjoy being in close proximity to the engine.

The test-bed is fitted with a 1½ litre B.L.M.C. engine which carries all the normal instrumentation, with the exception of an indicator.
1: Bench
2: Table
3: 80 gal. tank
4: Flow tank
5: Pump
6: Sink
A: Ascot water heater
☐: 250v A.C.
☐: 0-24v A.C./D.C.

The Mechanics Laboratory, Ashford

fig.5
1: Bench
2: Sink
3: Control board
4: Generator
5: Transformer
6: Rectifier
7: Low voltage unit
\( \oplus \): 200v D.C.
\( \bullet \): 415v A.C.
\( \times \): 0-24v A.C./D.C.

Electrical Laboratory, Ashford
The Engine Test House, Ashford.

1: Table
2: Drain
3: Test bed
4: Fire extinguishers
5: Observation window
6: Sink
\(\square\): 250v A.C. outlet

fig. 7
Accommodation for the new work was provided in three laboratories. One of these was an adapted classroom and the other two were constructed as part of an extension to the school, but in such a position that all three were widely separated.

The apparatus installed was rather unusual with regard to size and power requirements. The decision to use this apparatus was influenced to some extent by staff expertise and the possibility of the school being used in the evenings by the local Technical College.

4.6.7 EVALUATION

In July 1965 the A.E.B. set their last paper in Applied Electricity and Heat, an examination which the school used as the basis for their applied science studies at 'A' level. Part of a report on this examination published in 1963 by the A.E.B. reads as follows: "Very few candidates sat this examination. The standard was very poor indicating that the students involved were quite unprepared for the examination. These deficiencies in knowledge of simple basic physics was deplorable for an examination concerned with applications."

The Headmaster, Mr. Atkinson, agreed with these comments and thought that it reflected the lack of staff know-how which he felt existed in his school. For example, the engine test house was built because a young graduate joined the staff to teach physics who had specialised in heat engines at the university; before the test house was completed this master left the school, leaving no course notes or other benefits from his specialised training.

Since 1965 the applied science activity has remained as part of the 'A' level physics course and provides 16 periods/year of interesting experimental work for the students. Boys and girls (in the sixth form) not studying physics at 'A' level can take applied science as a general studies option if they wish, but there is no evidence available to show the effect it has had on them.

4.6.8 CONCLUSION

The approach to applied science developed at this school may have helped some students to develop an appreciation of the world of engineering but it is not considered by the Headmaster or the staff to be a very effective method.

Experience has shown that spreading the work over three widely separated laboratories was unsatisfactory and a full size engine test
The difficulty of appointing and retaining suitable staff to organise the applied science programme was considered also to be a major factor in determining the success, if any, of the activity.

4.7 TOWARDS A STANDARDISED APPLIED SCIENCE LABORATORY

The Middlesex Education Committee, as they approached various Headmasters concerning the introduction of applied science into the schools, quickly found that each Headmaster had different ideas and views on the number of laboratories required and the type of equipment needed.

If, as Dr. Gurr hoped, applied science laboratories were to become standard in Middlesex schools it would be necessary to estimate in advance the cost of construction.

With this aim in mind, Dr. Gurr formed a committee to produce the layout of a single applied science laboratory adequately equipped with the type of apparatus that would be acceptable to the County Grammar School.

This committee consisted of the Principal of Brunel College, (now Brunel University) the Principal of Hendon Technical College, and three Headmasters with experience of this type of laboratory.

The plan of the laboratory which they devised is shown in Fig. 8.

4.8 CRAY VALLEY SCHOOL FOR BOYS, KENT

(Formerly Cray Valley Technical High School)

This school was opened in 1954 as a Technical High School and immediately developed a craft wing that incorporated an engineering laboratory, two drawing offices, two woodwork shops, two machine shops and a junior workshop.

The first intake of pupils consisted of 199 thirteen year old boys and consequently it was July 1959 before any of these pupils left to take up places at a university.

4.8.1 POLICY

The purpose of the craft department was clearly defined by the first Headmaster, Mr. J. C. Kingsland and the late Mr. R. J. Mathew, first head of the department, by the four statements given below:

1. To foster interpenetration of subjects which are cognate.
2. To enable boys to gain some understanding of the purpose and
3. To give added realism to the education boys receive.
4. To establish a bridge between school and college, or employment.

Mr. Kingsland was convinced that the basis of all craft work was the creation of an object which was able to solve a problem. The quality of the solution, he believed, depended not only on the quality of the construction but also on the degree of reasoning exercised to obtain the solution.

All work carried out in the engineering laboratory was destined to be of an unexamined kind as the Headmaster wished to be free to experiment in engineering education.

4.8.2 THE ENGINEERING LABORATORY

This laboratory is situated in the single storey craft wing adjacent to the workshops, and is divided into four separate bays by means of glass partitions fitted with single doors, thus enabling one master to supervise the entire laboratory from any position. (Fig. 10.) Each of the four bays was originally equipped for a specific aspect of the work; one was a foundry, another was used for testing materials, a third was used for testing internal combustion engines, and the fourth had facilities for electroplating and spray painting. A floor plan of the laboratory is given in Fig. 9.

4.8.3 DETAILS OF ORIGINAL FACILITIES AND EQUIPMENT

THE FOUNDRY. This was equipped for the heat treatment of metals and included facilities for melting, mixing and casting alloys.

MATERIALS TESTING SECTION. This section was equipped with a Tensometer, an Izod impact tester, an Ohlsen hardness tester, a polishing machine and a microscope for metallurgy.

INTERNAL COMBUSTION ENGINE SECTION. This section was fitted with double doors so that a motor car could be driven into the room. A gantry was provided across the width of this section so that an engine or axle removed from a vehicle could be moved onto a stand for dismantling, examination or repair. In the middle of this room a single cylinder National Diesel engine rated at 6 h.p., was permanently installed. The engine was coupled to a rope brake and was used for teaching the standard range of engine tests.
Fig. 10. A view of the Engineering Laboratory at Cray Valley School showing the glass partitions which divide the workshop area into separate bays.

Fig. 11. The electronics area in the Engineering Laboratory at Cray Valley School.
experiments with nickel and chromium plating that could be performed with a low voltage D.C. supply.

An air compressor capable of delivering air at 150 psi was installed in this room and the air line piped to the workshop next door. The main use of this air was to test model steam engines.

One corner of this room was partitioned off to form a small paint spraying booth.

4.8.4 PRESENT DAY FACILITIES.

Mr. S. C. Brickell who succeeded Mr. Mathew as head of department in 1965 was particularly interested in electronics and consequently re-arranged the laboratory to include an electronics area.

The plating tanks are now installed in the spray painting booth; any spray finishing undertaken is accomplished by putting a board over the electroplating tanks and placing the work on this improvised 'bench'.

The space obtained by removing the plating tanks has been filled by moving the equipment from the Materials Section. The empty Materials Section has been converted into an electronics area by installing an oscilloscope and suitable test meters. Fig. 11.

A Ford engine has been added to the Internal Combustion engine bay while the Foundry continues unchanged.

4.8.5 FINANCE

The original equipment installed in the department cost £6,000 and was paid for by the local education authority. It has, however, been supplemented during recent years by gifts from the 'friends' of the school.

The present Headmaster finds that the running expenses are at least £1,000 per annum.

4.8.6 USE OF THE ENGINEERING LABORATORY

Theoretically the timetable is arranged so that all boys have the chance to use this laboratory in conjunction with their craft teaching. In practice however the first and second year boys only visit the laboratory for 2/3 periods a year and those in the third year hardly ever. Fourth year boys make extensive use of the foundry and are given the chance to complete at least one job with the plating tanks.

Boys in the fifth year test pieces of steel in the Materials section and have the chance to use the engine section as an extension to the physics lessons. Once a boy has been shown how to use the facilities
At sixth form level the boys have the chance to use the facilities for 3/48 of the 6 day timetable, either
a) As an extension of chemistry whereby they analyse and test various alloys
or
b) As an extension of physics when they have a more extensive course in heat engines and consider practical and theoretical aspects of A.C.

4.8.7 SUMMARY

The craft based engineering laboratory was divided into bays to provide separate working areas for the various activities to be undertaken. The glass partitions forming the bays were a valuable design feature as they enabled one master to supervise the entire working area.

The laboratory was established through the efforts of the first headmaster and was designed in the main to implement his ideas relating to craft teaching. Since that time different ideas have been brought into the department, through the appointment of new staff, and only a very careful re-arrangement of the existing facilities has enabled these ideas and accompanying apparatus to be incorporated.

4.8.8 EVALUATION

Mr. Kingsland, the first headmaster felt that the design approach used in the craft department, especially for constructing a steam engine in the fourth year, made heavy demands on the boys capacity to think and plan and was therefore educationally very sound.

No metalwork exams were taken but examinations in 'O' and 'A' level Technical Drawing were encouraged as Mr. Kingsland believed these had considerable therapeutic value on a boy's pride which carried over into other subjects.

During Mr. Kingsland's period as Headmaster the School did not keep any records of the numbers of boys entering universities to take science or engineering courses, but from the written evidence available in the school's filing system the present Headmaster, Mr. W. R. Turner, believes that an average of four boys a year qualified as engineers from those leaving between 1959 & 1962.

A personal statement to me by Mr. Kingsland in 1965 suggested that the applied science activity had had a profound influence on the sixth form boys and that in 1964 more boys selected university engineering courses than pure science courses.

Since 1967 when Mr. Turner became Headmaster records have been kept
Although Mr. Turner has not altered the way in which the applied science activity is organised he is not certain whether the significant drop in the number of boys entering engineering courses is due to him not emphasising the activity or whether it is due to a change in attitude of boys in favour of social and business studies.

TABLE 2

CRAY VALLEY SCHOOL FOR BOYS, KENT.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF BOYS LEAVING TO STUDY ENGINEERING AT THE UNIVERSITY</th>
<th>NUMBER OF BOYS LEAVING TO STUDY PURE SCIENCE AT THE UNIVERSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>1969</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>1970</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

4.8.9 CONCLUSION

The craft based applied science facilities developed in this school proved to be satisfactory for the work originally undertaken and, in the opinion of the first headmaster, fulfilled the stated aims.

In recent years however, some difficulty has been experienced in introducing new ideas and apparatus into the purpose built laboratory because such changes involved very careful re-arrangement of the original facilities in order to avoid wastage and excessive financial expenditure.

The appointment of a new headmaster and head of technical studies within a two year period may have been a contributory factor to the present tendency of the students to become less involved in the department’s activities.

4.9.0 DEDUCTIONS

1. The most satisfactory facility for a school applied science
approximately 1,000 sq.ft. equipped with miniature experimental apparatus and controlled by the science department.

Access to a workshop is desirable and for the convenience of both staff and students should be adjacent to the laboratory, separated, perhaps, by a glass partition.

2. It is not essential to introduce applied science through preparation for an external examination and, indeed, there is strong evidence to show that great interest can be aroused in students by using a non-examinable approach that widens and adds reality to the normal physics course.

4.10 OVERALL CONCLUSION

The applied science laboratories built and equipped for five of the pioneer schools in this branch of science education were all established through the enthusiasm of the respective headmasters, ably supported by one or two members of their staff.

Each laboratory is unique, reflecting the personal interests and educational beliefs of the men involved, and is based either in the science or craft department with very little overlap taking place, or indeed being encouraged.

All the work undertaken in the new laboratories has achieved some success when supervised by the founder/teacher. Severe setbacks can occur, when this enthusiast leaves the school as great difficulty is experienced in finding staff of any kind to replace him; appointing a man possessing sufficient knowledge and enthusiasm combined with teaching skill and a genuine interest in the work is almost impossible.
AIM

To study the nature of the many forms of adapted accommodation used for applied science activities and to assess the educational value of the work undertaken by students working in these premises.
5.1 AIM

To study the nature of the many forms of adapted accommodation used for applied science activities and to assess the educational value of the work undertaken by students working in these premises.

5.2 INTRODUCTION

Perhaps the best known example of an applied science laboratory that has been constructed from a modified prefabricated building especially to help boys educate themselves through technical activities, is the one at Sevenoaks School, Kent.

Dauntsey's School, Wiltshire which is almost as well known, has probably undertaken the most elaborate adaption of existing buildings in order to provide suitable facilities for offering studies in applied science.

5.3 SEVENOAKS SCHOOL

This is an independent school but takes about one third of its 600 pupils from the local education authority. In 1961 Mr. L.C. Taylor, then Headmaster of the school, appointed Mr. G.W.C. Sommerhoff to develop a Technical Activities Centre. After two years of preparation, which involved fund raising the Centre was opened in 1963. It was housed in a pair of prefabricated buildings equipped to provide spare time facilities for boys with creative, scientific, or technical interests and inventive minds.

5.3.1 THE ADAPTED BUILDINGS

The two prefabricated buildings, each of modern design and made from cedarwood, are mounted on concrete platforms, (Fig 1), and are separated by a water basin of surface area 1,000 sq. feet which is used for sailing radio-controlled boats and other craft (Fig. 2). The buildings have fibre glass insulation and are heated by a thermostatically controlled under floor heating system. The total floor area available to the boys is approximately 2,500 sq. ft. and is divided into
Fig. 1. The Technical Activities Centre at Sevenoaks School. This Centre has been built into two prefabricated buildings with a water basin between them.

Fig. 2. The water basin at Sevenoaks School.
THE MAIN LABORATORY  This room has a floor area of approximately 1,000 sq. ft. and contains eight movable work benches and one very long bench that is fixed to the floor. This latter bench incorporates two sinks together with main water and gas supplies. There are several cupboards and drawers available for storing components, and 120 ft. of open shelving is provided for larger items. Sufficient power points have been installed around the laboratory walls.

THE READING ROOM  This contains the Centre's library and periodicals, and also acts as a study for the master in charge.

TWO SMALL WORKSHOPS  These are situated at the front and back of the main laboratory and between them contain two lathes, a drill, electric jigsaw and an electric sander and grinder.

A COMPUTER ROOM  This contains three digital and one analogue computer teaching aid, and a teletype send/receive station which operates in conjunction with the ICT computer of a local manufacturer.

Boys interested in learning about computers are taught by a visiting computer expert who provides a maximum of 20 of them with a 1½ hour lesson each week for a term.

MODEL RAILWAY ROOM  This provides a place for boys to construct semi permanent layouts for 'OO' gauge rolling stock, complete with scenery, and also acts as a starting point for steam engines that run on a permanently laid track outside the building.

5.3.2 FINANCE

The total cost of the buildings including equipment and the water basin, was approximately £10,000, of which the first £5,000 was provided by the school and the remainder raised by appeals to Industry. Present running costs are estimated at £700 per annum.

5.3.3 WORK UNDERTAKEN

Boys first meet the Centre at the 13plus stage when they become familiar with the equipment and follow the very short courses that have to be passed before undertaking projects of their own choice.

The main work of the Centre takes place in the evenings when boys
Technical Activities Centre    Sevenoaks School

fig 3
attend on a voluntary club basis to investigate any technological problem that interests them.

5.3.4 THE EFFECT OF THE FACILITIES ON THE STUDENTS

There are always more boys wanting to join the club than the 80 that can be accommodated.

The only formal evaluation undertaken occurred at the end of the Centre's first year of operation. Mr. Sommerhoff compared the form position in physics of each boy attending the club, with his position at the beginning of the year. It was found that 80% of these boys had improved their position. 37

The school does not keep any records showing the career or course followed by pupils that have left so it is impossible to attempt to observe any change in the numbers choosing engineering.

Mr. Sommerhoff does not consider that any formal evaluation is necessary to judge the effect the Centre has on the boys in the school. He is satisfied to sense the 'atmosphere' that prevails and to see the quality of the problem solving that has been achieved. 38

5.3.5 CONCLUSION

This approach appears to have helped many boys to gain a practical understanding of theoretical physics and also has given them a chance to test their skills as designers.

If Mr. Sommerhoff left the school it seems unlikely that the boys would derive the same educational value from the facilities. It is essential to have a master in charge who either knows the answers to boys technical problems or who can suggest where to find them if interest and enthusiasm for project work is to be maintained.

5.4 DAUNTSEY'S SCHOOL

Mr. D.J. Forbes, then Headmaster of Dauntsey's School, Wiltshire, first considered the idea of introducing some form of applied science into the school during 1958. In the same year he appointed Mr. G.B. Harrison, a Cambridge Mechanical Science graduate, to the staff in order to fill a vacant position previously held by a conventional craft master. 39

At that time the School possessed very little accommodation for
teaching craft and certainly no laboratories or facilities for teaching applied science, so during 1959 Mr. Harrison produced a plan for a proposed engineering department incorporating an existing harness room and 'old forge' standing close to the existing woodwork room. As the School has a tradition that in the post 'A' level period each summer the boys - who have taken the examinations - undertake some useful construction work within the school grounds, Mr. Harrison decided that these boys could build the proposed engineering department. Although the major construction efforts took place in the summer the work continued, on a smaller scale, throughout the year using the co-opted services of 5th and 6th form boys who prefer to devote their games periods to 'Service to the Community'.

The final drawings and plans prepared by Mr. Harrison for the proposed engineering department showed a single storey structure, Fig. 5, incorporating the two existing buildings, together with four new rooms, all positioned around a central corridor, to be built on the site then occupied by the woodwork room. As Mr. Harrison wished to use the project approach to engineering he wanted plenty of open floor space to be available for assembling home built apparatus, so he designed the engineering laboratory without any conventional laboratory benches.

**5.4.1 THE ADAPTED BUILDINGS**

The floor plan (Fig. 4.), shows the general layout of the new department opened in 1965, and the following paragraphs, describe each room. The modifications cost £6,000 but have been valued at £15,000.

**THE HARNESS ROOM** This room has been converted into a general work-shop by fitting a plaster board ceiling, installing electric lighting and providing working surfaces in the form of two heavy movable tables and three fixed benches. Two of the latter each have four fitters vices bolted to them. Storage accommodation in the form of large steel lockers and open shelved racks is provided both for work under construction and for components salvaged from unserviceable motor cars.

Eight mains electrical points have been installed at intervals along the wall near the fixed working benches so that soldering irons and powered handtools may be used. The only tools provided in the room, are soldering irons, two metal cutting shears, a sheet metal bender, one very old vertically mounted hand-drill and a small selection of
Fig. 5. The front of the single storey structure that has been converted to form the engineering department at Dauntsey's School.

Fig. 6. The outside of the Engineering Laboratory at Dauntsey's School, showing in particular the special roof and windows.
THE OLD FORGE. This room is now referred to as the machine shop because of the addition of two Myford type ML 7 3½" lathes and one Raglan 'Little John'. 5" lathe. To visitors, at least, the room still retains much of its original character through the presence of a large blacksmith's forge.

In order to give the lathes a firm mounting the entire floor has been concreted and the general appearance of the room brightened with a plaster board ceiling. Electric strip lighting has also been installed together with a mains water tap and sink.

In addition to the lathes, the room houses a floor mounted electric pillar drill and grindstone; provision has been made for other electric tools by fitting four mains sockets.

Storage space for small items under construction and lathe tools is provided by means of wooden cupboards and a large ex-government steel locker standing on the floor. Storage accommodation for long lengths of tube and angle iron has been made by installing suitable supporting brackets, spaced at short intervals, along one wall of the room above a side bench.

The gas and electric welding equipment rests on wheeled trolleys so that it can be easily moved, but it usually remains beside the forge.

THE ENGINEERING LABORATORY. This room is 35 ft. square and has a large area of uninterrupted floor space. The roof is of the hyperbolic paraboloid type and is entirely supported by laminated wooden beams resting on concrete pillars built into the walls of the room. Although the boys actually made the roof and lifted it into position, advice regarding its design and construction was given by the Timber Development Association. The walls were built of bricks and mortar, windows at bench height being provided in the two outer walls.

The excellent natural illumination available throughout the laboratory is provided by windows fitted between the top of all four walls and the special wooden roof. Fig. 6.

The laboratory stands on concrete foundations and the wooden floor is mounted on blocks standing directly on the concrete foundation.
This wooden floor, together with those laid in all the other new rooms and the entrance hall of the department, was made from a large surplus floor – put up for auction at a local RAF station – which the School was able to purchase for £220.

Two fixed working benches, 2ft 3in wide were fitted inside the room along the outer walls and the space beneath them boxed in to form 30 small cupboards which are used to store the boys work. Along the wall at the back of these benches – just above the working surface – 14 mains power points have been installed together with a similar number of panels containing terminals which, taken in pairs, are able to supply 2, 6, or 12 volts D.C.

Additional concentrated light, for use in undertaking delicate work with miniature electric components, is provided by a number of 'swan neck' electric lamps which are also mounted on the wall at the back of the bench.

In order to avoid long lengths of electric cable trailing over the floor four mains output sockets have been installed under the floor near the centre of the room – accessible by lifting out wooden covers

Provision has been made for moving heavy equipment into the laboratory from outside by means of an overhead travelling hoist firmly mounted on a girder structure sunk into a concrete foundation.

One section of the floor measuring 20 ft. x 6 ft. has been finished as a concrete raft and is intended for mounting engines and other heavy equipment that might be forthcoming from industry or other generous sources. At the moment, one end of this raft is occupied by a 1938 single cylinder Lister petrol engine mounted for use with a home-made mechanical engine indicator, while the opposite end supports a very large water tank used for investigating flow characteristics.

The largest piece of equipment in this laboratory is a wind tunnel that was originally built at the School and has since been modified, by succeeding generations of school boys, so that it will give a windspeed of 56 knots.

The main entry door to the laboratory from the central corridor is designed to slide and so prevent potential accidents associated with the entry and exit of large numbers of boys, some of whom may be
The only omission is a mains water tap; at present the flow tank has to be filled from the fire hose installed in the central corridor.

**THE STORE ROOM** This small room, situated between the machine shop and the engineering laboratory, has been built to house short lengths of metal section, tin plate, copper and aluminium sheet, nuts bolts and washers and electric components together with all the catalogues sent to the School by equipment manufacturers.

Just inside the door is a counter behind which a boy can sit to issue the requirements of his colleagues, booking down the cost against the appropriate name. The small electrical components are stored behind this counter in small drawers - mounted in racks - while the metal rods and bars rest on wall racks. The extensive range of nuts and bolts are stored in drawers of a slightly larger size.

Twelve feet of this store has been sectioned off to form a very small 'private room' for use by the master in charge of the department; this room also acts as a store for the more valuable and sensitive instruments. One wall of this 'private room' has been fitted with an excellent working bench, a mains power-point and a low voltage supply.

**GARAGE** A brick garage nine feet wide, has been built into the small recess formed outside the engineering block by the walls of the store and the old forge. This garage has the overhead type of aluminium door and is used to store the canoes that have been made in the work-shops.

**THE DRAWING OFFICE** This room, which is adjacent to the modified harness room on the opposite side of the central corridor from the store room, was originally designed for technical drawing but is now also used for mathematics classes. As this room has no outside walls all the daylight has to come through six translucent fibre glass panels let into the cylindrical timber shell roof.

The home made drawing tables, constructed from square section aluminium, were made in pairs and only provide each of the 24 boys with a fixed horizontal working surface measuring 30" x 18".

A blackboard is provided along one of the walls for the benefit of the teacher, but there is only just enough space to stand between
Also provided in this room are two large glass fronted cupboards housing a small library of engineering books; three armchairs are available for boys to sit in while reading the books or discussing any of their design problems.

**COMMENT** The amount of natural light entering this room is clearly inadequate for drawing purposes but has been augmented by artificial strip lighting.

A wood preparation room, containing a circular saw, extends behind the drawing office and makes it impossible for masters to make themselves heard; the noise also disturbs the boy's concentration.

The school hopes to modify this present arrangement in future years.

**THE WOODWORK ROOM** This room replaces the woodwork shop that was demolished to make way for the new engineering department. Although the woodwork room is not really an integral part of this department, the woodwork master is very willing to assist with any project that requires some wooden part to be made.

5.4.2 OUTSIDE ASSISTANCE

Although the boys undertook the major part of the construction work needed for the new engineering department, it was decided to employ an outside contractor to plaster the walls and waterproof the roof.

5.4.3 FINANCE

Some of the money needed to buy the building material for this new department came from existing School funds, but the major part of it came from a grant given to the School by the Mercers' Company.

5.4.4 WORK UNDERTAKEN

Lessons in metalwork are provided for the boys in the lower school followed by the chance to participate in group project work.

At sixth form level boys studying for the Cambridge 'A' level Physics examination embark upon further projects that culminate in a report for an external examiner. A successful project can raise a boy's 'A' level physics examination result by as much as one grade.
5.4.5 THE EFFECT OF THE FACILITIES ON THE STUDENTS

Mr. Harrison, the master who founded the department, believed that he could tell which of the boys had engineering ability. He felt that many such boys were not great mathematicians yet possessed talents not normally recognised by universities and the traditional examination system. If some of these boys have had the chance to develop their initiative, as Mr. Harrison believes they have, then the facilities have been invaluable.

Mr. Harrison also believed that the facilities helped some of the school's more able boys to realise that engineering could offer them a challenge in life and encouraged them to apply for places in university engineering courses. Table 1 shows the number of boys applying for university engineering courses during the first four years of the programme.

In the opinion* of Mr. L.J. Taylor, B.Sc., Assistant Physics Master at the School until July 1969, the number of boys taking the engineering activity and then proceeding to follow a career in engineering reached a peak in 1965, and then began to fall. This trend may have been caused partly by Mr. Harrison leaving the School in July 1965, and partly by the fact that from the same date participation in project work became optional.

The results of a recent study, made by Mr. Taylor, concerning the educational value of Dauntsey's project approach to engineering, confirmed that technology was popular amongst boys of high ability, measured by performance in the 'A' level examinations. Mr. Taylor showed also that this approach seemed to provide information about a candidate, such as his degree of initiative and ability to devise apparatus, that was not revealed by standard examination methods.

* Obtained by personal interview August 1971.
TABLE 1

DAUNTSEY'S SCHOOL

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF LEAVERS WHO HAD TAKEN 'A' LEVEL COURSES</th>
<th>NUMBER OF LEAVERS ENTERING HIGHER ENGINEERING EDUCATION</th>
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<tr>
<td>1963</td>
<td>43</td>
<td>6</td>
</tr>
<tr>
<td>1964 XX</td>
<td>39</td>
<td>9</td>
</tr>
<tr>
<td>1965*</td>
<td>The School</td>
<td></td>
</tr>
<tr>
<td>1966</td>
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</tr>
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<td>1967</td>
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<tr>
<td>1968</td>
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</tr>
<tr>
<td>1969</td>
<td>data for</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>this period</td>
<td></td>
</tr>
</tbody>
</table>

X An engineering programme introduced into the school.

XX The adapted laboratory became available.

* Mr. G.B. Harrison, the founder of Dauntsey's engineering programme, left the school.
5.5 LESS FORTUNATE SCHOOLS

The rooms described above, in which adequate provision has been made for applied science activities, are outstanding and by no means typical of secondary schools.

In 1965, a questionnaire - compiled for the benefit of the 'Page Report' - was sent to 430 schools that were known to have an interest (either active or tentative) in applied science. 265 of these schools returned the forms partly or fully completed. These questionnaires were marked 'Confidential' and until 1971 had only been read by Mr. G. T. Page, M.A., who wrote the report. Through the kindness of Mr. Page, these questionnaires were lent to me on the condition that I do not allow any of the information to be published in public journals without the written consent of the schools concerned.

5.6 THE SITUATION IN 1965

The 'Page' questionnaire showed that only 42% of the 265 schools mentioned above claimed to have an applied science activity.

Question 5 on the questionnaire asked
'Do you have a laboratory wholly or partly used for engineering or applied science work'?

and Question 6 asked
'Do you have a laboratory where sixth-formers can tackle practical or project work in their own time? If 'yes' would you care to comment on (a) its accessibility? (b) the use made of it'?

The following information relates to schools who claimed to have an applied science activity but answered 'no' to question 5 and 'yes' to question 6.

1. VERY PRIMITIVE FACILITIES  
   Eight schools gave an affirmative answer to question 6 but were unable to supply any details, while others qualified their answer by such comments as
   'This is really a converted greenhouse'. - Westwood's G.S., Northleach, Glos.
   'A small room that we have made available under the stage'. - Rowlinson Technical School, Sheffield.
   'An attic. Three rooms equipped with benches, lighting and power. No tools or equipment are supplied by the school'. - Friends' School, Saffron Walden.
WORK UNDERTAKEN

In such accommodation the activities undertaken were usually of an electrical nature and concerned the building of models and the repairing of radios. This type of work was popular because it did not require very much space or expensive apparatus.

2. LABORATORY

PREPARATION ROOMS

Within the normal part of the school building preparation rooms linked with physics, chemistry and biology laboratories were popular places for sixth-form applied science work. These rooms were not usually fitted with any extra electrical points or cupboards for the benefit of this additional activity, but merely provided a working bench for a small group of senior boys to undertake constructional work. The size and number of these preparation rooms differed widely from one school to another illustrated by the following comments:-

'Preparation rooms in all three science departments are of a generous size and allow sixth-form boys to do project work'. - Cheltenham G.S.

'Physics preparation room - too small and too remote from the metalwork room, which is at the other end of the school'. - Cambridge G.S.

'Only a small prep/storage room'. - Chorlton G.S., Manchester.

WORK UNDERTAKEN

The nature of the work carried out in these preparation rooms varied from advanced physics experiments (Millikan was quoted as an example by Bemrose School, Derby) through 'radio servicing and experimental circuitry' to pure model making.

Chesterfield G.S., Derbyshire, however, who possessed a prep. room/workshop constructed a digital computer in 1964, and, in 1965, assisted Sheffield University with a project concerned with a satellite.

3. SCIENCE LABORATORIES

The existing physics, chemistry and biology laboratories had considerable use for introducing applied science as illustrated by the comment 'all laboratories available'. - Chatham House G.S., Ramsgate. One or two such schools had made minor modifications so as to provide extra
could leave partly finished work in safety, but this was rare.

Luton Secondary Technical School indicated that they realised there is a difference between pure and applied science laboratories when they made the comment 'the two physics laboratories are the nearest thing'; while others such as Haslingdon G.S., Rossendale considered their labs to be 'woefully inadequate for all sciences'.

Several schools such as Cranbrook School, Tunbridge Wells indicated that they allowed the science laboratories to be used for applied science projects but could not permit the work to extend over a long period of time because the laboratories were needed for normal teaching purposes.

WORK UNDERTAKEN

The work tackled was frequently directly related to the normal school physics or chemistry course rather than to engineering experiments or the solving of genuine industrial problems. Some schools such as St. Albans devised projects that involved laboratory work just for the benefit of the sixth-form in the post 'A' level period so that these students did not waste time during their final weeks at school.

SUMMARY

It seemed unusual for schools to provide special practical periods in their science laboratories during which experiments concerned with engineering principles could be undertaken; the normal practice seemed to be for the students to carry out either simple research into one of the three sciences, or standard experiments in modern physics. If a constructional approach was favoured then it was often suggested that apparatus suitable for use in the laboratories was built perhaps in association with the metalwork department.

4. CRAFT SHOPS

The school metalwork or woodwork shops, either, on their own, or, in conjunction with the science laboratories, were the rooms most widely associated with applied science activities. Some schools obviously considered the work carried out in their shops justified the title 'Engineering' while others liked to distinguish between engineering, model making, and the acquisition of trade skills.

The former attitude is illustrated by Elgin Technical Secondary School, Gateshead, who devoted part of their Engineering Workshops to projects of a type which 'tend to be closely connected to making';
while the Headmaster of Alsop High School, Derbyshire, provides an example of the latter by stating 'we have no special applied science room, but the boys learn skills by making canoes in the wood and metal rooms. They also make wrought iron grills for loudspeaker apertures in the school hall'. Students at Abbeydale G.S. for Boys, Sheffield, who only had limited access to the workshops, engaged in an activity described as 'constructing and repairing gear'.

A number of craft departments such as Luton Secondary Technical School had machine shops which enabled boys to organise clubs dealing with car and motor cycle repairs.

5. DRAWING OFFICE  A drawing office, with or without access to a workshop, was regarded by several schools such as the Grammar School for Boys, Bromley, Kent, as a room for applied science project work. They stated that the boys studied problems relating to engineering design and were shown the relevant mathematics and physics. Generally, however, at the end of such a course the boys were expected to sit an examination in technical drawing.

OTHER MODIFIED ACCOMMODATION

The questionnaire also revealed a reference to a 'Fine Measurements' room used for applied science work. Dane Court Technical High School has such a room, used only under staff supervision, for 'strength of material investigations and investigations into tool (cutting) design'.

5.7 ACCESSIBILITY OF MODIFIED ACCOMMODATION

The accessibility of the various 'centres' for applied science varied considerably as did the basis on which the facilities were available. This is illustrated by the following comments:-

AVAILABILITY
'Lunch-time and after school'. - Bishopshalt School, Uxbridge.
'EASY - any afternoons except weekends'. - Cranleigh School, Cranleigh.
'Always open'. - Grehams' School, Holt, Norfolk.
'By arrangement'. - Bryanston School, Blandford, Dorset.
'On a key lending basis'. - Marlborough College.
'Mainly used on Saturday evening'. - Cheltenham College.
'Not accessible very much owing to breakage of equipment'. - New Mills, Stockport.
as eligible to use the applied science activity as shown below:

'Upper-sixth scientists only'. - Archbishop Holgate's G.S., York.
'Only the third year sixth'. - Maidstone G.S.
'Limited to 2 - 3 boys in post 'A' level period'. - St. Albans.

ORGANISATION

'For approved boys'. - Truro School.
'Through club'. - Catholic College, Preston.
'Through the science society'. - Central G.S., Birmingham.

ATTENDANCE In many schools the number of students using the applied science facilities had to be limited through sheer lack of space and the need to share the room with other school activities.

The Headmaster of Cheltenham G.S. believed that attendance at 'centres' depended on:-

1) 'Policy being stressed by myself as Headmaster', and
2) 'Adaptability of staff'.

The second point was reinforced by Huddersfield New College who claimed to have 'no suitable instructor' and 'therefore unable to offer any applied science activity'.

5.8 EVALUATION

Headmasters of schools in this category were very reluctant to assess formerly the value of their applied science activities; but felt that some of the participants derived pleasure, satisfaction, and at times useful knowledge. Whether these participants obtained an accurate impression of the world of technology is almost unknown.

Two Headmasters, however, were willing to send me numerical data concerning their school leavers selecting pure science and engineering courses at the universities, Tables 2 and 3, which suggests that good facilities may influence a child's career choice.

5.9 CONCLUSION

These activities gave pupils the opportunity to undertake constructional or experimental activities which they would otherwise have been unable to pursue, and encouraged some of them to extend their academic knowledge in order to complete or repair their equipment. In only a very small number of cases did the activity
influence a pupil towards becoming a chartered engineer.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF STUDENTS ENTERING UNIVERSITY ENGINEERING COURSES</th>
<th>NUMBER OF STUDENTS ENTERING UNIVERSITY SCIENCE COURSES</th>
<th>NUMBER OF STUDENTS ENTERING COURSES FOR MEDICINE OR DENTISTRY</th>
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<tr>
<td>1964</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>1965</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1966</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1967</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1968</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1969</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1970</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

X  A converted greenhouse made available for applied science.

XX  A new, additional, biology laboratory became available.
### TABLE 3

**ROWLINSON TECHNICAL SCHOOL**

**SHEFFIELD**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF BOYS ENTERING UNIVERSITY ENGINEERING COURSES</th>
<th>NUMBER OF BOYS ENTERING UNIVERSITY SCIENCE COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1962</td>
<td>0</td>
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</tr>
<tr>
<td>1963</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1964</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1965</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1966</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>1967</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1968</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>1969</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>1970</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

**X** A small room under the stage made available for applied science.

**XX** Supervised applied science project work, housed in a workshop, became an integral part of the timetable.
5.10 A FOLLOW-UP STUDY OF SCHOOLS INADEQUATELY EQUIPPED FOR APPLIED SCIENCE

In 1971 I investigated the schools whose staffs, through the 10 Page Report questionnaire of 1965, had made it clear that their facilities for teaching applied science were completely unsuitable or totally inadequate. Examples of schools qualifying for places in this category were:

Chorlton G.S., Manchester - 'Only a small prep/storage room'.
Westwood's G.S., Northleach - 'This is really a converted greenhouse'.

After re-reading the 265 questionnaires, 31 schools were judged to fall into this category.

The present situation of these schools was assessed by preparing a questionnaire (Appendix 1) and sending it, with a covering letter, to each school. As the sample was numerically small a S.A.E. was enclosed with each letter/questionnaire so that these schools would be encouraged to complete and return the document. This technique produced a 77% response.

5.10.1 SCHOOLS THAT HAVE OBTAINED ADDITIONAL FACILITIES

Only three of the schools investigated have been able to make any improvements to their accommodation for applied science between 1965 and 1971. Elgin Senior High School who were originally using part of their workshops have built 'a special car maintenance workshop', New College, Huddersfield, have appointed a teacher who has introduced hydraulic benches and material testing equipment and Rowlinson Technical High School, Sheffield, who have vacated the 'small room under the stage' and moved into a workshop.

SCHOOLS THAT HAVE GIVEN UP OFFERING APPLIED SCIENCE

Six of the schools who were offering an applied science activity in 1965 now no longer claim to do so.

All of these schools say that they are still without special facilities for the work, and judging from the comments written by three of them, problems of space, time and suitable staff are currently presenting serious difficulties to the introduction of applied science. Kings Norton Grammar School for Boys, Birmingham, explained 'our accommodation and resources are fully occupied in teaching the pure sciences', while St. Brendan's College, Bristol, showed that their
rowing club, rugby, tennis, cricket and cross country activities'. Dame Allan's School, Newcastle-upon-Tyne, emphasised the importance of the teacher by saying that 'good teaching in applied science is an essential, to be taken before facilities'.

5.10.2 SCHOOLS THAT STILL OFFER APPLIED SCIENCE

a) SCHOOLS WITH SPECIAL FACILITIES

Nine of the eighteen schools still providing an applied science activity say they possess some kind of special room or laboratory where students can undertake the work. These rooms, vary in quality from 'a dungeon' at Bryanston School and various areas of craft departments and science laboratories in the majority of schools, to the 'special car maintenance workshop' at Elgin Senior High School, Gateshead.

Further investigation revealed that the 'dungeon' at Bryanston was a small room originally built for some other purpose situated a long way from the main school building.

Despite the variation in standards two-thirds of these schools said they are satisfied with their facilities.

EQUIPMENT This ranges from 'a lot of junk and a few good workshop tools' at Bryanston to expensive apparatus for testing metals installed in part of the craft department at Ravensbourne School for Boys, Bromley. In the majority of schools the equipment consists of metal working tools and whatever test meters can be borrowed from the science department.

WORK UNDERTAKEN Typical examples are, project work for the Nuffield Physical Science Course, car maintenance, 'O' and 'A' level metalwork and CSE physical science.

b) SCHOOLS WITHOUT SPECIAL FACILITIES

The nine schools in this category, still operate their applied science activity either from the craft or science departments. In the small sample examined the responsibility was about equally divided between these two departments.

Half the science departments involved are clearly dissatisfied with their lack of space and apparatus for applied science. Stamford
of a laboratory' and Bradfield College regretted being 'unable to leave apparatus out without danger of having to be removed for other classes'. The Beckett School, Nottingham would consider themselves lucky to have any apparatus or tools to be removed; their only pieces of equipment consist of an old motor car and motor cycle situated outside the building.

The craft departments seemed a little happier with their conditions; the troubles encountered were of an individual nature and did not form a trend.

**EQUIPMENT** Three schools were unable to give any details of the apparatus they had for applied science while those that did, can be summarised by the comments from Bradfield College, Berks, and Hallcroft School, Derbyshire, i.e. 'normal equipment of science laboratories' and 'metal and woodworking tools and machinery (lathes)'.

**WORK UNDERTAKEN** There is still a predominance of unexamined work of a constructional nature. Those schools that are presenting applied science as an examinable subject are using examinations such as CSE metalwork, City & Guilds Telecommunications and Oxford & Cambridge Applied Mechanics at 'A' level, and then only for a small number of pupils.

5.10.3 **AVAILABILITY**

Only two of the applied science activities were presented solely as after school or private time activities; the remainder were available during school hours. The two schools in the former category were boarding schools and offered their applied science activity as a non-examinable club activity in what they considered to be unsatisfactory accommodation.

5.11 **ARE SPECIAL FACILITIES NECESSARY?**

Fifty per cent of the schools that were attempting to present applied science to their students in conditions they considered unsatisfactory felt that special rooms and laboratories were essential for carrying out worthwhile work of an applied nature. The reasoning behind this view is summarised by Hallcroft School, Ilkeston, who said 'good facilities and tools are an incentive to good and conscientious work'.
A few schools such as The Beckett School, Nottingham, felt that however good the facilities a competent teacher is more essential when they stated 'laboratories are vital but good teaching comes first'.

Among the fifty per cent of the schools who did not think special laboratories were essential was Bryanston School who would be content with something less lavish than a purpose built laboratory but realised that 'poor ones (laboratories) are a hindrance'. Bradfield College, Berks, was worried that a special laboratory would 'attract the wrong boys for the wrong reasons', but I think this depends on how it is used and the calibre of the teacher in charge.

The vital role played by the teacher was mentioned many times and the general feeling can be summarised by the comment from Elgin Senior High School, Gateshead, 'a desire to do something is more important than the laboratory, most difficulties can be overcome eventually'.

5.12 CONCLUSION

During the last five years the majority of these schools have made very little progress towards providing adequate facilities for applied science teaching; this failure to improve the physical conditions has caused a number of them, either directly or indirectly, to terminate their applied science activity.

Many inadequately equipped schools however are continuing to provide applied science but find themselves unable to develop the activity because of the poor facilities or shortage of staff.

5.13 OVERALL CONCLUSION

This investigation has shown that many schools, without purpose built applied science laboratories, have to accommodate their applied science activities in rooms or modified areas ranging from satisfactory to primitive.

The scope of the work undertaken in these premises appears to depend on the size of the accommodation, the quality of the equipment and the calibre of the teacher; even under the worst physical conditions good teachers have been able to organise programmes that bring some pleasure and satisfaction to the participants.
Observations of headmasters and teachers, supported by numerical data, suggest that carefully adapted premises do have a beneficial effect on the outlook of students towards engineering and encourage some of them to follow a university course in the subject.

If worthwhile applied science activities are to continue and develop in schools, it is imperative that competent and enthusiastic teachers are forthcoming who are willing to take charge of them.

5.14 SUGGESTION

Unless a school has available a room of suitable size to adapt to the needs of an applied science activity and is able to provide adequate tuition and supervision, then it might be wiser to allow students to continue pursuing their personal technical interests on a club basis and not use the titles 'Applied Science' or 'Engineering' at all.

In this way boys and girls, especially at fifth and sixth-form level, will still derive great pleasure from whatever technical hobby they choose to follow but will not confuse it with direct preparation for a course of engineering at a university.
Questionnaire Concerning the Accommodation Available in Schools for Applied Science Activities

Please complete this questionnaire by writing the name of your school at the top and then placing ticks, or data, in the appropriate boxes after each question, and return it to G.C. Sneed at the University of Surrey, in the stamped addressed envelope provided.

NAME OF SCHOOL ____________________________

1. Do you provide an applied science activity for your students? YES NO

2. Is the activity part of an examinable course? YES NO

If YES, please state the title of the examination and the name of the Examining Board.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

3. Is the activity based in the craft department? science department? elsewhere?

If elsewhere, please state where.

________________________________________________________________________

4. Do you have a special room or laboratory where students can undertake applied science studies? YES NO
4. (contd)

If YES, is the room or laboratory equipped for

- Project work
- Formal experimental work
- Some other form of applied science

Please give a brief description of the equipment available.


5. Do you consider that the accommodation you have for applied science is suitable for your activity? YES NO

If NO, is the accommodation unsuitable through

- Being too small
- Lack of electricity
- Lack of water
- Lack of gas
- Originally built for some other purpose
- Being away from the main building
- Being inadequately equipped.

Please give a brief outline of any other reason that makes it unsuitable.


6. Is your applied science activity available to students

- During school hours?
- After school?
- At weekends?

7. Do you consider that good facilities are essential to interest boys and girls in applied science? YES NO

Please elaborate if you wish


THANK YOU
AIM

To investigate the possibility of advising secondary schools to use the educational resources of science and technological museums as a means of supplementing their own limited facilities for demonstrating how the science they teach is used by industry, to solve problems.
 CHAPTER 6

A STUDY OF THE FACILITIES FOR APPLIED SCIENCE EDUCATION OFFERED BY BRITISH SCIENCE MUSEUMS

6.1 AIM OF THE STUDY

To investigate the possibility of advising secondary schools to use the educational resources of science and technological museums as a means of supplementing their own limited facilities for demonstrating how the science they teach is used by industry, to solve problems.

6.2 EXTENT OF THE STUDY

The National Science Museum, South Kensington recently compiled (1969) a list giving the names and addresses of museums throughout Great Britain that were known to have collections relating to the fields of science, technology, or both. Sixty-six of these museums are classified as containing technological exhibits; nine of which contain also collections of a scientific nature.

A questionnaire was compiled and sent to these sixty-six museums of which 42 completed it either fully or in part. (Appendix 9)

The information collected from the questionnaires was supplemented by visiting 16 of the museums and interviewing members of the staffs.

Table 1 shows when the 42 museums considered in this study were founded, when their educational emphasis began, and the year they appointed an education director.

6.3 THE NATIONAL SCIENCE MUSEUM

The resources of the National Science Museum, South Kensington were investigated as a means of setting a standard by which other science and technological museums considered in this study could be compared.

The Science Museum endeavours to combine historical research with the task of educating people of all ages by giving them a knowledge of science and technology. An attempt to achieve the latter
<table>
<thead>
<tr>
<th>Museum</th>
<th>Location</th>
<th>Year Founded</th>
<th>Year Educational Emphasis Began</th>
<th>Year Director of Education Appointed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allied Ironfounders Museum</td>
<td>Ketley</td>
<td>1959</td>
<td>1959</td>
<td>-</td>
</tr>
<tr>
<td>Avery Historical Museum</td>
<td>Birmingham</td>
<td>1927</td>
<td>1927</td>
<td>-</td>
</tr>
<tr>
<td>Barnes Museum of Cinematography</td>
<td>St. Ives</td>
<td>1963</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bridewell Museum</td>
<td>Norwich</td>
<td>1925</td>
<td>1925</td>
<td>-</td>
</tr>
<tr>
<td>* British Piano Museum</td>
<td>Brentford</td>
<td>1963</td>
<td>1963</td>
<td>1963</td>
</tr>
<tr>
<td>* Buckler's Hard Maritime Museum</td>
<td>Beaulieu</td>
<td>1963</td>
<td>1963</td>
<td>-</td>
</tr>
<tr>
<td>Central Flying School</td>
<td>Little Rislington</td>
<td>1965</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Danor Engineering Ltd.</td>
<td>London</td>
<td>1955</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* EMI Museum</td>
<td>Hayes</td>
<td>Created itself</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ferranti Museum</td>
<td>Hollinwood</td>
<td>1960</td>
<td>1960</td>
<td>-</td>
</tr>
<tr>
<td>Festiniog Railway Company</td>
<td>Portmadoc</td>
<td>No date</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fleet Air Arm Museum</td>
<td>Yeovilton</td>
<td>1964</td>
<td>1964</td>
<td>-</td>
</tr>
<tr>
<td>* Holman Museum</td>
<td>Cambourne</td>
<td>1951</td>
<td>1951</td>
<td>-</td>
</tr>
<tr>
<td>* Independent Television Gallery</td>
<td>London</td>
<td>1968</td>
<td>1968</td>
<td>-</td>
</tr>
<tr>
<td>* Institute Geological Sciences</td>
<td>London</td>
<td>1837</td>
<td>1936</td>
<td>1936</td>
</tr>
<tr>
<td>* Kodak Museum</td>
<td>Wealdstone</td>
<td>1927</td>
<td>1946</td>
<td>-</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
<td>Lacock, Nr. Chipperham</td>
<td>1950</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lewis Textile Museum</td>
<td>Blackburn</td>
<td>1874</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
<td>London</td>
<td>1960</td>
<td>1960</td>
<td>-</td>
</tr>
<tr>
<td>* Manchester Museum of Science and Technology</td>
<td>Manchester</td>
<td>1969</td>
<td>1969</td>
<td>Advertised</td>
</tr>
<tr>
<td>Maritime Museum</td>
<td>Great Yarmouth</td>
<td>1967</td>
<td>1967</td>
<td>-</td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
<td>Maidstone</td>
<td>1858</td>
<td>1858</td>
<td>-</td>
</tr>
<tr>
<td>Museum of Science &amp; Engineering</td>
<td>Newcastle</td>
<td>1954</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* Museum of Science &amp; Industry</td>
<td>Birmingham</td>
<td>1950</td>
<td>1950</td>
<td>-</td>
</tr>
<tr>
<td>Museum of Transport</td>
<td>Glasgow</td>
<td>1964</td>
<td>1969</td>
<td>1941</td>
</tr>
<tr>
<td>Narrow Gauge Railway</td>
<td>Towyn</td>
<td>1951</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>National Maritime Museum</td>
<td>Greenwich</td>
<td>1934/7</td>
<td>1961</td>
<td>1961</td>
</tr>
<tr>
<td>Nottingham Industrial Museum</td>
<td>Nottingham</td>
<td>Not yet open to the Public</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Post Office Telephone Museum</td>
<td>Taunton</td>
<td>1957</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* Pilkington Glass Museum</td>
<td>St. Helens</td>
<td>1964</td>
<td>1965</td>
<td>-</td>
</tr>
<tr>
<td>* R.A.C. Tank Museum</td>
<td>Wareham</td>
<td>1923</td>
<td>1952</td>
<td>-</td>
</tr>
<tr>
<td>R.A.F. Museum</td>
<td>London</td>
<td>Not yet established</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* Rotunda</td>
<td>Woolwich</td>
<td>Present site 1820</td>
<td>1778</td>
<td>-</td>
</tr>
</tbody>
</table>
TABLE 1 (continued)
MUSEUMS CONSIDERED IN THIS SURVEY

<table>
<thead>
<tr>
<th>Museum</th>
<th>Location</th>
<th>Year Founded</th>
<th>Year Educational Emphasis Began</th>
<th>Year Director of Education Appointed</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Russell-Cotes Art Gallery</td>
<td>Bournemouth</td>
<td>1921</td>
<td>1968</td>
<td>-</td>
</tr>
<tr>
<td>* Science Museum</td>
<td>London</td>
<td>1857</td>
<td>1857</td>
<td>1955</td>
</tr>
<tr>
<td>* Shuttleworth Collection (1932)</td>
<td>Biggleswade</td>
<td>Open to Public 1964</td>
<td>1964</td>
<td>-</td>
</tr>
<tr>
<td>Tramway Museum</td>
<td>Crich</td>
<td>1959</td>
<td>1962</td>
<td>-</td>
</tr>
<tr>
<td>Transport Museum</td>
<td>Hull</td>
<td>1930</td>
<td>1966</td>
<td>1968</td>
</tr>
<tr>
<td>* Victory Museum</td>
<td>Portsmouth</td>
<td>1939</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wellcome Museum of Medical Science</td>
<td>London</td>
<td>1914</td>
<td>1914</td>
<td>-</td>
</tr>
<tr>
<td>Worcestershire County Museum</td>
<td>Kidderminster</td>
<td>1964</td>
<td>1966</td>
<td>1966</td>
</tr>
<tr>
<td>Wye College of Agriculture</td>
<td>Ashford (Kent)</td>
<td>Present site 1958</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Visited during the course of this study
aim is made by carefully presenting and displaying a vast number of static and working exhibits in warm and pleasant surroundings. In addition to the exhibits the museum operates a regular lecture service in a superbly equipped lecture theatre.

For the benefit of the youngest visitors there is a childrens gallery containing working models and displays especially designed to try and captivate their imaginations.

In 1969 the Science Museum was voted a budget of over £1,000,000 and employed 413 staff to maintain and protect the exhibits and to provide the illustrated educational lectures and demonstrations.

Industry does not normally contribute money to the museum but provides valuable support by preparing and offering its products as educational exhibits to help fill the 300,000 sq. ft. of floor space the museum has available for display purposes.

6.4 THE NEW MANCHESTER MUSEUM

It is very encouraging to see that a new science museum, opened in October, 1969, stated as long ago as 1966 that 'its most important educational function would be to help arouse at the earliest stage possible the latent interest of youngsters who happened to have natural aptitudes for technology'.

Although it is still very early days in the life of this museum the staff, consisting of a director and research assistant, have plenty of ideas they wish to develop. Amongst their ideas is the provision of a public forum for science and technology as a means of spreading technological knowledge to the general public, including the non-scientific members of the community.

Financial support for this museum comes from Manchester University the University of Manchester Institute of Science and Technology and the City of Manchester.

6.5 TYPICAL DIFFICULTIES EXPERIENCED BY MUSEUMS

Unfortunately, very few of the museums considered in this investigation are able to offer any educational programmes that would help secondary schools with the applied aspect of their science
teaching. The fundamental reason for this seems to be a shortage of money, which in turn leads to inadequate buildings to house scientific and technological collections and insufficient staff to organise educational services.

Typical examples of the difficulties are given below.

**INADEQUATE BUILDINGS** The Lackham School of Agriculture houses its collection of old agricultural implements in a small building that has no facilities for study, while the farm machinery belonging to the museum attached to Wye College is kept in a building without either heat or light.

The Manager of the Independent Television Gallery regrets that he has neither the space nor the staff to offer lectures or demonstrations.\(^{47}\)

**SHORTAGE OF STAFF** The Avery Historic Museum owned by W & T Avery Ltd., has a Curator who is expected to combine the responsibilities of the post with a fulltime job elsewhere in the Company.\(^{48}\)

The Lackham School of Agriculture Museum has no fulltime director or staff. All maintenance has to be done by interested students on a part-time basis assisted by the Warden whenever he can spare the time from his many other duties.

The Narrow Gauge Railway Museum, Towyn, and the Tramway Museum, Crich, rely almost entirely on voluntary labour to restore their exhibits to working order while the Buckler's Hard Maritime Museum is run by an Honorary Curator who is the head of a history department in one of the local schools.\(^{49}\)

**AN EXTREME CASE** Perhaps one of the extreme cases is the Museum of Science and Engineering in Newcastle-upon-Tyne. The director of this museum says that the local authorities do not provide money for staff, facilities, equipment, or decoration and repair.\(^{50}\) When I visited this museum in 1970 many of the exhibits were deteriorating and the whole display area was in need of rearranging.
6.6. SERVICE MUSEUMS

During the course of visiting a number of Training Establishments belonging to the armed services it became apparent to me that the teaching staffs used great skill and imagination in presenting to their trainees complicated pieces of technological equipment in a simple manner. Therefore it seemed logical to include Service Museums in this study in the hope of finding some of the teaching aids preserved and then suggesting that they be made available for use in civilian schools.

R A F The Fleet Air Arm Museum, Yeovilton, has a collection that includes aircraft models, relics, documents and photographs that portray the history of naval aviation from 1920 to the present day. In addition to the models there are some real aircraft on view and the weapons that they carry.

The Curator welcomes school children and makes every effort to keep the atmosphere of the museum lively and free from the musty image attributed to so many other museums.

In 1969 Dr. John Tanner, Director of the R.A.F. Museum, High Holborn wrote and told me that he was keen to establish educational facilities within the museum and then encourage liaison with schools. These wishes, he said, would only be fulfilled when the next batch of staff joined him.51

The Museum associated with the R.A.F. Central Flying School, Little Rissington, started in 1946 as a hall for demonstrating equipment to airmen. As the equipment became obsolete some sectionalised engines were added and an attempt made to portray various themes of aviation. This museum can arrange visits for school parties but are not often called upon to do so.

ARMY The Royal Artillery Institution, Woolwich, encourages schools to visit their museum which contains a display of ordnance from 1346 to 1945. There are no facilities for lectures or for providing other kinds of educational aids.

An exhibition of armour is presented by the R.A.C. Tank Museum. Unfortunately their educational capabilities are limited by the absence of classrooms or cinemas and the existence of only one
executive officer.

NAVY H.M. Dockyard, Portsmouth, contains the Victory Museum. The Curator of this museum, Captain Hack, regrets that he only has enough staff to supply guides in the ship. Visitors to the museum must gain their information by reading the labels placed beside each exhibit. The contents of the museum give no indication of how ships or their equipment utilise basic scientific principles; the emphasis is on naval history.

SUMMARY

The evidence presented above suggests that Service Science Museums also suffer from lack of money and staff, and possess very little material that could assist a school teacher to demonstrate interesting and genuine applications of science to his students.

All the interesting technical teaching aids used by service training establishments are subject to strict security regulations and cannot be made available to civilian schools.

6.7 PUBLICITY DESCRIBING EDUCATIONAL FACILITIES

However restricted the educational services in science museums may be, it is important that some means of conveying information concerning existing exhibits and services be made available to science teachers, parents and students thus enabling such facilities to be used to the best advantage.

Section 2.2 of the questionnaire was written in the hope of finding out if such publicity material existed, and how it reached prospective visitors. The evidence obtained is presented in the next three sections.

EXISTENCE OF PUBLICITY MATERIAL

Thirty-eight museums gave information on this point. (Appendix 1) Twenty of these museums have no publicity of any kind and the remaining eighteen offer, in one or more of the following forms, a very limited advertising and publicity service.

Press Advertisement - the most favoured.
Teachers' professional journals.
Career advisory panels.
Teachers' Centres.
Official circulars to schools.
Social teaparties held at the museum.
Newsletters.
Leaflets available on request.
The latter seven methods are roughly equally favoured.

DISTRIBUTION TO SCHOOLS

Information on this point was supplied by thirty-three museums (Appendix 2). Twelve museums regularly post advertising material direct to classroom teachers by name and six museums post advertising material just addressed to the schools. Five museums said that they sent the material both to teachers personally and to their schools in general.

Twelve museums post advertising material to a school addressed to the Headteacher, of these only one does not send personally to a teacher as well. Nine museums post advertising material to a local director of education.

Nineteen museums do not post any advertising material at all.

DISTRIBUTION TO THE GENERAL PUBLIC

Thirty-three museums supplied this information (Appendix 3). Twenty-four museums have short articles about their work appearing in newspapers; of these sixteen consider that they have an average of at least one each month, while the Russell-Cotes Museum states they have twelve a month.

Nineteen museums have some association with television companies or their programmes, mainly by lending exhibits for use in television productions. Only staff from the Museum of Carriages and Art Gallery, Maidstone and the National Science Museum have given televised talks.

SUMMARY AND OBSERVATIONS

Only a very limited amount of publicity material is issued by museums to teachers for the purpose of informing them of the services and activities that are available.
Fortunately most of this material is sent to a school addressed to a teacher by name; my experience of school commonrooms has shown that failure to do so this results in the material remaining unopened or being thrown away.

Publicity for the general public is also very limited and probably only catches the attention of the people who would in any case make a visit to the museum.

6.8 PREPARING FOR A MUSEUM VISIT

All the available publicity and guide material was read in order to ascertain the nature of any preparatory help offered by museums to prospective individual visitors or group leaders. From this source the following information was deduced.

Twenty-three museums in this study produced booklets describing their exhibits, but thirteen of these sold them at prices as high as 25p a copy.

The Science Museum, South Kensington strongly advised teachers and group leaders to make a private preliminary visit. If distance made this impossible written enquiries concerning the availability of any exhibit of specific interest were recommended in order to avoid disappointment.

The National Maritime Museum emphasised the physical strain of visiting a museum and suggested that group leaders should select just two or three galleries, and not attempt to cover the whole exhibition.

Only Pilkington’s offered direct personal assistance with the preparation of a visit. This took the form of a regular teacher’s seminar entitled, 'How to use a Museum'.

6.9 ADMISSION CHARGES

Several American Science Museums offer reduced admission charges for teachers and in Portland, Oregon, for example, waive the charge altogether.

Section 2.1 parts (c) and (d) were included in the questionnaire to find out if similar privileges were given to teachers and their
pupils in this country.

Nine out of the thirty-six museums who answered these questions levied an admission charge to their main collections; in all but two cases this charge was waived to teachers. These two exceptions were only prepared to grant this privilege to teachers accompanying a school party (Appendix 4).

With regard to children, one museum only charged on a Thursday, two kept the charge to 2½p per child and three waived the charge for school parties.

6.10 CONDUCTING THE VISIT

The technique of taking children to a museum and then allowing them to wander about individually to freely examine the exhibits was actively discouraged by nineteen of the museums that answered section 4 of the questionnaire (Appendix 5).

Of these, fourteen were able to offer each visiting party a guide although in three cases the service was limited or restricted. The remaining five expected the teachers to supervise the children and provide instruction.

In fourteen museums the children were allowed to inspect the exhibits unsupervised, but five of these expected teachers to be on the premises and willing to take responsibility for the children's behaviour.

DEDUCTION

Observation in four museums that provided guide services and permitted children to wander around suggested that the latter was the most popular method with teachers when the collection of information was required for the completion of a formal 'questionnaire'. This also applied to the sketching of exhibits as part of a class activity. Conversation with random teachers, in charge of museum parties also suggested that the free approach - properly organised - was most beneficial to children engaged in a project.

Table 2 shows some museum attendance figures for school children, and the general public during 1969.
**TABLE 2**

MUSEUM ATTENDANCE 1969

<table>
<thead>
<tr>
<th>Museum</th>
<th>Attendance By School Children in Organised Visits (Per Year)</th>
<th>Total Public Attendance (Per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Piano Museum</td>
<td>A few school parties</td>
<td>*</td>
</tr>
<tr>
<td>Buckler's Hard Maritime</td>
<td>*</td>
<td>80,000</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
<td>Not known</td>
<td></td>
</tr>
<tr>
<td>Holman</td>
<td>59 parties cont. 1,658 children</td>
<td>7,866</td>
</tr>
<tr>
<td>Independent Television Gallery</td>
<td>3,611 children</td>
<td>*</td>
</tr>
<tr>
<td>Institute of Geological Sciences</td>
<td>650 parties cont.6,000 students</td>
<td>*</td>
</tr>
<tr>
<td>Kodak</td>
<td>30 parties/week</td>
<td>*</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
<td>100 children</td>
<td>2,000</td>
</tr>
<tr>
<td>Lewis Textile</td>
<td>2,378 (S) 1,744 (P) 532 (G.T.)</td>
<td>*</td>
</tr>
<tr>
<td>Maritime - Great Yarmouth</td>
<td>4 parties</td>
<td></td>
</tr>
<tr>
<td>Museum &amp; Art Gallery - Maidstone</td>
<td></td>
<td>7,000</td>
</tr>
<tr>
<td>Museum of Transport - Glasgow</td>
<td>Several hundred per week</td>
<td>*</td>
</tr>
<tr>
<td>Museum of Science &amp; Engineering - Newcastle</td>
<td></td>
<td>4,859</td>
</tr>
<tr>
<td>Pilkington Glass</td>
<td>10 parties per week</td>
<td>*</td>
</tr>
<tr>
<td>R.A.C. Tank</td>
<td>3,000 parties</td>
<td>*</td>
</tr>
<tr>
<td>Russell-Cotes</td>
<td>152 parties cont. 2,549 children</td>
<td>*</td>
</tr>
<tr>
<td>Science Museum - London</td>
<td></td>
<td>2,170,000</td>
</tr>
<tr>
<td>The Shuttleworth Collection</td>
<td>9,000 students</td>
<td>*</td>
</tr>
<tr>
<td>Wellcome Museum of Medical Science</td>
<td>250 sixth-form students</td>
<td>*</td>
</tr>
<tr>
<td>Worcestershire County</td>
<td>210 parties cont.7,249 children</td>
<td>*</td>
</tr>
</tbody>
</table>

P  Primary School Children
S  Secondary School Children
G.T. Grammar or Technical School Children
*  No data available
6.11 PROVISION OF PRINTED MATERIAL TO ASSIST A MUSEUM VISIT

In addition to the literature describing exhibits that is available in twenty-three of the museums, the National Maritime Museum offers a 4p booklet entitled 'The Log of my Visit', written for the benefit of children between the ages of 10 and 13 years. This booklet provides space for a child to write notes and contains suggestions for class work to be undertaken on returning to school.

FREE MATERIAL

Perhaps the most useful free material available was that offered by the Worcestershire County Museum, and the Museum of Science and Industry, Birmingham. These museums provide children with questionnaires to be answered in conjunction with the visit. The Worcestershire County Museum questionnaire takes the form of a series of five small four-page duplicated sheets with anything up to twelve questions on each. The majority of the questions are chosen so that they can be answered by looking at the exhibits in an intelligent manner. The Museum of Science and Industry, however, provide a questionnaire that requires a little more research before the forty answers can be obtained; a typical question is,

'What is Bakelite, and when was it invented'?

A CASE AGAINST THE PROVISION OF FREE MATERIAL

The National Science Museum, South Kensington considers that the provision of free material does more to increase the litter on its floors and adjacent streets than it does to assist visiting children.

Thirty-three museums gave information concerning printed material (Appendix 6).

6.12 CLASSROOMS

It is not uncommon to find that an American Science Museum has one or more classrooms which are used by schools for formal lessons, given by their teacher, illustrated with material normally on view in the museum.

Section 1 (d) was included in the questionnaire to find out whether English science museums possessed similar facilities and if
so, whether they were being used.

Thirty-three museums answered the question; the information obtained is shown in Table 3.

Only twelve museums possessed one, or more, classrooms; half of these having been built in the last three years. Five are in regular use and only three claim to use them for ten or more hours a week.

The Science Museum, South Kensington uses its large lecture theatre (seating capacity of 173) for operating its free lecture service. For the benefit of senior school pupils a series of joint industrial lectures are given each year so that leading technologists can demonstrate how pure science is applied to industrial processes. Whenever these lectures are given the lecture theatre is filled to capacity with school children, which suggests that school science teachers want their students to learn about the industrial applications of science.

SUMMARY

Very few English museums possess classroom facilities. Of those that do, at least a third are rarely used because there are no museum staff available to organise or give lectures.

English museums do not encourage school teachers to use the museum classrooms for lessons of their own. Tradition, perhaps, expects the museums to provide lecturers to address invited audiences.

6.13 LENDING MATERIAL TO SCHOOLS

Taking a group of children to a science museum can occupy at least half of a school day and therefore such visits cannot be undertaken without disrupting the school timetable, and the science teachers probably incurring the displeasure of their colleagues.

If a museum were prepared to lend some of its smaller exhibits as illustrative material for a school based science lesson, at least some of the facilities of the museum would become available at frequent intervals throughout the academic year.

Section 7 of the questionnaire revealed that fifteen museums
<table>
<thead>
<tr>
<th>Museum</th>
<th>Number of Classrooms</th>
<th>Average Hours Weekly Use per Room</th>
<th>Year Classroom Opened</th>
<th>Year of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>School Holidays</td>
<td>School Term</td>
<td></td>
</tr>
<tr>
<td>Central Flying School</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>*</td>
</tr>
<tr>
<td>Institute of Geological Sciences</td>
<td>1</td>
<td>18</td>
<td>22</td>
<td>1936</td>
</tr>
<tr>
<td>Manchester Museum of Science &amp; Technology</td>
<td>1</td>
<td>Only occasional use</td>
<td></td>
<td>1969</td>
</tr>
<tr>
<td>Museum of Transport - Glasgow</td>
<td>1</td>
<td>Nil at present</td>
<td></td>
<td>1969</td>
</tr>
<tr>
<td>National Maritime Museum</td>
<td>2</td>
<td>*</td>
<td>*</td>
<td>1937 1965</td>
</tr>
<tr>
<td>Pilkington Glass Museum</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1964</td>
</tr>
<tr>
<td>Russell-Cotes Museum</td>
<td>1</td>
<td>3</td>
<td>10</td>
<td>1968</td>
</tr>
<tr>
<td>Science Museum - London</td>
<td>1 small 8 large</td>
<td>20(max)</td>
<td></td>
<td>1932 Rebuilt 1965</td>
</tr>
<tr>
<td>The Shuttleworth Collection (1932)</td>
<td>1</td>
<td>*</td>
<td>*</td>
<td>1968</td>
</tr>
<tr>
<td>Transport Museum - Hull</td>
<td>1</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Wellcome Museum of Medical Science</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>1967</td>
</tr>
<tr>
<td>Worcestershire County Museum</td>
<td>1</td>
<td>Little Variable</td>
<td>Variable</td>
<td>1967</td>
</tr>
</tbody>
</table>

* No data available
+ Not operational
were prepared to lend specimens and materials to schools although four of these stated that they would only do so for special occasions (Appendix 7).

The material available under these loan schemes can be divided into the three categories, individual exhibits, films and slides and portable locked show cases. Unfortunately, none of these educational aids had any bearing on the applications of school science relative to industry. The only available exhibit of a technological nature was a 19th century electromagnetic machine used for the treatment of diseases. This machine appeared on a loan list published by the Worcestershire County Museum.

The National Science Museum offers slides showing any of the exhibits in their possession. Unfortunately, these slides measure 3\(\frac{3}{4}\)" x 3\(\frac{3}{4}\)" a size which does not fit the type of projector available in many schools.

The Wellcome Museum of Medical Science offers its slides mounted in the popular 2" x 2" holders, but despite this advantage neither museum has a heavy demand on this particular service.

The Hull School Museum Service lends locked show cases containing material listed under various titles. Further enquiries revealed that the material offered under the title 'Scientific and Industrial History' which is the nearest to anything technological, covers model aeroplanes, cars and steam engines. Their cases are most used by primary schools.

The Wellcome Museum of Medical Science which offered show cases suitable for the upper forms of secondary schools had to discontinue the service due to high cost and low demand.

6.14 PRIVILEGES FOR SCIENCE TEACHERS

At least one American Science Museum offers teachers free admission, teaching hints and information for making simple apparatus, while others offer the chance to participate in industrial visits to update their knowledge.

Paragraph 6.9 summarised the privileges in admission charges while Section 2, Question 1(c) and Section 3(c) of the questionnaire were written to reveal additional privileges that were available,
and to obtain an idea of the extent to which museums served as a lesson preparation source for teachers.

Thirty-two museums answered the questions thereby showing that there were no additional privileges for teachers beyond those available to any member of the public.

Twenty-seven museums thought that teachers (unclassified) availed themselves of museum facilities, but five felt that teachers very rarely attempted to use the material they had available.

**OBSERVATION**

Since only ten museums made an admission charge it was not necessary in many cases for a teacher to identify himself in order to gain free admission. One therefore supposes that museum attendants either recognise the local teachers or else have based their statistics on formal letters or verbal requests for help.

6.15 **MUSEUM MEMBERSHIP**

A few of the small specialised museums such as the Tramway Museum, Crich, and the Narrow Gauge Railway Museum, Towyn, encourage people to become members. These offers of membership provide the museum with a source of income and free restoration labour.

Four museums, however, offer a membership scheme as a means of providing an education service, but these do not cater especially for students interested in technology (Appendix 8).

6.16 **COURSES FOR TEACHERS**

At the present time none of the museums in this survey offered any courses for teachers.

The National Maritime Museum offered a course in the Planetarium some months ago but the offer was not accepted by any teacher so the course was not organised.

6.17 **COURSES FOR STUDENTS**

None of the museums in this survey offered courses for students.
6.18 FINANCIAL SUPPORT FROM INDUSTRY

Outside the sphere of industrially owned museums, only the Wellcome Museum of Medical Science receives any financial support from industry.

6.19 ZONAL ANALYSIS OF MUSEUM FACILITIES

In order to examine museum educational facilities on a zonal basis the museums considered in this study were divided into four groups according to their distances from London. Table 4 lists the museums in each zonal group and the accompanying graph, Table 5, indicates how the various museum services and facilities compare, zone with zone, and with the national pattern obtained by considering all the museums in the study.

6.20 SUMMARY AND CONCLUSIONS

SUMMARY OF FINDINGS

(1) **Administration.** Seven out of the forty-two museums examined in this study had appointed a Director of Education.

(2) **Physical facilities.** Five museums stated that their educational displays were almost non-existent through lack of money or shortage of staff and a further four museums expressed regret that their educational services were seriously curtailed through lack of space or maintenance.

Twelve museums possessed classrooms of which nine had a single classroom and one, three classrooms. The average hours of weekly use of these classrooms ranged from 0 to 18 hours in school holiday periods to 0 to 22 hours in term time. A typical figure in each case would be four hours.

(3) **Public relations.** Eight methods were used to inform the schools and general public of museum activities; the most popular being through newspaper advertisements.

Twelve museums posted announcements to Headteachers by title; all but two of these museums also sent notices to teachers by name.
### MUSEUMS WITHIN 30 MILES OF LONDON

<table>
<thead>
<tr>
<th>Museum</th>
<th>Director of Education</th>
<th>Publicity for Education</th>
<th>Postal distribution of publicity material</th>
<th>One or more newspaper articles per month</th>
<th>Provision of guide service</th>
<th>Provision of printed material</th>
<th>Provision of free printed material assisting a visit</th>
<th>Teaching material loan or deposit</th>
<th>Educational membership for classes of education</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Piano</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danor Engineering Ltd</td>
<td></td>
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<tr>
<td>EMI</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent Television Gallery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute Geological Sciences</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kodak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Maritime</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rotunda</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Science Museum</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wellcome Museum Medical Science</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### MUSEUMS BETWEEN 30 & 110 MILES OF LONDON

<table>
<thead>
<tr>
<th>Museum</th>
<th>Director of Education</th>
<th>Publicity for Education</th>
<th>Postal distribution of publicity material</th>
<th>One or more newspaper articles per month</th>
<th>Provision of guide service</th>
<th>Provision of printed material</th>
<th>Provision of free printed material assisting a visit</th>
<th>Teaching material loan or deposit</th>
<th>Educational membership for classes of education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avery Historical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckler's Hard</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Central Flying School</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Museum of Science &amp; Industry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shuttleworth Collection (1932)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Wye College of Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Limited Service - not included in the total
<table>
<thead>
<tr>
<th>MUSEUMS BETWEEN 110 &amp; 200 MILES OF LONDON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allied Ironfounders</td>
</tr>
<tr>
<td>Bridewell</td>
</tr>
<tr>
<td>Ferranti</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
</tr>
<tr>
<td>Manchester Museum of Science and Technology</td>
</tr>
<tr>
<td>Maritime</td>
</tr>
<tr>
<td>Post Office Telephone</td>
</tr>
<tr>
<td>Pilkington Glass</td>
</tr>
<tr>
<td>RAC Tank</td>
</tr>
<tr>
<td>Tramway</td>
</tr>
<tr>
<td>Worcestershire County</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>% 9 36 27 55 55 64 36 18 9 27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MUSEUMS OVER 200 MILES FROM LONDON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnes Museum of Cinematography</td>
</tr>
<tr>
<td>Festiniog Railway Company</td>
</tr>
<tr>
<td>Holman</td>
</tr>
<tr>
<td>Lewis Textile</td>
</tr>
<tr>
<td>Museum of Science &amp; Engineering</td>
</tr>
<tr>
<td>Museum of Transport</td>
</tr>
<tr>
<td>Narrow Gauge Railway</td>
</tr>
<tr>
<td>Transport</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>% 25 25 38 25 50 63 12 38 0 25</td>
</tr>
</tbody>
</table>

National % 17 47 42 48 58 70 30 33 12 36
British museum services

- Director of Education appointed
- Publicity for education services
- Postal distribution to schools of publicity material
- One or more newspaper articles per month
- Provision of guide service
- Provision of printed material describing exhibits
- Provision of free printed material assisting a visit
- Teaching material loan scheme
- Educational membership scheme
- Classrooms available for lectures or demonstrations

Museums within 30 miles of London
Museums between 30 & 110 miles from London
Museums 110 & 200
Museums over 200 miles from London

100%
Newspaper articles concerning museum activities were only occasionally printed and personal appearances by museum staff in television programmes were only cited in two cases.

(4) Museum educational activities. The most common educational activity was a class or party visit.

A regular guide service was provided by twenty-seven museums while another six described their guide service as limited; in two cases this meant the service only functioned in the evenings or when a volunteer was available.

Free printed material of an educational nature was offered by ten museums while an additional thirteen had printed material available for purchase.

Ten museums operated an exhibit loan scheme for the benefit of schools but none of these schemes offered any material of immediate use to schools interested in teaching applied science.

Four museums organised educational membership schemes for children, but the activities did not extend to applied science.

None of the museums provided any courses for the benefit of children or teachers.

(5) Zonal analysis of museum educational services. The highest percentage of Directors of museum education are employed either in museums within 30 miles, or over 200 miles from London. Both these zones are well below the national average for providing free printed material to assist museum visits and for obtaining newspaper articles relating to museum activities.

Museums within 30 miles of London record also the highest provision percentage rating for classrooms and a guide service.

Museums situated between 30 and 110 miles from London are without any Directors of Education but have the highest provision percentage rating for five out of the ten educational services examined.

The provision of printed material describing the various exhibits
CONCLUSIONS

Over 25% of the museums considered in this study had their educational activities seriously curtailed through either insufficient money, inadequate premises or shortage of staff.

Most museums make some attempt to notify schools of the educational services they have to offer, but it seems that very little information reaches the general public to help them realise the valuable teaching work that could be carried out by museums if more money and facilities were available.

The 'School Party' visit, with or without an official guide, is the most usual method of incorporating museum material into a school educational programme. A few museums try to help teachers to make such visits of lasting value by supplying pre-visit advice and suggestions for post-visit classroom activities.

None of the museums had made any serious attempt to evaluate the effectiveness of museum party visits; even records of the numbers and age groups of children visiting the museums were difficult to obtain and in some cases no such records were kept.

Science and Technology museums in general, possess very little that would help trigger the enthusiasm of young people for applied science. A great deal of the stored material would be of value to students studying the history of science, but very little is designed, or presented, to satisfy the curiosity of those children who want to know how the science they learn at school is used for the benefit of mankind in the world today.

6.21 SUGGESTIONS

1) Any spontaneous interest triggered in visitors when they inspect an exhibit should receive immediate follow up by offering sources of further reading or names and addresses of clubs that pursue a particular activity. Such information should be displayed on or near each exhibit.

2) In museums with several galleries at least one should have the exhibits placed so that parties of 20 visitors can all see individual
exhibits at the same time and so benefit from verbal instruction that is given by an accompanying teacher or guide.

3) All museums should have at least one classroom capable of seating a minimum of 40 people. Apparatus for providing audio-visual aids is essential in each classroom as well as facilities to enable exhibits normally displayed in the museum galleries to be readily wheeled in for a particular demonstration or lecture.

4) If parties of children and adults are being encouraged to visit museums and spend a considerable amount of time attending lectures or studying exhibits sufficient cloakrooms, restaurants and sandwich eating facilities must be provided.

5) Museums should try to provide booklets and pictures, relating to the exhibits, that are written in language comprehensible to school children and available at a price they can afford.

6) A number of carefully selected exhibits should be made available for children to handle and, where possible, use as there is nothing so exciting as touching 'real' things.

7) Museum loan services should be extended to cover the needs of science teachers. Small pieces of industrial equipment chosen for their ability to add realism to school science would make invaluable additions to the loan list.

8) As many of the future exhibits as possible should be presented in such a way that visitors can operate them and immediately learn by what they see or hear.
## APPENDIX 1
PUBLICITY DESCRIBING EDUCATIONAL FACILITIES

<table>
<thead>
<tr>
<th>Museum</th>
<th>Type of Publicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Piano</td>
<td>Advertisements in Teacher's Journals</td>
</tr>
<tr>
<td>Buckler's Hard</td>
<td>Leaflets</td>
</tr>
<tr>
<td>Institute geological Sciences</td>
<td>Press Advertisements. Newletters</td>
</tr>
<tr>
<td>Kodak</td>
<td>Press Advertisements</td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
<td>Press Advertisements</td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
<td>Press Advertisements. Official Education Committee Circular</td>
</tr>
<tr>
<td>Museum of Science and Industry</td>
<td>Press Advertisements. Leaflets</td>
</tr>
<tr>
<td>Museum of Transport</td>
<td>Newsletters</td>
</tr>
<tr>
<td>National Maritime</td>
<td>Press Advertisements</td>
</tr>
<tr>
<td>Pilkington Glass</td>
<td>Press Advertisements. Education Committee Bulletin</td>
</tr>
<tr>
<td>R.A.C. Tank</td>
<td>Press Advertisements</td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
<td>Tea Parties for Teachers</td>
</tr>
<tr>
<td>Science Museum</td>
<td>Press Advertisements. Leaflets</td>
</tr>
<tr>
<td>Shuttleworth Collection (1932)</td>
<td>Circulars to Schools</td>
</tr>
<tr>
<td>Tramway</td>
<td>Through Teachers' Centre (Verbal)</td>
</tr>
<tr>
<td>Transport</td>
<td>Through Teachers' Centre (Verbal)</td>
</tr>
<tr>
<td>Victory</td>
<td>Career Advisory Panel</td>
</tr>
<tr>
<td>Worcestershire County</td>
<td>Through Teachers' Centre. Education Committee Circular</td>
</tr>
</tbody>
</table>

### Summary

- Press Advertisements: 9
- Official Circulars: 3
- Through Teachers' Centres: 3
- Leaflets: 3
- Teacher's Journals or Bulletins: 2
- Newsletters: 2
- Career Advisory Panel: 1
- Tea Party: 1
# APPENDIX 2

## FORMAL DISTRIBUTION OF PUBLICITY MATERIAL TO SCHOOLS

<table>
<thead>
<tr>
<th>Museum</th>
<th>Notices Posted and Addressed to Teachers By Name</th>
<th>Notices Posted and Addressed to A School</th>
<th>The Headteacher</th>
<th>Director of Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent T.V. Gallery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Institute Geological Science</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lewis Textile</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
<td>(Very rarely)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Museum of Science &amp; Industry</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Museum of Transport</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>National Maritime</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pilkington Glass</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Science Museum</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Not Always</td>
</tr>
<tr>
<td>Shuttleworth Collection (1932)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tramway</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Transport</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Worcestershire County</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Museums that do not post publicity material to schools.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avery Historical</td>
</tr>
<tr>
<td>Barnes Museum of Cinematography</td>
</tr>
<tr>
<td>British Piano</td>
</tr>
<tr>
<td>Buckler's Hard Maritime</td>
</tr>
<tr>
<td>Central Flying School</td>
</tr>
<tr>
<td>Danor Engineering Ltd.</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
</tr>
<tr>
<td>Holman</td>
</tr>
<tr>
<td>Kodak</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
</tr>
<tr>
<td>Manchester Museum of Science and Technology</td>
</tr>
<tr>
<td>Museum of Science and Engineering</td>
</tr>
<tr>
<td>Nottingham Industrial Museum</td>
</tr>
<tr>
<td>Post Office Telephone Museum</td>
</tr>
<tr>
<td>R.A.C. Tank</td>
</tr>
<tr>
<td>Victory</td>
</tr>
<tr>
<td>Wellcome Museum Medical Science</td>
</tr>
<tr>
<td>Wye College of Agriculture</td>
</tr>
<tr>
<td>Museum</td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Avery Historical</td>
</tr>
<tr>
<td>Barnes Museum of Cinematography</td>
</tr>
<tr>
<td>British Piano</td>
</tr>
<tr>
<td>Buckler's Hard</td>
</tr>
<tr>
<td>Central Flying School</td>
</tr>
<tr>
<td>Danor Engineering Ltd.</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
</tr>
<tr>
<td>Holman</td>
</tr>
<tr>
<td>Independent Television Gallery</td>
</tr>
<tr>
<td>Institute Geological Sciences</td>
</tr>
<tr>
<td>Kodak</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
</tr>
<tr>
<td>Lewis Textile</td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
</tr>
<tr>
<td>Manchester Museum of Science &amp; Technology</td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
</tr>
<tr>
<td>Museum of Science &amp; Engineering</td>
</tr>
<tr>
<td>Museum of Science &amp; Industry</td>
</tr>
<tr>
<td>Museum of Transport</td>
</tr>
<tr>
<td>Narrow Gauge Railway</td>
</tr>
<tr>
<td>National Maritime</td>
</tr>
<tr>
<td>Post Office Telephone</td>
</tr>
<tr>
<td>Pilkington Glass</td>
</tr>
<tr>
<td>R.A.C. Tank</td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
</tr>
<tr>
<td>Science Museum</td>
</tr>
<tr>
<td>Shuttleworth Collection (1932)</td>
</tr>
<tr>
<td>Tramway</td>
</tr>
<tr>
<td>Transport</td>
</tr>
<tr>
<td>Victory</td>
</tr>
<tr>
<td>Wellcome Museum Medical Science</td>
</tr>
<tr>
<td>Worcestershire County</td>
</tr>
<tr>
<td>Wye College of Agriculture</td>
</tr>
</tbody>
</table>

* No details available
APPENDIX 4
MUSEUMS MAKING AN ADMISSION CHARGE

<table>
<thead>
<tr>
<th>Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ (T) Buckler's Hard Maritime</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
</tr>
<tr>
<td>* Maritime - Great Yarmouth</td>
</tr>
<tr>
<td>* Museum of Carriages &amp; Art Gallery</td>
</tr>
<tr>
<td>+ Museum of Science &amp; Engineering</td>
</tr>
<tr>
<td>x Russell-Cotes Art Gallery</td>
</tr>
<tr>
<td>(T) Shuttleworth Collection (1932)</td>
</tr>
<tr>
<td>* Victory</td>
</tr>
<tr>
<td>Worcestershire County</td>
</tr>
</tbody>
</table>

+ Entry fee 6d
(T) Teachers admitted free only when accompanying a party of children
* Entry free to parties of children
x Entry charge on Thursdays
<table>
<thead>
<tr>
<th>Museum</th>
<th>Guide Service Provided</th>
<th>Supervised Parties Essential</th>
<th>Children Permitted to Wander</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avery Historical</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Barnes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Bridewell</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Piano</td>
<td>* Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Buckler's Hard</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Central Flying School</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danor Engineering</td>
<td>No</td>
<td>+ ✓</td>
<td>No</td>
</tr>
<tr>
<td>EMI</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
<td>No</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Holman</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Independent T.V. Gallery</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Institute Geological Sciences</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Kodak</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Lackham School of Agriculture</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Lewis Textile</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>London Telecommunication Regional</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Manchester Museum Science &amp; Technology</td>
<td>Yes</td>
<td></td>
<td>No answer</td>
</tr>
<tr>
<td>Maritime - Great Yarmouth</td>
<td>* Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Museum of Carriages &amp; Art Gallery</td>
<td>* Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Museum of Science &amp; Engineering - Newcastle</td>
<td>No</td>
<td>+ ✓</td>
<td>No</td>
</tr>
<tr>
<td>Museum of Science &amp; Industry - Birmingham</td>
<td>No</td>
<td></td>
<td>* Yes</td>
</tr>
<tr>
<td>Museum of Transport - Glasgow</td>
<td>*x Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Narrow Gauge Railway</td>
<td>No</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>National Maritime</td>
<td>Yes</td>
<td></td>
<td>Not encouraged</td>
</tr>
<tr>
<td>Post Office Telephone</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Pilkington Glass</td>
<td>No</td>
<td>+ ✓</td>
<td>No</td>
</tr>
<tr>
<td>R.A.C. Tank</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Science Museum - London</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Shuttleworth Collection (1932)</td>
<td>Yes</td>
<td></td>
<td>+ Yes</td>
</tr>
<tr>
<td>Tramway Museum</td>
<td>*x Yes</td>
<td></td>
<td>+ Yes</td>
</tr>
<tr>
<td>Transport Museum - Hull</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Victory</td>
<td>No</td>
<td>+ ✓</td>
<td>No</td>
</tr>
<tr>
<td>Wellcome</td>
<td>Yes</td>
<td>✓</td>
<td>No</td>
</tr>
<tr>
<td>Worcestershire County</td>
<td>No</td>
<td>+ ✓</td>
<td>No</td>
</tr>
<tr>
<td>Wye College of Agriculture</td>
<td>* Yes</td>
<td></td>
<td>No answer</td>
</tr>
</tbody>
</table>

* Limited or restricted service

x Only in the evening or when volunteer available

+ Teacher expected to remain on the premises and take responsibility for the children
APPENDIX 6

PROVISION OF PRINTED MATERIAL TO ASSIST A MUSEUM VISIT

<table>
<thead>
<tr>
<th>MUSEUMS THAT PROVIDE DESCRIPTIVE MATERIAL</th>
<th>MUSEUMS THAT DO NOT PROVIDE DESCRIPTIVE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum</td>
<td>Museum</td>
</tr>
<tr>
<td>Barnes Museum of Cinematography</td>
<td>* National Maritime</td>
</tr>
<tr>
<td>Buckler's Hard</td>
<td>Post Office Telephone</td>
</tr>
<tr>
<td>Central Flying School</td>
<td>Pilkington Glass</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
<td>* R.A.C. Tank</td>
</tr>
<tr>
<td>* Institute Geological Sciences</td>
<td>Russell-Cotes Art Gallery</td>
</tr>
<tr>
<td>* Lackham School of Agriculture</td>
<td>* Science Museum</td>
</tr>
<tr>
<td>* Lewis Textile</td>
<td>* Shuttleworth Collection (1932)</td>
</tr>
<tr>
<td>* Maritime</td>
<td>* Tramway</td>
</tr>
<tr>
<td>* Museum of Science &amp; Engineering</td>
<td>* Victory</td>
</tr>
<tr>
<td>+ Museum of Science &amp; Industry</td>
<td>Wellcome Museum Medical Science</td>
</tr>
<tr>
<td>* Museum of Transport</td>
<td>Worcestershire County</td>
</tr>
<tr>
<td>* Narrow Gauge Railway</td>
<td></td>
</tr>
</tbody>
</table>

* Material had to be bought
+ Material out of print
### Museums Lending Material to Schools

<table>
<thead>
<tr>
<th>Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buckler's Hard</td>
</tr>
<tr>
<td>* Kodak</td>
</tr>
<tr>
<td>Lewis Textile</td>
</tr>
<tr>
<td>London Telecommunications Regional</td>
</tr>
<tr>
<td>* Museum of Carriages &amp; Art Gallery</td>
</tr>
<tr>
<td>Museum of Science &amp; Industry</td>
</tr>
<tr>
<td>Museum of Transport</td>
</tr>
<tr>
<td>* National Maritime</td>
</tr>
<tr>
<td>Russell-Cotes Art Gallery</td>
</tr>
<tr>
<td>Science Museum</td>
</tr>
<tr>
<td>* Tramway</td>
</tr>
<tr>
<td>Transport (Hull)</td>
</tr>
<tr>
<td>Victory</td>
</tr>
<tr>
<td>Wellcome Museum Medical Science</td>
</tr>
<tr>
<td>Worcestershire County</td>
</tr>
</tbody>
</table>

* Will only lend material for very special occasions

### Museums That Have No Loan Service

<table>
<thead>
<tr>
<th>Museum</th>
<th>Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avery Historical</td>
<td>Lackham School of Agriculture</td>
</tr>
<tr>
<td>Barnes Museum of Cinematography</td>
<td>Maritime</td>
</tr>
<tr>
<td>British Piano</td>
<td>Museum of Carriages &amp; Art Gallery</td>
</tr>
<tr>
<td>Central Flying School</td>
<td>Museum of Science &amp; Engineering</td>
</tr>
<tr>
<td>Danor Engineering Ltd.</td>
<td>Narrow Gauge Railway</td>
</tr>
<tr>
<td>Fleet Air Arm</td>
<td>Post Office Telephone</td>
</tr>
<tr>
<td>Holman</td>
<td>Pilkington Glass Museum</td>
</tr>
<tr>
<td>Independent Television Gallery</td>
<td>R.A.C. Tank</td>
</tr>
<tr>
<td>Institute of Geological Sciences</td>
<td>Shuttleworth Collection (1932)</td>
</tr>
</tbody>
</table>
APPENDIX 8

MUSEUMS OFFERING MEMBERSHIP SCHEMES

<table>
<thead>
<tr>
<th>Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Museum of Carriages &amp; Art Gallery</td>
</tr>
<tr>
<td>Narrow Gauge Railway</td>
</tr>
<tr>
<td>* Russell-Cotes Art Gallery</td>
</tr>
<tr>
<td>* Shuttleworth Collection (1932)</td>
</tr>
<tr>
<td>Tramway</td>
</tr>
<tr>
<td>Transport</td>
</tr>
<tr>
<td>* Wellcome Museum Medical Science</td>
</tr>
<tr>
<td>* Worcestershire County</td>
</tr>
</tbody>
</table>

* Membership scheme provides an education service
+ Acts as the home of various learned societies
Questionnaire Concerning Educational Facilities in British Science Museums

Please complete this questionnaire by writing the name of your museum at the top and then placing ticks, or data, in the appropriate boxes after each question, and return it to G.C. Sneed, Director, Shell School Technology Programme, University of Surrey, Guildford, Surrey.

Name of Museum

1. General
   (a) In which year was your museum founded?
       
   (b) Approximately when did your present educational emphasis begin?
       
   (c) When was the position of a Director of Education established?
       
   (d) How many classrooms do you have?
       When were they constructed?
       What are the average number of hours of use per room per week in
       i) school holidays?
       ii) term time?

2. Public Relations Aspect
   1. (a) Do you have any form of family museum membership programme? If YES please give some details.
       
   (b) Is there a museum membership scheme for school children or students?
       
   (c) Is there an admission charge to your museum for,
i) Unaccompanied children?  
  ii) Children in school parties?  
  iii) Adults?  

(d) If there is an admission charge to your museum do teachers receive a special admission rate?  

If YES are teachers admitted free?  

(e) Do science teachers receive any special privileges?  

If YES please give details.

   YES  NO  

2.  

(a) Does your museum produce notices describing your educational activities?  

(b) Are notices of your educational activities posted directly to teachers and/or students?  

(c) Are such notices posted directly to schools addressed  

   i) To the school?  
   ii) To the Principal or Head Teacher?  
   iii) To the Local Director of Education.  

(d) Do you have any other means of letting schools and teachers know what educational services your museum has to offer?  

If YES please give details.

   YES  NO  

(e) Does your museum participate in any educational radio or TV activities?  

If YES please give details.

   YES  NO  

(f) How would you describe your relationship with local newspapers?  

   YES  NO  

(g) Please state the estimated number of newspaper articles that are printed every month concerning your museum.
3. Museum Relationship with Local School Education Authorities

(a) Do the authorities assist in planning educational programmes at the museum? 

(b) Are the authorities asked to assist? 

(c) Do groups of students, or groups of teachers make use of the museum educational facilities for study or lesson preparation? 

If YES please give details. 

(d) Does your LEA provide any financial Assistance towards museum educational programmes? 

YES | NO

4. Museum Visits

(a) Does your museum permit groups of children to be brought from schools just to 'wander about'? 

(b) Does your museum require that parties of children should be guided either 

   i) By a teacher? 
   YES | NO

   ii) By a museum guide? 
   YES | NO

(c) Does the museum offer a guide service? 

   YES | NO

(d) Does the museum provide printed material pertaining to the exhibits? 

   YES | NO

If YES is it placed in the hands of the teacher and/or the students? 

(Please send sample of any such publication) 

(e) Does the museum have special (auditorium) demonstrations (other than those connected with the exhibits) for visiting groups of school children? 

If YES, how frequently? Please include descriptions.
(f) What means do you employ to encourage school groups to plan a specific educational visit?

(g) If possible, please provide attendance figures for students attending in school groups for the last three years. A breakdown by form - especially sixth forms - would be helpful. If these figures are not available please quote data just for primary and secondary schools.

5. **Museum Courses for Students**

(a) Please send me any publications you have describing term time and holiday courses provided by the museum.

If you can provide the numbers who have enrolled for any such courses over the last three years it would be extremely helpful.

(b) Does your museum provide any activities for sixth form students who are particularly interested in science or engineering? (Please state numbers attending such courses).

(c) Are any of your student courses sponsored by industry?

6. **Museum Educational Services for Teachers**

(a) Do you provide any educational activities especially for science teachers?

If YES please give details.
(b) Can you estimate the number of teachers from secondary schools attending such activities during 1966, 1967 and 1968?

7. **Other Museum Educational Activities**

Please indicate if your museum engages in any of the following activities. Please elaborate if the answers are YES:

(a) Career guidance - especially for engineering

(b) Lending apparatus or exhibits to schools

(c) Provision of mobile demonstrations in a school playground or hall.

(d) Organize industrial visits or field trips.

(e) Organize Science Fairs.

(f) Produce publications other than those pertaining to the exhibits.

(g) Provision of specialised lecturers who will visit schools.

Elaborations

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

THANK YOU
AIM

To evaluate the educational and inspirational value of the third Molecule Club production 'HELP', on children and their school activities.
7.1 AIM

To evaluate the educational and inspirational value of the third Molecule Club production 'Help', on children and their school activities.

7.2 INTRODUCTION

The Molecule Club came into being in April 1968 as a result of Lady Miles realising that her grand-children did not take very much interest in the science they were taught at school, but nevertheless, seemed capable of learning subject matter that was presented in three dimensions, and in an exciting manner. This attitude towards learning was Lady Miles believed, typical of many children.

As Lady Miles owned the Mermaid Theatre she decided to try and take science into the theatre and provide a new form of scientific entertainment for the benefit of children between the ages of 8 and 12 years. The productions resulting from this idea are staged under the general title of the 'Molecule Club' and now form a small but regular part of the activities of the Mermaid Theatre Organisation.

AIM The aim of the Molecule Club as stated by the management is 'To awaken the interest of young children, showing them that science and its applications are part and parcel of everyday life'. It is hoped also that the performances demonstrate, 'science is not confined to books, schoolrooms and universities and not above the heads of all but the select and clever few'.

FINANCE The Molecule Club productions are very expensive to stage as professional actors, actresses, musicians, scriptwriters and supporting stage staff are employed to take the acting parts, produce the dialogue, and build the scenery respectively.

Seats were originally sold, in 1968, at 3/6 (17½p) each. With 500 seats available, and filled, twice a day throughout a run of two weeks, each production incurred a loss of several hundred pounds which was made up by support from organisations such as The Arts Council, The Department of Education and Science, the
ILEA, industry and private individuals.

At the present time, 1971, seats are sold at 25p each, but with ever rising overheads, the Molecule Club cannot function without the generosity of outside support.

**FREQUENCY OF PERFORMANCE** Financial problems confine the Molecule Club to staging two or three productions each year at the Mermaid Theatre in London. In the intervening months a 6 week tour of the provinces is arranged which is very popular but not financially profitable.

7.3 THE FIRST TWO MOLECULE CLUB PRODUCTIONS

These were given the individual titles 'Lights Up' and 'OK for Sound' and showed elementary experiments relating to light and sound. In both these productions the scientific demonstrations were mixed with comedy and songs in order to present a lively and amusing 90 minute entertainment.

**OBSERVATION** Commendable as these productions were I felt they lacked a climax and seemed to end only when there were no more demonstrations available. No feeling of achievement had been conveyed when the time came for the children to leave the theatre.

7.4 THE THIRD MOLECULE CLUB PRODUCTION

In November 1968 Sir Bernard and Lady Miles invited me to become the Technical Adviser to the Molecule Club and assist in staging a production dealing with mechanics.

This honorary appointment gave me the opportunity to suggest that the new production should be based on a story that would lead to a spectacular finale so that the children would leave at the end of each performance feeling that science was exciting and useful to them.

**THEME** The scriptwriter, Mr. Gerald Frow, conceived the idea of centering the story on a disused railway station called 'Molecule Club Halt'. The lost property office of this station contained a large crate which housed a statue of George Stephenson, the steam pioneer (Fig. 1)
Fig. 1. The stage set designed for the Molecule Club Production 'Help'.
Two porters who had been 'left behind' when the station became non-operational wanted to move the crate and lift the statue onto a suitable plinth in the middle of the station. This gave a reason for needing some mechanical assistance and led to the title 'Help'; it gave also a natural ending to the performance when this had been achieved.

The first porter had some knowledge of mechanical principles and in between songs and dialogue was able to instruct the second porter; both of them were guided in their scientific thinking by an attractive young lady who wanted to unveil the mounted statue. This approach provided a means of introducing a teaching aspect into the production, together with a spectacular finale obtained by lifting the crate and statue into position with a block and tackle, operated by children from the audience (Fig. 2).

**EXPERIMENTS** During each performance numerous experiments and demonstrations were provided to assist with the teaching aspect of the production. I designed and help build the six large scale demonstration rigs that showed the principles behind:

- the first order lever,
- the second order lever,
- the inclined plane,
- the screw - as a 'wrapped up' inclined plane,
- the wheel and axle as an 'opened out' second order lever,
- a pulley system (Fig. 3).

**7.5 PILOT TRIAL**

Twenty-five 8-9 year old children of average ability from Westborough Primary School, Guildford, were invited to visit the University of Surrey so that they could be given a lesson on elementary mechanics illustrated with some of the apparatus built for use at the Mermaid Theatre. This class was not given any preparation for the visit as the teacher did not feel sufficiently confident of her knowledge of mechanics to do so.

Upon arrival the children were given verbal instruction on the meaning of first and second order levers and encouraged to try and think of simple items that utilised the same principles. Wherever possible the formal instruction was enlivened by means of diagrams
Fig. 2. The crate and statue just after the latter had been hoisted into position by the children standing in the foreground.

Fig. 3. The pulley system demonstration, made from bicycle and pram wheels, connected to a large spring balance.
on the blackboard. During the lesson the law of the lever was 'discovered' using a large first order lever and then shown to be valid also for the second order lever, using the very large stage apparatus (Figs. 4, 5 & 6).

The scientific interpretation of work was demonstrated and the advantage of using an inclined plane for lifting a load explained verbally and by means of a giant inclined plane, spring balance and suitcase on wheels (Fig. 7).

It was further demonstrated with large scale apparatus that a screw can be obtained by wrapping an inclined plane around a pole, (Figs. 8 & 9).

The lesson was concluded by showing that a second order lever could be 'opened out' to make a wheel and axle (Fig. 10) and then utilised for lifting water out of a well (Fig. 11).

By the time the children had asked a number of questions this lesson and series of demonstrations occupied just under two hours.

**Observation** The children appeared to be extremely interested throughout the lesson and were able to classify simple machines such as a lemon squeezer and village pump handle fairly easily for themselves. Two or three of the brighter children could understand double levers and successfully classified garden shears and nutcrackers.

**Follow Up** Upon returning to school Mrs. Purvis the teacher in charge of the class, asked the children to write a letter to me and also encouraged the children to make models and perform simple experiments based on what they had seen at the university.

Four of the children's letters are shown in Figs.12 & 13. These reveal that the children grasped that the lesson concerned levers and machines and enjoyed the style of presentation. The large apparatus also appears to have made a deep impression, partly by its size, which no doubt seemed extra large in a comparatively small room.

Figures 14, 15 & 16 are accounts written by two of the children who were inspired to experiment for themselves and one who built
Fig. 4. Children being used as 'weights' in the first order lever demonstration.

Fig. 5. The first order lever demonstration in equilibrium, six feet above the stage.
Fig. 6. The equipment designed to demonstrate a second order lever.

Fig. 7. A suitcase being dragged up an inclined plane by a force smaller than its own weight.
Fig. 8. An inclined plane being 'wrapped around a cylinder' to form a screw thread.

Fig. 9. A hexagon head being added to the 'screw'.

Fig. 10. The white spoked wheel and axle came into view as the outer end of the short lever, mounted on the board, was moved through a circular path.

Fig. 11. A wheel and axle mechanism being used to lift a bucket out of a well.
Dear Mr. Sneed,

Thank you for letting us come.
I liked it where you made a screw. I liked every thing, especially the pictures on the blackboard.

Yours sincerely,
Mark Hayward.
Dear Mr. Sneed,

Thank you very much for letting us come to the university. It was very nice.

I especially liked the screen that you made. Now I know a lot about levers. I enjoyed it very much.

Yours sincerely

Jackie Walker.
Westborough School
Southway
Guilford
12th February 1970

Dear Mr. Sneed,

We had a nice time and I liked it. When you showed us how to
shift the case and I liked it. When you showed us a screw
and I would like to thank you and your
friends.

love from
Susan Saunders.
Guildford
12th February 1940

Dear Mr Sneed,

Thank you for showing us the well and the other machines, we enjoyed the visit very much. The machine I liked was the well, the sneer looked very big.

Yours sincerely,
Katharine Richards.
I used the equalizer and the ruler and some washers. I put two washers on the right side on the 4 and one washer on the left hand side. I found out that they balanced one washer was on the right end of one we found that the weight was twice as far away from the pivot.

<table>
<thead>
<tr>
<th>Number of washers</th>
<th>Distance from center</th>
<th>Number of washers</th>
<th>Distance from center</th>
</tr>
</thead>
<tbody>
<tr>
<td>one washer</td>
<td>5 inches</td>
<td>two washers</td>
<td>2 1/2 inches</td>
</tr>
<tr>
<td>one washer</td>
<td>10 inches</td>
<td>two washers</td>
<td>5 inches</td>
</tr>
</tbody>
</table>
I used the incants Scrooby.

I put the bucket of clay on the other end and then I moved the bucket to the middle when I put it in the middle and I could not lift it because the nearer the cup to the further away with the effort the easier.

I made a railway signal from Meccano it worked with a first order lever.

Then I made a remote control signal which used 2 first order levers and a second order lever.
and analysed a model railway signal. These accounts, I think, show understanding of the subject matter and the ability of the children to apply the knowledge they gained to their own situation.

**CONCLUSION** The subject matter was not too difficult for young children of average ability who were completely without any formal preparation. The apparatus was undoubtedly attractive to children and the method of presentation seemed likely to inspire children to take both a theoretical and a practical interest in simple machines.

7.6 PRELIMINARY PUBLICITY FOR THE THEATRE PRESENTATION OF 'HELP'

The Theatre management notified schools within a radius of approximately 20 miles of London, of their forthcoming production 'Help' by sending pamphlets and booking forms to LEA'S, and by individual invitations to Headteachers of private schools.

7.7 EVALUATION In addition to visiting the theatre in March 1970 and watching 8 complete performances in order to judge child and teacher reaction, I prepared a questionnaire (Appendix 1) and sent it to the 148 schools who took parties of children to see the production.

Sixty-four schools completed and returned the questionnaire. Information from these documents has enabled the following paragraphs to be written.

7.8 AGE RANGE AND SIZE OF SCHOOL PARTIES ATTENDING

The ages of children attending the Molecule Club production 'Help' varied between 7 and 16; the majority however were between 10 and 11 years.

School parties varied considerably in size. The Wolsey Junior Sch. filled the theatre for one performance with 480 children while a primary school in Sevenoaks took just 9. The average party size was just under 70 children.

7.9 ADMISSION CHARGE

Practically all the children attending paid the admission charge themselves, the school only providing the money for the transport.
Even though the price of admission is kept well below a profit making figure one junior mixed and infants school in the W.C.1. area of London wrote to me and said 'we are in a very deprived area and since the price of admission has risen (to 25p) we can no longer afford to attend. Pity!'

7.10 PREPARATION OF THE CHILDREN FOR THE VISIT

The questionnaire showed that 50% of the children were given some form of preparation.

**BRIEF PREPARATION** Of the children receiving preparation 68% were given a brief type. This usually took place during an afternoon a few days before the visit to the theatre. In its simplest form it consisted of short talks or discussions mentioning the five machines to be seen, illustrated in some cases with a few pictures. Considerable emphasis seems to have been given to the fact that the show was to take place in a theatrical setting.

In a slightly more elaborate form the teacher gave a short lesson on elementary mechanics and demonstrated how weights could be lifted by using small levers, pulleys and ramps.

**EXTENDED PREPARATION** 32% of the children receiving preparation were given an extended type. A more extended form of preparation took place in some schools by linking previous lessons with the forthcoming stage production. Highfield School, Highgate, for example, had devoted the whole of the previous terms science lessons to simple machines and Thorntree Infants School, S.E.7, had carried out a small project on the history of the wheel.

Parkgate Junior Mixed, Watford, and Squirrel's Heath Junior School, Romford, mentioned that they had taken school TV science programmes which had dealt with levers and pulleys and wanted to use the stage show as a follow up.

Only Timbercroft Junior Mixed School, Plumstead, reported mentioning points of behaviour as part of the preparation. Observation in the theatre by the management and myself suggested that a few more schools might have been well advised to have given some emphasis to this subject before visiting the theatre.
7.11 PRIOR KNOWLEDGE

Just over one third of the schools that provided some form of preparation felt that their efforts had not given the children any real knowledge of mechanics.

From the schools that did not attempt to give any formal preparation just over a third considered that the children already possessed some knowledge of mechanics.

This latter observation suggests, perhaps, that influences outside the school such as mechanical toys and books assist children's natural curiosity for 'how things work'.

**SUMMARY**

In the opinion of the accompanying teachers, forty-seven percent of the children visiting the theatre had some prior knowledge of the subject matter presented on the stage.

7.12 PROVISION OF LESSON NOTES

Upon arrival at the theatre each teacher was given a sheet of notes, Appendix 2, in order to assist them with answering questions and preparing follow up exercises or experiments.

All but four of the teachers said that they had found the notes valuable. One of the teachers that did not find the notes valuable gave the reason as 'not for our age range (they had taken a group of seven year olds) and another considered themselves 'already familiar with the topics', but stated that the notes 'were useful to those who were not'.

7.13 IMMEDIATE IMPACT

Eighty percent of the schools reported that they had to either discuss the production or answer questions in order to satisfy the immediate interest it aroused amongst the children. In many cases the questions started within minutes of leaving the theatre and in a few instances continued throughout the journey back to school.

Only one school reported an immediate impact but no lasting impact.
Seventy-nine percent of the schools indicated that the presentation had given impetus to class projects and influenced children's reading material for periods varying between one week and one year after the visit to the theatre. For example, Compton Primary School, E.C.1. reported that a group of 9-10 year old children who were below average academically were encouraged to do their own research work and produce satisfactory projects.

A teacher at Holmshill Secondary School, Borehamwood, discussed the contents of the production with his class one week after the theatre visit and formed the opinion that 'the children had learnt and retained a fair amount of information'.

As an example of a six week retention period Littlegrove C.P. School, E. Barnet, quoted the case of a boy experiencing difficulty opening a tin of paint, this boy took a spoon and 'at the top of his voice said "my new fangled magic - a lever". The 'magic' probably refers to a scene in the production where the actor wore a magicians hat while he described and demonstrated the use of a lever for lifting a crate (Fig. 17)

After a six-month period had elapsed since seeing the production, Beulah Junior School, Thornton Heath, observed that 'children made intelligent references to the show during science lessons covering related material'.

In addition there is evidence to suggest that the stage presentation of science enables children to learn scientific principles and recall them up to one year after visiting the theatre. Surbiton High School stated that 'twelve months later questioning showed that they (the children) had retained many of the basic principles, and Amherst County Primary School, Sevenoaks, found that their children 'could clearly remember scientific detail about the programme'.

Examples of lasting impressions after a long period were also observed during informal talks between teachers and children at The Lady Eleanor Holles School, Hampton Hill. One teacher at
One of the actors wearing a magician's hat to create an atmosphere of expectancy amongst the children while he demonstrated how to lift the crate with a plank of wood.
High Cross School, Tottenham was delighted to report that 'children have recalled experiments and results that they saw - I had forgotten these until reminded by the children'.

Other examples of Lasting Impact, but with no time lapse given are quoted below.
'Signs of impact came out long afterwards in the form of experiments they did'. High Wycombe American Dependent School.
'Class can remember most of the salient points. Many small points of humour were much appreciated'. Cypress J.M. School, South Norwood.
'They could give the types of levers for some months after'. Brooklands J.M. & I. School, S.E.3.
'Children appear to have retained the principles suggested by the programme'. Sheen Mount County Primary, S.W.14.
'From written accounts of their outing and from questioning in subsequent lessons quite a percentage of the class showed a good understanding of simple machines'. Holy Trinity C.E. (J.M.) School, Richmond.

7.15 CHILDREN UNDERSTAND THE USEFUL APPLICATIONS OF SCIENCE

In addition to encouraging young children to take an interest in science and assisting with the teaching of some of the fundamental principles, there is evidence that the production helped children to realise that science can be applied for the benefit of society. St. Edward's C.E. Primary School, Romford, reported that 'Questions and follow up work showed that the impact was on usefulness of mechanics to mankind'.

7.16 SCHOOL SCIENCE LESSONS BASED ON 'HELP'

Sixty-seven percent of the schools that answered the questionnaire stated that they had based their science lessons on the theme of the production 'HELP'.

In three schools the thrill of lifting genuine loads as achieved on the stage was transferred into the classroom. Queens Park Junior School 'used levers to lift heavy classroom furniture' and Cypress J.M. School, allowed children to lift teachers by means of pulley systems. Such experiments were undoubtedly undertaken with enthusiasm as a teacher from the Queens Park Junior School said, 'it is a
wonder they didn't lever off the school roof'.

Group work was undertaken in several schools so that the children could either carry out teacher selected experiments, or work on simple projects. Typical examples of organised group experiments came from Wykeham Primary School, N.W.10, who quoted 'work on simple balances to establish the law of the lever' and from Littlegrove C.P. School, E. Barnet, who 'made screws from card and pencils, lifted loads with pulleys, balanced pennies on a ruler and made gears from tin lids'. The completed project at Leavesden Green C.P. School, Leavesden, consisting of models and illustrations was used as a display in the entrance to the school hall.

Two schools not only followed up the ideas and principles covered in 'Help' but extended the theme; for example, St. Matthews School, Tolworth, became involved in the topics of power and natural energy.

Holy Trinity C.E. (J.M.) School, Richmond and Heatherton House School, Chesham, used some of the material from 'Help' to augment a section of their own science course, entitled 'Making Work Easier', based on Hanson & Evans Book 'Science From the Beginning'. The stage production was also found suitable as back up material, for the BBC T.V. programme 'Science All Around', in Wykeham Primary School.

Most school science lessons took place in the classroom or hall but Amherst C.P. School found that the children could apply their newly acquired knowledge to identify the simple principles being used by workmen building an extension to the school, and children from the Sacred Heart Grammar School, Wealdstone, were able to discuss and identify levers used in their homes, both with parents and teachers.

One boy from Longfield J.M. School, Harrow, became so interested in the subject of Mechanics that he is reported as 'being able to give a short lecture' on the subject.

7.17 EFFECT ON LESSONS OTHER THAN SCIENCE

Schools were able to quote instances of the stage production influencing mathematics, drama, craft and free activity periods. For example, Scargill Junior School, Rainham, found the children making
references to what they had seen at the theatre 'during the ensuing months in mathematics'. Tiffin Girls School, Kingston, reported 'the older girls (16 year olds) wanted to consider the problems of staging the production', and the pupils of Heatherton House School, Amersham, 'made a 3D model of a stage and equipped it with miniature versions of the apparatus'.

The Parsonage Farm Junior School, Rainham, found that children handling scissors and shears in craft lessons recognised these tools as examples of double levers.

In the completely free atmosphere of a play period the Michael Faraday J.M. School, S.E.17, observed 'children were so interested in the play that they experimented when they had the choice of following any activity offered'. This experimentation used simple balances, pulleys and levers, and the construction of 'life size machines'.

7.18 INSPIRATIONAL VALUE OF THE PRODUCTION

MODEL MAKING. Forty-five per cent of the schools reported model making activities.

In many schools model making took the form of constructing small non-load carrying replicas of the equipment seen on the stage. The Cypress J.M. School, reported children using meccano parts to make a working model of a well and see-saw, while a class from Hurst C.P. School, produced sufficient models to mount a display in the corridor outside their room.

Children from the Wykeham Primary School, N.W.10, became excited about railway signals and built a number of working models.

Not all the model making activities were straight imitation, or confined to the school classroom. A teacher from City of London School for Girls (Preparatory Department) reported 'signs of inventiveness emerging as children who had seen the show tried to devise and build simple machines for lifting small weights'. Sheen Mount C.P. School, S.W.14, found that the modelling of basic machines started in school, inspired the children to carry on the activity at home; several children brought along models of machines they had built in their own private time.
Seventy percent of the schools reported experimental activities.

Although many of the experiments performed were almost exact copies of those shown at the theatre the teachers and children together used great ingenuity to reproduce them as shown in section 7.16.

However, there were instances reported of experimental inspirations directly accredited to children. The Michael Faraday J.M. School, had a group of children who built a see-saw themselves and tried to calculate where to sit in order to keep it in equilibrium; one child from this same group also suggested mounting a pulley on the P.E. apparatus in order to lift heavy weights. The subject of levers seems to have appealed to a large number of children but especially to Beulah Junior School, who spent a considerable time 'devising ways of weighing people without using proper equipment!'.

During the stage show a suitcase on wheels was dragged up an inclined plane to demonstrate that a smaller force was needed than to lift it vertically. At the same time it was suggested that this technique may have been used to construct the pyramids. Children from the Hugh Myddleton J.M. School, reproduced this experiment by dragging a roller skate up a ramp, while children from St. Matthews Primary School were inspired to build a pyramid using the inclined plane technique.

Fox Hill J.M. School, S.E.18, reported that they had insufficient space to let their children carry out experiments but despite this drawback children were known to have performed some simple experiments at home using wheelbarrows and spades.

The possible reason for experimentation being more prevalent than model making may be due to time-table arrangements. It is not unusual in junior co-ed schools for boys and girls to be separated for handwork and needlework instruction, thus placing them under the care of a teacher, already committed to a project, who probably did not accompany the party visiting the theatre.

Over eighty percent of the schools considered that the production had inspired their children with a
desire to understand simple machines. An outstanding example of this inspiration was given by the Michael Faraday J.M. School, who quoted the case of a boy, 'who normally dislikes reading but considered books because he wanted more information'.

7.19 EDUCATIONAL VALUE OF THE PRODUCTION

One hundred percent of the teachers who saw 'Help', and answered the questionnaire, considered that the production had educational value.

7.20 ENTERTAINMENT VALUE OF THE PRODUCTION

Only one teacher said they did not enjoy the show - no reason was given.

All the teachers considered that the children they accompanied enjoyed the performance.

7.21 PRESENTATION MADE GREATER IMPACT THAN THE SCIENTIFIC CONTENT

Three teachers made the point that the style and presentation made the most lasting impression, only some of the principles being retained. For example Fitzjohn's (J.M.) School, Hampstead, found 'Children willing to discuss the show but not the educational content'. Squirrels Heath Junior School, Romford, had already taught the subject of mechanics and 'the children regarded the show chiefly as entertainment'. This attitude may, therefore, have been induced by the teacher.

7.22 SCHOOLS ON WHICH THE PRESENTATION MADE NO EDUCATIONAL IMPACT

Five schools reported that no immediate or lasting impact had been observed on the groups of children they took to the theatre; however, individuals did become inspired to make models and bring in articles from children's magazines describing machines they had learned about in the stage production. Ninety-nine percent of the children in these groups were in the 9-10 age range.

Only one of these five schools, Parkgate Junior Mixed School, had given their children any preparation and this had been done by allowing them to watch a TV programme; in the words of the teacher 'some of the children were blase and said they knew all about levers before they went'.

The vast majority of the children from this category of school were reported as enjoying the show, as did the teachers accompanying them.

Despite this apparent failure of the production to rise above just entertainment value, all the accompanying teachers considered the production to have educational value and wanted the Molecule Club to devise new productions for the benefit of their schools in years to come.

7.23 FAVOURABLE COMMENTS

'Extremely valuable educational happenings. In all cases great interest has been shown by the children and they have been stimulated into doing a wide range of follow up activity'. Amherst C.P. School.

7.24 CONSTRUCTIVE CRITICISM

'A little slow - otherwise experiments clearly understood'. Cheam Common Junior School.
'Ice cream interval unnecessary'. P.N.E.U. School, Rickmansworth.

7.25 FUTURE PRODUCTIONS

All but two of the teachers wanted more scientific topics to be presented as Molecule Club productions.

One of the minority was the only teacher to have said they did not enjoy the show, even though they stated the children they accompanied had had a lasting impact made on them and were inspired to make models and understand simple machines. The other teacher gave their reason for not wanting further productions as 'our science course covers a wide range'.

Forty-six percent of the teachers wanting additional productions nominated Magnetism and Electricity as the topics they would like to see presented.

7.26 DEDUCTIONS
1. Ninety-six percent of the children in the sample examined were influenced by the Molecule Club Production 'Help', either through follow up lessons and activities, or by personal inspiration.

2. Almost one third of the sample audience consisted of children who had received no preparation and who were thought to have had no prior knowledge of the subject matter presented in the stage production.

3. Irrespective of preparation or prior knowledge children gained a greater inspiration for experimentation than for model making (Table 1).

4. The greatest inspiration to experiment was produced in those children who had prior knowledge of the subject matter, but only received brief preparation for the theatre visit (Table 2).

5. The greatest all-round educational effect was on children who had received extensive preparation and who had some knowledge of the subject matter.

6. The enthusiasm of the teachers in charge of the visiting parties played a vital role in helping the respective children to develop latent talents triggered by the production.

7. Teachers appreciated notes relating to the subject matter of the production.

7.27 CONCLUSIONS

The Molecule Club Production 'Help' successfully combined education with entertainment in a manner that appealed both to children and teachers.

A number of schools based their science lessons on the theme of the production and used the theatre visit as a means of inspiring children to take an interest in technology. Lessons other than science ones were influenced by the production.

It is not essential for children seeing 'Help' to have prior
### TABLE 1

<table>
<thead>
<tr>
<th>Category of Children Visiting the Theatre</th>
<th>Inspirational Value of the Production (Expressed as a % of Each Category)</th>
<th>% of Schools Attending in each Category</th>
</tr>
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<tr>
<td></td>
<td>Model Making</td>
<td>Experimentation</td>
</tr>
<tr>
<td>No Preparation. No Prior Knowledge</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>No Preparation but with Prior Knowledge</td>
<td>36</td>
<td>45</td>
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<tr>
<td>Preparation. No Prior Knowledge</td>
<td>58</td>
<td>75</td>
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<td>Preparation &amp; Prior Knowledge</td>
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<td>83</td>
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</tbody>
</table>

### TABLE 2

Breakdown of category 'Preparation and Prior Knowledge' shown in Table 1.

<table>
<thead>
<tr>
<th>Category of Children Visiting the Theatre</th>
<th>Inspirational Value of the Production (Expressed as a % of Each Category)</th>
<th>% of Schools Attending in each Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model Making</td>
<td>Experimentation</td>
</tr>
<tr>
<td>Brief Preparation &amp; Prior Knowledge</td>
<td>40</td>
<td>90</td>
</tr>
<tr>
<td>Extensive Preparation &amp; Prior Knowledge</td>
<td>62</td>
<td>75</td>
</tr>
</tbody>
</table>
knowledge of the subject matter, or to receive any form of preparation, in order to understand it and be inspired to carry out interesting and useful follow-up work. If a teacher wishes to prepare the children the greatest overall educational value is obtained by giving a thorough preparation. However, care must be taken to see that the children do not become over confident and consider that they know everything about the subject.

The inspiration engendered into children appears to trigger talents in experimentation more than model making. This, to some extent is controlled by the class teacher, but there is evidence to show that this production, irrespective of conditions in school, gives a stimulus to a child's inventiveness and a desire to express itself.
APPENDIX 1

UNIVERSITY OF SURREY
Institute for Educational Technology

SHELL SCHOOL TECHNOLOGY PROGRAMME

Please complete this questionnaire by writing the name of your school at the top and then placing ticks (or data) in the appropriate boxes after each question, and return it to: G.C. Sneed, Director, Shell School Technology Programme, Institute for Educational Technology, University of Surrey, Guildford, Surrey.

Name of School: ____________________________

1. Did you see the Molecule Club show 'Help'?  
   YES  NO  

2. Please state the age and approximate number of children that you took to see the show. 
   AGE: ____________________________  NUMBER: ____________________________

3. Were the children prepared in any way for the show before they went?  
   YES  NO  
   If YES, please give details.

4. In your opinion did the children have any knowledge of mechanics before going to the theatre?  
   YES  NO  

5. Did you, the teacher, enjoy the show?  
   YES  NO  

6. Did you consider that the children you accompanied enjoyed the show?  
   YES  NO  

7. Do you think the show had any educational value?  
   YES  NO  

8. Did you have to answer questions concerning the show when you returned to school?  
   YES  NO  

9. Did the show make any lasting impact on the children?  
   YES  NO
APPENDIX 1 (contd)

9. (contd)

If YES, please give details.

_____________________________________________________

_____________________________________________________

_____________________________________________________

10. Have you based any of your school science lessons on the theme of the show 'Help'?

   YES NO

If YES, please give details.

_____________________________________________________

_____________________________________________________

_____________________________________________________

11. Did the show inspire the children to

   1) make models
   2) carry out simple experiments
   3) understand simple machines

   YES NO

If YES, please give details.

_____________________________________________________

_____________________________________________________

_____________________________________________________

12. Did you find the 'Teachers Notes' given to you at the theatre of any value?

   YES NO

13. Would you like other scientific topic presented as Molecule Club productions?

   YES NO

   If YES, please name two topics that you would like to see presented.

   1. 
   2. 

THANK YOU
NOTES FOR TEACHING STAFF

It is suggested that these notes are read in conjunction with the diagrams drawn on the programme.

**Levers**  In its simplest form a lever is a rigid bar which can be turned freely round a fixed point known as the fulcrum. There are always at least two forces acting on the bar; one of these is the load or resistance and the other the effort being made to lift or overcome this force.

Although it is possible to classify any lever into one of three orders or classes, the stage performance only displayed two of them - the 1st and 2nd orders - in order that this particular machine should not dominate the show. If your class tells you that some simple device belongs to a particular order of lever, immediately check the answer by visualising the position of the fulcrum, load and effort. Should the device mentioned have no apparent fulcrum it is probably not a lever; beware, however, of suggestions which sound impossible at first but which are correct when used in a special way. A typical example of this category is a table knife. Used in the conventional way a table knife is not a lever but when held in a position to chop or thinly slice food it clearly becomes a second order lever. Once the position of the fulcrum load and effort have been established it is only a matter of comparing their arrangement with the simple diagrams appearing on the back of the programme.

A third order lever has the fulcrum at one end, the load or resistance at the opposite end and the effort somewhere in between (Fig. 1).

**Fig. 1**

![Diagram of a third order lever](image)

Two examples of this class of lever are the human forearm and a fishing rod.
Some simple machines are made up from a pair of levers and are classified as double levers of the appropriate order. When analysing such a machine once again either visualise or sketch the position of the forces and fulcrum. Figure 2 shows a force diagram for a pair of scissors.

![Figure 2](image)

By considering just one of the levers it is clear that it belongs to the 1st order, hence a pair of scissors is a double first order lever.

The stage performance also demonstrated the law of the lever which enables calculations to be undertaken regarding the magnitude of forces and distances employed in all orders of the lever. The most concise way of stating this law is that the anti-clockwise moment is exactly equal to the clockwise moment when the lever is in equilibrium. (A moment of a force is the product of a force and its perpendicular distance to the fulcrum).

**Useful definition** Work is said to be done when a force moves its point of application in the direction of the force. Work is measured by the product of the force and the distance through which it moves.

**The inclined Plane** The purpose of any machine is to provide an easier way of doing work. The inclined plane is such a machine and provides a way of lifting a heavy load; it was probably used by the Egyptians during the construction of the pyramids.

If the plane makes a large angle with the horizontal a greater effort will have to be made-to lift any given load - than if the plane is tilted only slightly. However, the total work required to
raise the load through any **vertical height** will be the same irrespective of the angle of inclination of the plane.

The frictional forces between the load and the plane have a considerable effect on the efficiency of this machine, and it is more advantageous to roll loads up than to drag them. The explanation for this fact is that the resistance due to rolling friction is smaller than that of sliding friction and hence the use of the inclined plane for loading barrels.

Ask the class to find out how the inclined plane has been modified in modern factories for the efficient loading of flat bottomed boxes. (Answer. The inclined plane has been built with metal rollers across the inclined section so that sliding friction has been changed to rolling friction).

**Screws** The screw is yet another type of simple machine that is used for raising loads by the application of relatively small forces. As with all machines, the **distance** the heavy load is raised is small compared with the **distance** moved by the effort. Whenever a screw is turned through one revolution it advances a distance known as its pitch. In the case of a screw jack there may be 12 threads to the inch and so the car is lifted $1/12''$ for every complete revolution of the threaded portion. The effort exerted by the operative will depend however on the length of the handle (or tommy bar); with a handle about 6 inches long it is possible to lift one corner of a 1 ton family car with an effort of approximately 51bs wt.

Even if the thread of the screw is kept clean and well greased there is always considerable friction between the screw thread and the nut in the lifting block and also at the base plate. It is because of these large frictional forces that the load cannot 'unscrew' itself and descend by itself.

In addition to lifting motor cars, screw devices such as presses and clamps are used by bookbinders and carpenters for securing joints while glue is setting.
Pulleys  A system of pulley wheels can make it possible for a man to lift a load several times his own weight. In addition, a pulley system allows a heavy weight to be raised by pulling down on a rope instead of a direct upward lift. This change in direction of effort allows a human being to make the effort with greater ease.

The simplest fixed single pulley system just alters the direction of the effort; its magnitude is still equal to the load being lifted. The combination of one fixed and one movable pulley enables the load to be lifted by an effort equal to half the load, since the load is now supported by two sections of rope. At first this sounds as if we are getting something for nothing, but this is not the case. The 'catch' is in the fact that the load is raised only half the distance moved by the effort.

A useful pulley system generally consists of a combination of a fixed and movable pulley block with as many as four pulleys in each block. This pulley machine is then mounted high above the object to be lifted so that the operative has to apply a comparatively small downward pull.

Wheel and Axle  As shown in the demonstration the wheel and axle can be considered as an 'opened out' second order lever.

The effort is always made tangentially to the circular path described by the end of the handle while the load is raised by the string wrapping itself around the axle. The distance moved by the effort during each revolution of the system is, clearly, much greater than the distance through which the load rises. This latter distance is equal to the circumference of the axle. Assuming that the machine is free from friction, the work put in will be equal to the work got out, hence it is possible to raise a large load with only a small effort.
CHAPTER 8

SCHOOL APPLIED SCIENCE IN THE U.S.A.

**AIM**

To study the development of the Engineering Concepts Curriculum Programme and the problems associated with introducing it into the schools.

An attempt will be made also to assess the reaction of teachers, students and other interested parties towards the new Programme material.
8.1 INTRODUCTION

It has been found in America that less than one in five high school graduates have studied physics during their school course. According to figures obtained by the American Institute of Physics there has been a steady decline in the number of students taking an interest in the physical sciences. The reasons for this decline have not been firmly established but many teachers believe that part of the trouble is the general disinclination of students to cope with the abstract and highly intellectual approach taken by the modern physics course.

8.2 THE CREATION OF A SCHOOL TECHNOLOGY PROGRAMME

At a meeting of the National Science Foundation (NSF) held in Washington in 1963 it was decided to investigate the possibility of finding more desirable approaches to the study of physical science, at high school level, than those at present used, although considerable effort has already been made by other projects along the same lines. Five engineers at this meeting headed by Dr. E.E. David, Jr. (Bell Telephone Laboratories) applied an engineers outlook to the problem. They felt that the existing courses failed to convey to the students the impact that physical sciences made on the every-day world. The idea occurred to them to develop an approach that would tie physical principles to the man-made world and hence bring forward the influence of technology.

8.3 THE FORMATION AND AIM OF ECCP

Under the sponsorship of the Commission on Engineering Education, a project, now known as the Engineering Concepts Curriculum Project (ECCP), was formed with the aim of creating a course for use at 11th or 12th grade level that would give all students the chance to acquire some knowledge of technology and hence a broader education.

8.4 A PILOT TRIAL

In the summer of 1964 a grant was obtained from the NSF, some

*The Commission on Engineering Education is a non profit making organisation dedicated to the development of new educational resources. Executive Director Dr. N.A. Hall.
suitable material written, and in the spring of 1965 a short trial carried out at Brooklyn Polytechnic Institute of a few three-hour sessions held on Saturday mornings. The class was comprised of five high school teachers and fifteen high school students. The enthusiastic response to this experiment enabled a further grant to be obtained from the NSF which permitted the material to be lengthened, to cover a course of one year, and tried out in five high schools in the New York area (Appendix 2), during the academic year 1965-66. All the material for this trial was produced by a group of 30 men meeting at Tarrytown, New York, during July and August, 1965. This group included college professors, high school teachers, and industrial engineers and scientists (Appendix 3).

8.5 THE ECCP APPROACH

The emphasis of the project was on laboratory experiments and fundamental concepts, care being taken not to make the course vocational, or a substitute for physics.

The text was written so that the student was confronted with the observable world and then encouraged to understand the basic concepts on which various devices, such as computers, depended.

The authors were asked to make the text material interesting, palatable and acceptable to students who were not necessarily destined for a career in science or engineering and who had no knowledge of physics and not more than two years of high school mathematics.

A special feature of the programme was the experimental equipment developed with the aim of making abstract ideas become alive and real. For example, each pair of students was provided with a logic circuit board that taught logic networks in the form of electric circuits.

8.6 SOME FINDINGS FROM THE INITIAL FIVE-SCHOOL TRIAL

A total of 90 students from the five schools studied the new programme; of these approximately 60 had not taken any course in physics. The progress made by the two groups - the 30 with physics and the 60 without - was not considered by the teachers to be spectacularly different.

Reaction from the five schools, monitored by regular meetings
between the teachers and organisers of the project, indicated that the approach from the outside world back to first principles was workable and capable of appealing to a broader audience than pure physics courses.

The trial revealed also that the level of the material was uneven and that much of it was too difficult. It was further agreed by the teachers that the subject matter was too narrow and contained too much detailed mathematics.

8.7 THE FIRST SUMMER SCHOOL

In 1966 the sponsors of ECCP made it possible for 28 selected mathematics and science teachers - drawn from 15 States - to attend a six-week seminar at the University of Colorado, Boulder (Appendix 4). At the same time and under the same roof a very distinguished group of university teachers and industrial engineers were gathered together (Appendix 3). These men were commissioned to shorten and amend, in the light of experience, the existing 28 chapter syllabus, and then explain it to the school teachers' seminar.

I was invited to spend four weeks at this combined seminar and writers course and was able to speak, at length, to both the teachers and the writers individually. The following observations were made.

ORGANISATION   Lectures for the teachers began at 8 a.m. every morning and organised study continued throughout the day. Several afternoons each week were devoted to practical work in the laboratory so that the teachers could familiarise themselves with the special apparatus developed for the course. These laboratory sessions were supervised by Dr. D.W. Hagelbar (Bell Telephone Laboratories) who had designed most of the apparatus, which it was hoped would be available for use in the 28 schools from September, 1966.

SELECTING AND TESTING THE CLASSROOM EQUIPMENT   Earlier in the year specifications of apparatus needed for the course had been issued to manufacturers (Appendix 5). Prototypes of this apparatus were sent to Boulder and throughout the period of the summer school extensive experiment were carried out by Professor E.J. Angelo and Dr. J.R. Goldgraben (PIB) to evaluate their quality and to decide which were the most suitable for adoption by ECCP. Fig. 1 shows the apparatus finally selected.
Fig. 1(a) The analogue computer incorporates two integrator adders, three scalar adders, a variable direct current signal generator and a timing circuit permitting integration for 0.1, 0.25 and 1 second intervals. This single unit simulates simple dynamic systems.

Fig. 1(b) The 'Polylab' is a single unit made up from an oscilloscope, a signal generator - working between 1 and 20,000 cycles/second, an electronic switch, a 15 volt d.c. power supply and an electronic voltmeter with a range 0 - 100 volts.
EQUIPPING THE TRIAL SCHOOLS

At the conclusion of the seminar each teacher was given a duplicated copy of the new text in the form of single sheets held together with a staple. This amended text contained fifteen chapters which were divided into three sections under the headings - Logic and Computers, Models and Measurements and Energy and Control.

The apparatus needed for the class experiments was expected to reach the trial schools, free of charge, within a few weeks of the teachers leaving Colorado. It was made quite clear that this free issue of laboratory equipment applied only to the trial schools. Any other schools who wished to adopt the ECCP Programme were expected to buy the equipment. Fig. 2.

EVALUATION

Although the ECCP experiment had not at that time been in progress long enough to produce any scientific evidence as to its success, it was felt among participants that it would help future citizens to understand and make decisions in a highly technical world.

8.8 THE SECOND SUMMER SCHOOL

The second ECCP summer school was held in the University of Colorado, Boulder, in 1967 under the leadership of ECCP Assistant Director B.A. Sachs. This course, like the first one held in 1966, lasted for six weeks and was designed to acquaint a group of 30 high school teachers (specialising in mathematics and science) with the text and apparatus used in the ECCP so that they would be able to introduce the scheme into their schools from September, 1967 (Appendix 6).

This new group of teachers were resident at the University for the entire period of six weeks. They were joined for their last three weeks by the previous year's group of 28 teachers who had acquired one year of classroom teaching experience with the text.

At the same time as the teacher training programme was taking place in Colorado, a small group of experienced teachers and university professors were working at the Polytechnic Institute of Brooklyn - under ECCP Associate Director Dr. E.J. Piel - to develop either additional or modified text material, better end of chapter tests and new demonstrations and student experiments. After working on these sections for three weeks some members of the group flew to Colorado to explain to the assembled teachers the results of their work. Some of the additional class
Fig. 2(a) The Logic Circuit Board consisting of relays, manual switches and lamps energised by a low voltage power supply. This unit enables students to connect up "and", "or", and "not" circuits as well as combinations that add, subtract and transfer data from one circuit to another.

Fig. 2(b) This Sonar Set demonstrated remote sensing and measurement. The oscillator generated 20/60 pulses per second at 12,500 hertz which were transmitted by the horn transducer. These pulses bounced off the reflector, returned to the horn and were then displayed on an oscilloscope. The distance between the blips representing the transmitted and reflected pulses indicated distances up to 7 metres. (This unit has now been withdrawn from the course because of its high cost.)
Fig. 2(c) The Cardiac. A cardboard device that simulates basic computer action.

Fig. 2(d) An electrically operated variable speed mass spring unit, used to demonstrate resonance.
experiments demonstrated were both interesting and instructive, but in England would be considered as only suitable for students studying science in the lower forms of a secondary school.

After successfully completing the summer school course teachers received credits counting towards the award of a higher degree under a plan set up by the University of Colorado.

8.9 SOME DEDUCTIONS CONCERNING THE ECCP TRIAL YEAR 1966-67

I arranged a three week stay at the University of Colorado in the summer of 1967 so that it overlapped the 'new' teachers course and the arrival of the experienced teachers. In this way it was possible to learn something of the modifications that had been made to the text during the intervening months and also to find out the reaction of the experienced teachers after a year of presenting the ECCP course to groups of students in their high schools.

As well as talking to the experienced teachers individually and in the seminar groups, I asked them to complete a questionnaire, Appendix 8, in order to obtain data concerning their personal experience with ECCP material. By means of these interviews and the questionnaire the following information was deduced about the 1966-67 trial teaching year.

PARTICIPATING HIGH SCHOOL STUDENTS

NUMBERS AND GRADES The average number of students studying the ECCP material in any school was approximately 20, with the maximum and minimum figures being 32 and 6 respectively. The vast majority of these students were in the 12th grade although nearly half the participating schools provided a course for students in the 11th grade. Only one school had recruited all its students from the 11th grade, and only one school had a small group (6) in the 10th grade.

PROPORTION OF BOYS AND GIRLS In every mixed school except two, at least twice as many boys as girls wished to take the course.

METHOD OF ENROLMENT Only two schools admitted to having obtained their ECCP students by non-voluntary means. One of these exceptions employed a basis of selection and the other used conscription.
PREVIOUS KNOWLEDGE  Almost without exception all the students had studied some mathematics in previous years, but very few had any background of physics.

CURRENT STUDIES  The vast majority of the students were studying mathematics but very few were receiving teaching in the field of physics. It seems that American boys consider physics to be a difficult subject and therefore many do not choose to study it when a credit-counting for a college entry - can be obtained more easily by studying another subject.

TEACHING TIME  Most schools spent approximately $4\frac{3}{4}$ hours each week on ECCP work, but one school claimed to devote as much as 5 hours 50 minutes to the subject. However, ideas on the division of the total teaching time between theoretical and practical work varied considerably. One school gave four times as much time to the theoretical side as to the practical; another gave twice as much theory as practical while several of the schools divided the time equally.

THE COURSE

STUDENT APPEAL  The majority of teachers thought that the course as it was in the year 1966-67, appealed equally to the boys and girls, but a minority felt that it offered the greatest attraction to the boys. The 'newness' of the subject and the challenge it offered were put forward as reasons for some students volunteering to take the course.

THE TEXT  I tried to find out whether the students found the subject matter easy or difficult to understand; but this proved a difficult problem as in the classes studying the subject there was a very wide range of student ability, and there was no basis on which to compare one school's group with another. However, the impression was gained that the majority of teachers considered the standard to be about right for the average student although several teachers felt certain sections were too detailed and abstract to hold the student's interest for any length of time. Two teachers refused to use some of the material in the classroom until it had been drastically revised and brought into line with what they considered to be the real needs of a high school.

The major criticism of the text was about its length; almost without exception the teachers had been unable to cover the complete text in one year. Some teachers had mis-givings about their own
understanding of the material and so thought that the slow pace possibly was attributable to them, but hoped to remedy this in future years.

The end of section tests were thought to be insufficiently graded and could do with some modification.

Some extra experiments and demonstrations were thought to be desirable in order to create more interest in the text.

THE EQUIPMENT Unfortunately one or two teachers did not receive some of the equipment until near the end of the year and so had been unable to test it to full advantage. Those who did manage to give it a trial were a little disappointed with the 'polylab' and the analogue computer because they experienced drifting and the equipment needed frequent maintenance. However, as with most new equipment teething troubles are to be expected, but the manufacturers were keen to make modifications to the circuits in order to eliminate these troubles. Once the units were in working order the teachers thought they would be very useful, especially the small analogue computer.

When asked to comment on the teaching worth of the equipment the teachers agreed unanimously that the logic circuit board was excellent and performed well under classroom conditions.

The Cardiac - a cardboard model of a computer used to demonstrate the internal stages that take place - also was considered to be excellent although it did require complete student concentration in order to obtain success.

The mass-spring demonstration - a model to represent mechanically what is meant by resonance in an electric circuit - was considered to be good although it had a limited use.

STUDENT ENJOYMENT Teachers reported that at the end of the course almost every student decided that he or she had enjoyed the study; but it seemed that it was the apparatus and experiments that made the course enjoyable and different from other school subjects.

One school teacher said that at the conclusion of the course he had asked his students to write a short account of their reaction to the instruction and opportunity that the course provided and one boy wrote,
'the most interesting, exciting and instructive I have ever taken'.

COURSE CREDIT  At the conclusion of the course every teacher except one had given their students a test and awarded some form of credit for their effort. The majority of the teachers classified the subject as being equal to any of the normal school science courses when deciding the number of credits that should be awarded.

COURSE INFLUENCE  Even though the course was not designed to attract young people to a career in engineering - but to provide some understanding of the technical everyday world to the college bound student - one or two teachers believed that a few boys had some earlier ambitions concerning a career in engineering reinforced by the course.

SOME GENERAL COMMENTS BY TEACHERS

'Too early to evaluate the course'.
'Course generally very successful'.
'Enjoyed teaching the course and have learnt a lot from it'.
'The interest generated perhaps depends upon the teacher'.
'Would like more laboratory reports to accompany experiments'.
'Adding a new course produces problems - money a problem'.

8.10 EXPANSION OF THE ECCP TEACHER TRAINING PROGRAMME

As teacher training was such a vital part of the ECCP a number of colleges and universities submitted proposals to the NSF, in 1967, for organising and housing future summer institutes.

Several universities at that time were very anxious to offer help to local schools offering the ECCP course. One example of this type of university assistance came from the University of Rochester, New York, where 10 teachers from local high schools in the area were taken through a training programme to acquaint them with the ECCP text and experiments.

In 1968 the summer teacher training programme expanded to five institutes held at the University of Massachusetts, University of Wisconsin, Harvey Mudd College, P.I.B., and the University of Houston. Between them these institutes prepared 138 teachers for extending the ECCP programme during the academic year 1968-9.

Six summer teacher training institutes were held in the period July/August 1969 at the University of Wisconsin, Harvey Mudd College,
University of Washington, P.I.B., University of Illinois and the University of Massachusetts. Two CCSS institutes * were involved also with ECCP.62

In September 1969 Memphis State University (Herff College) organised an inservice Institute that assisted 30 local teachers engaged in the ECCP programme. These teachers attended a 3 hour class one night a week for nine months. The Institute was supported by NSF funds.

During the summer of 1970 six summer institutes were held. The venues were the same as in 1969 with the exception of the University of Massachusetts which was replaced by the Pennsylvania State University.

An enrolment history for the ECCP is given in Appendix 7.

8.11 SOME DEDUCTIONS CONCERNING THE 1969 SUMMER INSTITUTES

I sent a questionnaire (Appendix 9) and covering letter to each of the eight centres housing summer institutes. Five of these questionnaires were completed and returned, thus enabling me to make the following deductions.

PARTICIPATING TEACHERS Approximately 30 teachers attended each institute for six weeks. The vast majority were teachers of science, the minority were teachers of mathematics. Every teacher had been carefully selected and not merely accepted as a result of an application. The criteria used for selection were position in the school and academic background. It was hoped to attract teachers with a strong academic background who were in a position to take positive steps to introduce ECCP into their schools.

ORGANISATION Each day's work lasted between six and eight hours with the time equally divided between theory and practical work. The practical work was voted to be the most enjoyable by the participating teachers.

FINANCE At the conclusion of the course each teacher was given a cheque to cover a stipend of $ 75 a week + $ 15 dependent allowance.

* University of South Florida, University of Colorado.
The Co-operative College-School Science Programme (CCSS) of the National Science Foundation provides opportunities for colleges, universities and similar institutes to work with school systems in improving elementary and secondary school science and mathematics programmes.
TEACHERS COMMITTED TO INTRODUCE ECCP  Only about 50% of the teachers attending were committed to introducing the ECCP into their school in September, 1969.

TEACHING MATERIAL  Every teacher was given a copy of the text material.

8.12 THE COST OF EQUIPPING SCHOOLS

By November, 1967 the PIB were receiving a large number of enquiries from schools concerning the quantities and cost of buying apparatus for the ECCP programme. The official ECCP recommendation for a group of 24 students was 12 LCB's, 8 analog computers, 8 polylabs and one demonstrator kit consisting of a mechanical amplifier, a stability experiment and a mass spring demonstrator marketed as a package costing $4,960. ECCP staff suggested, however, that a reduction to $2,000 in the capital expenditure could be made by having groups of four instead of three students using each analog computer and polylab and by assigning pupils to demonstrate more expensive pieces of equipment.

The cost of buying a complete set of ECCP apparatus was still causing problems in the schools in 1969 and the minimum outlay of $2,000 was regarded by many educational administrators as high. For this reason considerable thought was given to ways of reducing the cost of manufacturing the equipment. The manufacturers were also considering simplifying the design of the equipment so that maintenance and repairs could be carried out by the teachers. To help with this aspect of the work manuals were prepared and manufacturers travelling representatives trained to advise on diagnosing faults.

By December, 1970 a major effort directed towards simplifying both the apparatus and its method of manufacture, had reduced the initial cost of the full ECCP apparatus package to $3,000. For schools with serious financial problems advice is offered on how a minimum capital expenditure of $1,500 will allow some useful classroom experimental work to be undertaken.

8.13 DEVELOPMENT OF THE TEXT

In June, 1970 a complete revision of the standard text material was completed and is expected to be ready for publication in 1971. Two significant changes have been made. First, the literary style and readability are improved, by employing only three men, so as to achieve a higher degree of uniformity. More illustrations are included and the algebraic content reduced. Secondly, a greater emphasis is made on societal problems. In the words of an ECCP spokesman, 'It is hoped to give our readers enough understanding to survive in a technological society'.

8.14 AN INVESTIGATION INTO THE ACCEPTANCE OF THE ECCP PROGRAMME

During September, 1969 I visited three schools in the Houston area that were offering the ECCP programme, the University of Houston, and the administrators of the local education system. From the views expressed by teachers and administrators in this area it seemed that several career guidance directors and physics teachers needed to be convinced about the value of the new programme. The physics teachers were worried about the introduction of a new course that they thought might further reduce the already dwindling numbers enrolling for high school physics programmes; while the guidance directors were concerned about the status of the new course and its effect on the acceptance figures of students for colleges.

In order to find out whether these fears were held in every area of the U.S.A. offering the ECCP programme I prepared a short questionnaire, Appendix 10, and sent it to the 58 pioneer teachers who were trained at Colorado in 1966 and 1967. Forty teachers completed and returned the questionnaire which enabled me to make the following deductions.

EFFECT OF ECCP ON ENROLMENT TO PHYSICS CLASSES

50% reported no change in enrolment to physics classes.
20% reported a decrease in enrolment to physics classes.
30% reported an increase in enrolment to physics classes.

REASONS FOR STUDENTS CHOOSING TO ENROL FOR ECCP

No definite answer. It seemed that students chose ECCP because they liked what the teachers told them about the course and the favourable comments made by students who had already taken the course. The teachers of ECCP did not believe the students saw the course as a replacement for physics. A few teachers reported
cases of students taking the physics and ECCP courses.

EFFECT OF ECCP ON COLLEGE ENTRANCE

It was unanimous that no college acceptance problems had arisen that could be attributed to a student having enrolled for the ECCP.

VALUE OF ECCP MATERIAL TO STUDENTS EMBARKING ON FURTHER COURSES OF STUDY

Non college bound students (the majority) - of some value to those who entered computer orientated training.

College bound students (very few) - gave them a better understanding of the world of engineering.

8.15 A LOCAL EDUCATIONAL PROBLEM

Throughout the academic year 1969-70 a group of teachers from city schools around Brooklyn met and discussed their problems in presenting the ECCP programme. They believed it was very much easier to discuss technological innovations in the middle class suburbs than in central city areas where the people tended to distrust technological devices and have also language problems. These meetings culminated in a workshop being held at PIB in the summer of 1970 to try and make ECCP more meaningful to urban students of low ability. During the course of the workshop over 100 student-activity worksheets were developed each accompanied by teachers notes. These sheets are success orientated so that students with poor academic backgrounds achieve a positive educational experience. It is expected that 10 teachers will try this new material in schools during the academic year 1970-71.

8.16 EVALUATION

An evaluation programme was developed by the combined efforts of the staff from ECCP headquarters and the Psychological Corporation of New York. This programme consisted of an aptitude test, five forty-minute student achievement tests, a final student examination lasting eighty minutes and questionnaires completed by the teachers.

Each school was asked to select five non-ECCP students, with similar academic backgrounds to the ECCP students to sit the tests and form the control group.
At the conclusion of each test the completed answer sheets were returned to the Psychological Corporation for machine scoring.

Analysis of the test results and questionnaire enabled the ECCP staff to draw the following conclusions. (65) (66)

1. The course was suitable for students in grades 10, 11 and 12. This was considered to be a very important finding as many people had expressed the opinion that several of the topics and concepts had been developed beyond the grasp of the average non-science student in the 10th grade.

2. The course was suitable for students who had only two years of mathematics although with three years of mathematics achieved higher results.

3. Boys and girls seemed to achieve equal success provided that they had similar academic capacities.

8.17 SUMMARY AND CONCLUSIONS

SUMMARY

The ECCP has been developed through the inspired leadership of Dr. E.E. David Jr. - who is now President Nixon's Chief Science Advisor with the aim of helping every child to realise the significance of technology in the everyday world.

The special apparatus needed for the student experimental work was designed by staff members of the Bell Telephone Laboratories and the text written by a group of consultants commissioned for the purpose.

In order to try out the new material on a wide geographic scale, for one year, twenty-eight selected teachers of mathematics and science were given suitable training in 1966 at a six-week Summer School in preparation for starting the course in their schools the following September.

Despite problems both inside and outside the classroom interest in the programme has continued to grow. In 1968 and 1969 it was found necessary to expand the teacher training programme to five and six summer institutes respectively in order to help prepare the increasing
number of teachers considering introducing the Project into their schools.

Enrolment figures show that in 1970 the project had attracted 401 teachers operating the course in 396 schools.

CONCLUSIONS

The majority of students who chose the one year ECCP elective course are from the 12th grade and spend approximately $4\frac{1}{2}$ hours each week engaged in the appropriate theory and practical work. Students who complete the course satisfactorily receive credits, thus giving the ECCP equal academic status with the well established subjects.

At first the cost of the equipment needed to introduce the course into a school caused some concern amongst school administrators, but the manufacturers now have modified the experimental units and improved production techniques so as to reduce the initial capital expenditure.

Concern expressed by teachers in some parts of America regarding the adverse effect ECCP might have on the enrolment figures of physics classes, does not seem to have been as serious as at first anticipated; in fact some schools have reported increased enrolment for physics classes since the introduction of ECCP.

Students applying for university entry have found ECCP to be a subject recognised by admission tutors and have not therefore jeopardised their chances of acceptance by choosing this new elective course.

As a result of written tests and feedback from teachers and students the headquarters staff of ECCP believe they have made good progress towards devising a curriculum that fulfills its aims.
Appendix 1
THE ENGINEERS RESPONSIBLE FOR INITIATING ECCP

E.E. David, Jr. (Bell Telephone Laboratories)
R.L. Garwin (International Business Machines Corporation)
D.A. Huffman (Massachusetts Institute of Technology)
J.R. Pierce (Bell Telephone Laboratories)
G.I. Robertson (Bell Telephone Laboratories)
A.B. Rosenstein (University of California)
J.G. Truxal (Polytechnic Institute of Brooklyn)

Appendix 2
THE FIVE SCHOOLS USED FOR THE PILOT TRIAL OF ECCP

Glen Rock, New Jersey
Staples High School, Westport, Connecticut
James Caldwell High School, West Caldwell, New Jersey
Brooklyn Technical High School, Brooklyn, New York
West Essex High School, Caldwell, New Jersey
<table>
<thead>
<tr>
<th>Name</th>
<th>Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.J. Angelo</td>
<td>Polytechnic Institute of Brooklyn</td>
</tr>
<tr>
<td>N.W. Badger</td>
<td>Garden City High School, N.Y.</td>
</tr>
<tr>
<td>E.S. Barrakette</td>
<td>International Business Machine Corporation</td>
</tr>
<tr>
<td>J.A. Barss</td>
<td>Andover, Mass.</td>
</tr>
<tr>
<td>D.L. Bitzer</td>
<td>University of Illinois</td>
</tr>
<tr>
<td>J. Bordogna</td>
<td>University of Pennsylvania</td>
</tr>
<tr>
<td>L. Braun</td>
<td>Polytechnic Institute of Brooklyn</td>
</tr>
<tr>
<td>A.E. Bryson</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>D.R. Coffman</td>
<td>James Caldwell High School, N.J.</td>
</tr>
<tr>
<td>R.L. Garwin</td>
<td>International Business Machine Corporation</td>
</tr>
<tr>
<td>J.R. Goldgraben</td>
<td>Polytechnic Institute of Brooklyn</td>
</tr>
<tr>
<td>A.J. Goldstein</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>D.W. Hagelbarger</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>L.D. Harmon</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>W.H. Hayt</td>
<td>Purdue University</td>
</tr>
<tr>
<td>C. Hellman</td>
<td>Bronx High School of Science, N.Y.</td>
</tr>
<tr>
<td>L. Hollinger</td>
<td>Glen Rock High School, N.J.</td>
</tr>
<tr>
<td>D.A. Huffman</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>W.H. Huggins</td>
<td>Johns Hopkins</td>
</tr>
<tr>
<td>C.E. Ingalls</td>
<td>Cornell</td>
</tr>
<tr>
<td>L.G. Johnson</td>
<td>Sidwell Friends School, Washington</td>
</tr>
<tr>
<td>R.W. King</td>
<td>Staples High School, Conn.</td>
</tr>
<tr>
<td>A.E. Korn</td>
<td>James Caldwell High School, N.J.</td>
</tr>
<tr>
<td>G. Maler</td>
<td>University of Colorado</td>
</tr>
<tr>
<td>J.R. Pierce</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>G.I. Robertson</td>
<td>Bell Telephone Laboratories</td>
</tr>
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<td>A.B. Rosenstein</td>
<td>University of California</td>
</tr>
<tr>
<td>S. Schenberg</td>
<td>Board of Education, N.Y.</td>
</tr>
<tr>
<td>W.M. Siebert</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>M. Simpson</td>
<td>West Essex High School, N.J.</td>
</tr>
<tr>
<td>R.A. Went</td>
<td>West Essex High School, N.J.</td>
</tr>
<tr>
<td>G.B. Williams</td>
<td>University of Michigan</td>
</tr>
<tr>
<td>J.D. Ullman</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>A. Van Dam</td>
<td>Brown University</td>
</tr>
<tr>
<td>E.E. Zajac</td>
<td>Bell Telephone Laboratories</td>
</tr>
<tr>
<td>Teacher</td>
<td>School</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Edmund R. Anderson</td>
<td>Monroe Senior High School</td>
</tr>
<tr>
<td>Edward G. Blakeway</td>
<td>Needham-Broughton High School</td>
</tr>
<tr>
<td>Brother Donnan, C.F.X.</td>
<td>Nazareth High School</td>
</tr>
<tr>
<td>Thomas M. Barnshaw</td>
<td>The Episcopal Academy</td>
</tr>
<tr>
<td>Elbert Felton</td>
<td>Reagan High School</td>
</tr>
<tr>
<td>Marlow D. Gibby</td>
<td>Poway High School</td>
</tr>
<tr>
<td>Gary Goodness</td>
<td>Niskayuna High School</td>
</tr>
<tr>
<td>L.S. Hollinger</td>
<td>Glen Rock High School</td>
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<tr>
<td>R.W. King</td>
<td>Staples High School</td>
</tr>
<tr>
<td>Alfred E. Korn</td>
<td>James Caldwell High School</td>
</tr>
<tr>
<td>Estis D. Lander</td>
<td>Pasadena High School</td>
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<tr>
<td>Dean C. Larsen</td>
<td>Bear Creek Jr.-Sr. High School</td>
</tr>
<tr>
<td>Donald C. Lea</td>
<td>The Hill School</td>
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<tr>
<td>Thomas Liao</td>
<td>Brooklyn Technical High School</td>
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<tr>
<td>Monroe R. Lott</td>
<td>Jordon Voc. High School</td>
</tr>
<tr>
<td>James J. McNeary</td>
<td>Washington Park High School</td>
</tr>
<tr>
<td>William M. Magee</td>
<td>Andrew Warde High School</td>
</tr>
<tr>
<td>Capt. Herbert Marable</td>
<td>Severn School</td>
</tr>
<tr>
<td>Thomas M. Piziak</td>
<td>Russell High School</td>
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</tbody>
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APPENDIX 4

ECCP TEACHERS AND SCHOOLS IN 1966-7 TRIAL
<table>
<thead>
<tr>
<th>Teacher</th>
<th>School</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert K. Putnam</td>
<td>Highline Senior High School</td>
<td>Seattle, Washington</td>
</tr>
<tr>
<td>Madolyn J. Reed</td>
<td>Phillis Wheatley High School</td>
<td>Houston, Texas</td>
</tr>
<tr>
<td>Stanley Rhodes</td>
<td>Staples High School</td>
<td>Westport, Connecticut</td>
</tr>
<tr>
<td>W.H. Schadel</td>
<td>John Dickinson High School</td>
<td>Wilmington, Delaware</td>
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<tr>
<td>C.L. Seltzer</td>
<td>Weequahic High School</td>
<td>Newark, New Jersey</td>
</tr>
<tr>
<td>R.G. Shaw</td>
<td>MacArthur Senior High School</td>
<td>Houston, Texas</td>
</tr>
<tr>
<td>Sister Mary Conrad</td>
<td>Annunciation High School</td>
<td>Detroit, Michigan</td>
</tr>
<tr>
<td>Charles R. Stoughton</td>
<td>Iolani School</td>
<td>Honolulu, Hawaii</td>
</tr>
<tr>
<td>Robert A. Went</td>
<td>West Essex High School</td>
<td>North Caldwell, New Jersey</td>
</tr>
</tbody>
</table>

APPENDIX 4 (CONT'D)
APPENDIX 5

MANUFACTURERS CONCERNED WITH DEVELOPING ECCP EQUIPMENT

Bell Telephone Laboratories, N.J.
Electronics Associates Inc.

APPENDIX 7

ENROLMENT HISTORY

<table>
<thead>
<tr>
<th>Year</th>
<th>Institute</th>
<th>Number of Teachers Prepared</th>
<th>Number of Schools Teaching ECCP</th>
<th>Approximate Student Enrolment</th>
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<tbody>
<tr>
<td>1965-1966</td>
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<td>5</td>
<td>5</td>
<td>95</td>
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<td>28</td>
<td>28</td>
<td>715</td>
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<tr>
<td>1968-1969</td>
<td>5 NSF Institutes</td>
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<td>1969-1970</td>
<td>6 NSF Institutes</td>
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<td>7000</td>
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<tr>
<td>Teacher</td>
<td>School</td>
<td>State</td>
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<tr>
<td>----------------------</td>
<td>-------------------------------------------------</td>
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<td></td>
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</tr>
<tr>
<td>James D. Barlow</td>
<td>Camelback High School</td>
<td>Phoenix, Arizona</td>
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<tr>
<td>Elito J. Bongarzone</td>
<td>The Wheatley School</td>
<td>Old Westbury, New York</td>
<td></td>
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<tr>
<td>Charles M. Bowers</td>
<td>Peters Township Jr.-Sr. High School</td>
<td>McMurray, Pennsylvania</td>
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<td>Lawrence Braden</td>
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<tr>
<td>Joe Braly</td>
<td>Saguaro High School</td>
<td>Scottsdale, Arizona</td>
<td></td>
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<tr>
<td>John A Braswell</td>
<td>Melbourne High School</td>
<td>Melbourne, Florida</td>
<td></td>
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<td>Thomas A. Brook</td>
<td>Nathan Hale High School</td>
<td>Seattle, Washington</td>
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<td></td>
</tr>
<tr>
<td>David H. Brown</td>
<td>Evergreen Senior High School</td>
<td>Evergreen, Colorado</td>
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<tr>
<td>Charles W. Camp</td>
<td>Amherst-Pelham Regional High School</td>
<td>Amherst, Massachusetts</td>
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<tr>
<td>Georges P. Caplette</td>
<td>Lincoln Jr.-Sr. High School</td>
<td>Lincoln, Rhode Island</td>
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<tr>
<td>John W. Chapman</td>
<td>Golden Senior High School</td>
<td>Golden, Colorado</td>
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</tr>
<tr>
<td>Edwin Dural</td>
<td>Bear Creek Jr.-Sr. High School</td>
<td>Morrison, Colorado</td>
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<tr>
<td>Jonathan Erion</td>
<td>Alameda High School</td>
<td>Denver, Colorado</td>
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<tr>
<td>Henry S. Fraze</td>
<td>Northeast High School</td>
<td>St. Petersburg, Florida</td>
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<tr>
<td>Bro. Aubin Hart</td>
<td>Nazareth High School</td>
<td>Brooklyn, New York</td>
<td></td>
<td></td>
</tr>
<tr>
<td>James Hicks</td>
<td>Barrington High School</td>
<td>Barrington, Illinois</td>
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<tr>
<td>Samuel Kalsmith</td>
<td>W. Tresper Clarke High School</td>
<td>Westbury, New York</td>
<td></td>
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<tr>
<td>Richard W. Kaskoun</td>
<td>North Shore High School</td>
<td>Glen Head, New York</td>
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</tbody>
</table>

APPENDIX 6

ADDITIONAL ECCP TEACHERS AND SCHOOLS IN 1967-8 TRIAL
### ADDITIONAL ECCP TEACHERS AND SCHOOLS IN 1967-8 TRIAL

<table>
<thead>
<tr>
<th>Teacher</th>
<th>School</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>David L. Krill</td>
<td>Jefferson Senior High School</td>
<td>Lakewood, Colorado</td>
</tr>
<tr>
<td>Anthony Krimovich</td>
<td>East Meadow High School</td>
<td>East Meadow, New York</td>
</tr>
<tr>
<td>Jeddie Lowder</td>
<td>Rigby High School</td>
<td>Rigby, Idaho</td>
</tr>
<tr>
<td>Joseph A. Mascetta</td>
<td>Mt. Lebanon High School</td>
<td>Pittsburgh, Pennsylvania</td>
</tr>
<tr>
<td>William J. Shaffer</td>
<td>Rawlins High School</td>
<td>Rawlins, Wyoming</td>
</tr>
<tr>
<td>Robert E. Showers</td>
<td>East High School</td>
<td>Green Bay, Wisconsin</td>
</tr>
<tr>
<td>Chester Spangler</td>
<td>Roy High School</td>
<td>Roy, Utah</td>
</tr>
<tr>
<td>Sidney W. Storer</td>
<td>Tyee High School</td>
<td>Seattle, Washington</td>
</tr>
<tr>
<td>Alvin Wheeler</td>
<td>William Horlick High School</td>
<td>Racine, Wisconsin</td>
</tr>
<tr>
<td>Gerald R. Winjum</td>
<td>Lakewood High School</td>
<td>Lakewood, Colorado</td>
</tr>
</tbody>
</table>

APPENDIX 6 (CONTD)
APPENDIX 8

SCHOOL NAME ___________________________ State _______________________

TEACHERS NAME ________________________

1. Number of students taking the ECCP programme in your high school 1966-67.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11th grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any other grade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Did the above students volunteer or were they conscripted to take the ECCP programme?

3. What was the total time spent teaching ECCP each week? [ ]

4. How much of this weekly time was devoted to
   a) theory [ ]  b) practical lab sessions [ ]

5. a) Had the students working with the ECCP programme any previous knowledge of
   i) physics      ii) mathematics
   b) How many years of high school mathematics and physics had been given?

6. Were the ECCP students currently taking the course on
   a) physics [ ]  b) mathematics [ ]

7. Would you estimate that the ECCP course was of equal interest to the boys and girls?
   If not, were boys more interested than girls?

8. Did you give the students any formal test at the end of the course in order to estimate what they had learnt?

9. Was any form of credit given for the ECCP course?
10. Did your students find the course
   a) difficult □  b) easy to follow □

11. Did your students enjoy the ECCP course? If your students enjoyed the course please state what appealed to them most:
   a) text □  b) equipment □
   c) experiments □  d) anything else □

12. If the ECCP course did not appeal to the students please state why you think the programme failed to catch their imagination.

13. Did you manage to teach the entire course as shown in the text?

14. Please indicate by a single word such as excellent, good, fair, poor - the teaching value of the following items of laboratory equipment:
   a) Poly Lab □
   b) Analogue Computer □
   c) Logic Circuit Board □
   d) Mass-spring demonstration □
   e) Cardiac □

15. Did the ECCP equipment give you any trouble? If so, please indicate the nature of this trouble.

16. Do you consider that the ECCP course influenced any student so much that he decided to embark on a college study of engineering.

17. Do you consider that the course needs more experiments or demonstrations? If so, please state the part of the course where they are needed:
   a) Experiments □
   b) Demonstrations □

18. Are you expecting to teach ECCP in your school during 1967-68?

   How many students are you expecting to attend the course from:

   Boys  Girls
   12th  □  □
   11th  □  □
   10th  □  □
   Any other □  □
19. Will you need more equipment for the session 1967-68 than you had last year? If so, will your school have to pay for it?

20. Do you consider a computer terminal an essential addition to your ECCP equipment? If so, why?

21. If your school already has a terminal where was it situated?
   a) In a classroom
   b) In a laboratory
   c) In an office
   d) Elsewhere

22. a) Would you allow students to use the terminal when you are not present in the room?
   b) If the answer to the above section is NO, will it mean that you have to give up some of your free time in order to supervise the terminal?

23. In your experience are school supervisors and principals enthusiastic about ECCP?

24. Do you know of any school supervisors and/or principals who oppose the introduction of ECCP to their schools? (just answer yes or no)

25. Would you like to see ECCP taught in most American high schools? If your answer is YES which do you think will be the greatest difficulty to overcome:
   a) lack of teachers with a knowledge of ECCP
   b) lack of money to buy the apparatus
   c) any other reason

26. Do you feel any need to simplify the text as it is now written?

27. Please write any other comment or statement that you feel will help me to obtain a true picture of the success, or otherwise, of the ECCP programme to date.

G. C. Sneed
Private Investigation by G.C. Sneed into ECCP Summer Programmes provided by American Centres of Higher Education

Please complete and return this questionnaire to:

G.C. Sneed,
University of Surrey,
Institute for Educational Technology,
Guildford,
Surrey, England.

1. Name of Summer ECCP Centre:

2. Number of Teachers attending:

3. How many of the teachers were:
   a) mathematics specialists?
   b) science specialists?

4. Were the teachers attending your course obtained by careful selection or as random volunteers? Please state which and elaborate a little on the method of selection.

5. Were the teachers paid to attend this course? YES NO
   If, YES, how much?

6. Period of attendance:

7. Number of hours worked by teachers each day:

8. a) Number of hours of theory in the complete course:
   b) Number of hours of practical work in the complete course:

9. Did any of the teachers find that the work discussed was too difficult for them? YES NO
   If, YES, please elaborate:
10. Did any teachers with ECCP experience act as instructors?  
   YES  NO

   If, YES, how many?  □  

11. Did any of the University staff act as instructors?  
   YES  NO

   If, YES, how many?  
   FULL TIME □  PART TIME □  

12. Did the teachers appreciate the theory or the practical part the most? Please state which:

13. At the completion of the course were any ECCP materials given to the teachers?  
   YES  NO

   If, YES, please state what they were:

14. Were all the schools from which the teachers came pledged to operating an ECCP programme from September 1969?  
   YES  NO

   Please elaborate:

   ____________________________________________
   ____________________________________________
   ____________________________________________
UNIVERSITY OF SURREY

SCHOOL TECHNOLOGY PROGRAMME

Please complete this questionnaire, by placing ticks or comments after each question, and return it to G.C. Sneed, Director, Shell School Technology Programme, Institute for Educational Technology, University of Surrey, Guildford, Surrey, England.

Name of School

1. Has the introduction of the ECCP influenced the number of students enrolling for the school physics classes?
   YES [ ] NO [ ]

   If, YES, has the new work had the effect of
   1) increasing the enrolment to physics classes? [ ]
   2) decreasing the enrolment to physics classes? [ ]

2. a) Please state what you believe to be the reasons behind students choosing to enrol for the ECCP:

   __________________________________________
   __________________________________________
   __________________________________________

   b) Do you think that the students see the ECCP as replacing physics?
      YES [ ] NO [ ]

   c) Do any of your students enrol for concurrent ECCP and physics courses?
      YES [ ] NO [ ]

      If, YES, please state how many students are in this category: [ ]

3. Have any of your ECCP students encountered difficulties in obtaining acceptance at a college, which can be attributed to them having enrolled for this new course?
   YES [ ] NO [ ]

   If, YES, please elaborate:

   __________________________________________
   __________________________________________
   __________________________________________
4. Has the ECCP material proved of value to students embarking on further courses of study?

If, YES, please elaborate in the case of;

a) Non-college bound students

b) College bound students
A STUDY OF THE FACILITIES FOR SCIENCE EDUCATION OFFERED BY AMERICAN SCIENCE MUSEUMS

AIM

To investigate the type and scope of assistance being offered by selected science museums, within the U.S.A., for the benefit of students and science teachers in both primary and secondary schools. The study was confined to the educational programmes of 21 science museums situated throughout the 50 American States.
CHAPTER 9

A STUDY OF THE FACILITIES FOR SCIENCE EDUCATION OFFERED BY AMERICAN SCIENCE MUSEUMS

9.1 INTRODUCTION

In recent years much discussion has arisen in American schools concerning their science and technological education. Considerable effort has been devoted to producing new teaching materials for use within the schools but very few people seem to have studied the teaching facilities and aids that already exist outside the schools, in the museums. 68,69,70

9.2 AIM OF THE STUDY

To investigate the type and scope of assistance being offered by selected science museums, within the U.S.A., for the benefit of students and science teachers in both primary and secondary schools. The study was confined to the educational programmes of 21 science museums situated throughout the 50 American States.

9.3 SELECTING MUSEUMS FOR THE STUDY

The museums selected, Table 1, were chosen from those that had appointed at least one full time education administrator and were classified in the Museums Directory of the United States and Canada as 'Science Museums' or 'Children's and Junior Museums' (71).

This choice was influenced also, to some extent, by the geographic location of the museums as it was hoped to visit at least half of them during several annual study tours of the United States of America.

9.4 CONDUCTING THE STUDY

Four visits to the United States between 1966 and 1970 have enabled me to investigate, at first hand, 15 of the museums selected for this study.

In addition to personal visits and interviews with museum administrators information has been collected by the following three methods:-

1) sending out questionnaires (Appendices 2&3)
2) reading publications produced by the museums
3) reading books and articles relating to museum education.
## MUSEUMS SELECTED FOR THE STUDY

<table>
<thead>
<tr>
<th>Location</th>
<th>State</th>
<th>Name of Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>Maryland</td>
<td>Maryland Academy of Sciences</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>Michigan</td>
<td>Cranbrook Institute of Science</td>
</tr>
<tr>
<td>Boston *</td>
<td>Massachusetts</td>
<td>Museum of Science</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>Connecticut</td>
<td>Museum of Art, Science &amp; Industry</td>
</tr>
<tr>
<td>Brooklyn *</td>
<td>New York</td>
<td>Brooklyn Children's Museum</td>
</tr>
<tr>
<td>Buffalo *</td>
<td>New York</td>
<td>Buffalo Museum of Science</td>
</tr>
<tr>
<td>Charlotte *</td>
<td>North Carolina</td>
<td>Charlotte Children's Nature Museum</td>
</tr>
<tr>
<td>Chicago *</td>
<td>Illinois</td>
<td>Museum of Science &amp; Industry</td>
</tr>
<tr>
<td>Concord *</td>
<td>California</td>
<td>Diablo Valley College Science Centre</td>
</tr>
<tr>
<td>Fort Worth *</td>
<td>Texas</td>
<td>Fort Worth Children's Museum</td>
</tr>
<tr>
<td>Houston *</td>
<td>Texas</td>
<td>Houston Museum of Natural Science</td>
</tr>
<tr>
<td>Los Angeles *</td>
<td>California</td>
<td>California Museum of Science &amp; Industry</td>
</tr>
<tr>
<td>Morristown *</td>
<td>New Jersey</td>
<td>Morris Junior Museum</td>
</tr>
<tr>
<td>Newark *</td>
<td>New Jersey</td>
<td>The Newark Museum</td>
</tr>
<tr>
<td>Oak Ridge *</td>
<td>Tennessee</td>
<td>American Museum of Atomic Energy</td>
</tr>
<tr>
<td>Philadelphia *</td>
<td>Pennsylvania</td>
<td>The Franklin Institute Science Museum</td>
</tr>
<tr>
<td>Portland</td>
<td>Oregon</td>
<td>Oregon Museum of Science &amp; Industry</td>
</tr>
<tr>
<td>Rochester *</td>
<td>New York</td>
<td>Rochester Museum of Arts &amp; Sciences</td>
</tr>
<tr>
<td>St. Louis</td>
<td>Missouri</td>
<td>Museum of Science &amp; Natural History</td>
</tr>
<tr>
<td>San Jose *</td>
<td>California</td>
<td>Youth Science Institute</td>
</tr>
<tr>
<td>Washington</td>
<td>D. C.</td>
<td>The Smithsonian Institution</td>
</tr>
</tbody>
</table>

* Museums visited
9.5 THE SCOPE AND PURPOSE OF MUSEUM EDUCATION

The 1965 directory of the American Association of Museums listed over 5,000 museums in the United States, but only 80 of these were classified as 'Science Museums'.

A survey (72), carried out in 1963, of 2,000 American museums disclosed that 80% were executing formally organised educational or training programmes for children, adults, students, volunteer workers, and staff members. More than one third of these museums received their major support from local, state, or federal governments. In 1962, 600 museums large and small representing 50 states, reported a total of nearly 8 million school children participating in guided tours, classes or museum lectures during a single year. From these statistics it is evident that museum education is no small venture.

The building of new exhibits to teach and interpret scientific principles is one of the most actively pursued and closely studied activities in science museums at the present time. Technological expertise and artistry are being combined to devise the ingenious models and visual aids that can be found in nearly all of the major science museums.

The world's largest museum designed especially for children at Fort Worth, Texas, considers that its most important task is to be of service to the local school teachers, while the Brooklyn Childrens Museum wants to 'reach the interested student' and the Smithsonian Institution seeks to 'make children aware of learning about things in a museum'.

The Diablo Valley College Science Centre states its purpose as 'Aiding the teachers of the area to motivate students in science'.

A recent statement from the Rochester Museum of Arts and Sciences gives its purpose as: 'an extension of the classroom, a sort of 'school outside a school'..... a tremendous curriculum resource providing a never ending source of curriculum enrichment'.

The by-laws of the Youth Science Institute in San Jose, California, provided the following quotation. 'The specific and primary purpose for which the Institute was formed is to kindle interest and inspire young people to leadership in scientific endeavours and to provide the opportunities, guidance, material and human resources necessary to achieve this purpose'.
## TABLE 2
SIGNIFICANT DATES IN THE DEVELOPMENT OF EDUCATIONAL PROGRAMMES IN MUSEUMS

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>Year Administrative Position Established for Education</th>
<th>Year Educational Emphasis began</th>
<th>Year Museum was founded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>1963</td>
<td>1961</td>
<td>1797</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>1958</td>
<td>1930</td>
<td>1930</td>
</tr>
<tr>
<td>Boston</td>
<td>1947</td>
<td>1949</td>
<td>1830</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>1962</td>
<td>1958</td>
<td>1958</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>1899</td>
<td>1899</td>
<td>1899</td>
</tr>
<tr>
<td>Buffalo</td>
<td>1869</td>
<td>1862</td>
<td>1861</td>
</tr>
<tr>
<td>Charlotte</td>
<td>1964</td>
<td>1951</td>
<td>1947</td>
</tr>
<tr>
<td>Chicago</td>
<td>1933</td>
<td>1933</td>
<td>1933</td>
</tr>
<tr>
<td>Concord</td>
<td>1961</td>
<td>1961</td>
<td>1961</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>1953</td>
<td>1943</td>
<td>1939</td>
</tr>
<tr>
<td>Morristown</td>
<td>1958</td>
<td>1922</td>
<td>1913</td>
</tr>
<tr>
<td>Newark</td>
<td>1947</td>
<td>1909</td>
<td>1909</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>1956</td>
<td>1956</td>
<td>1949</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>1951</td>
<td>1957</td>
<td>1824</td>
</tr>
<tr>
<td>Portland</td>
<td>1958</td>
<td>1959</td>
<td>1944</td>
</tr>
<tr>
<td>Rochester</td>
<td>1926</td>
<td>1926</td>
<td>1912</td>
</tr>
<tr>
<td>St. Louis</td>
<td>1959</td>
<td>1959</td>
<td>1959</td>
</tr>
<tr>
<td>San Jose</td>
<td>1953</td>
<td>1953</td>
<td>1953</td>
</tr>
<tr>
<td>Washington</td>
<td>1958</td>
<td>1958</td>
<td>1846</td>
</tr>
</tbody>
</table>
From the charter of the Charlotte Childrens' Nature Museum, North Carolina comes a statement of their aim: 'to increase and diffuse among children a knowledge and appreciation of natural history; to bring about a better understanding of their places, their responsibilities and their duties in conserving the natural resources of their country and to supplement their normal school work to whatever extent may be practicable'.

SUMMARY

The consensus of opinion among museum education administrators seems to be that the primary purpose of the science museum is to supplement science education in the schools.

Table 2 shows some significant dates in the development of the museum educational programmes considered in this study.

9.6 PUBLICITY FOR MUSEUM EDUCATION

The major problem in the publicity field was not the preparation of advertising material but its distribution to subject teachers. The larger museums usually maintained a separate public relations staff who had the task of preparing the promotional material which frequently took the form of routine releases for newspapers and radio.

The distribution problem was tackled in several ways as shown in Table 3 below.

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of museums in the study using the method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addressing material to the Principal</td>
<td>18</td>
</tr>
<tr>
<td>Addressing material to individual teachers</td>
<td>12</td>
</tr>
<tr>
<td>Addressing material to the school</td>
<td>9</td>
</tr>
<tr>
<td>Personal contact with teachers</td>
<td>7</td>
</tr>
<tr>
<td>Distribution by School District</td>
<td>2</td>
</tr>
<tr>
<td>Distribution by School 'Museum Representatives'</td>
<td>3</td>
</tr>
</tbody>
</table>

Almost every museum kept some kind of mailing list for sending announcements directly to schools but found it impossible to keep an accurate list of individual teachers. Museum staff felt that promotional material addressed to the School or Principal usually failed to reach the classroom teachers for whom it was intended.
The Franklin Institute Science Museum believed that it had made some improvement in this situation by marking on the envelope the nature of the contents and for which grades it was intended.

In Rochester, the school district has co-operated by asking each Principal to appoint a 'museum representative' who will be responsible for receiving and distributing printed material from the museum.

In Boston the school district includes museums announcements within the pages of the official publications sent to every teacher.

9.7 MUSEUM RELATIONSHIP WITH NEWS MEDIA

Table 4 shows the use of news media by the various museums. Newspapers are the most frequently used medium, while only two museums averaged over fifteen hours of radio programming per month.

Several museums indicated that they were used frequently as resources for local radio and television stations.

The Fort Worth Museum is allowed to occupy ten minutes of the weekly programme 'Childrens Hour' that is produced by one of the local radio stations. This programme is estimated to reach a child audience of half a million.

The Franklin Institute was the only museum which employed a full-time person to produce radio and television programmes.

The Museum of Natural Science in Houston frequently has one of its staff giving a talk on a childrens early morning television programme. Figures 1 and 2, taken by the author from a television screen, show part of a programme describing the action of a camera.

9.8 PREPARATION FOR MUSEUM VISITS

The museums in this study tried a number of methods to impress teachers with the importance of preparing for visits both with regard to education and the general welfare of their students. These methods include brochures and suggestions for follow-up activities.

Some museums offer printed matter relating to the various exhibition sections. The Museum of Science and Industry in Chicago
## TABLE 4
USE OF NEWS MEDIA BY MUSEUMS (1968)

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>Average no. newspaper articles per month</th>
<th>Average hours of radio programming per month</th>
<th>Average hours of television programming per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>20</td>
<td>16 *</td>
<td>*</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>3</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Boston</td>
<td>14</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>4</td>
<td>1 *</td>
<td>0</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>11</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Buffalo</td>
<td>45</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Charlotte</td>
<td>15</td>
<td>*</td>
<td>+</td>
</tr>
<tr>
<td>Concord</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>6</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Houston</td>
<td>10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Morristown</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Newark</td>
<td>150</td>
<td>+</td>
<td>2.5</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>1</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>100</td>
<td>40</td>
<td>0.5</td>
</tr>
<tr>
<td>Portland</td>
<td>15</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Rochester</td>
<td>20</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>St. Louis</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>San Jose</td>
<td>4</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Washington</td>
<td>20</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* no data available
+ reported as 'occasional'
Figure 1  'CADET DON' introducing a staff member from the National Science Museum, Houston, to a child audience.

Figure 2  A close-up shot of a camera enabled the museum expert to show the children the figures around the lens mounting.
publish four such publications, entitled 'Handbook for Self-Guided Tours', one each for grades kindergarten to three, grades four to six, grades seven to eight and general groups. Those written for specific grades are designed around main topics in the Chicago school systems science and social studies curricula. A tour of approximately one hour is planned for each topic; a description of each exhibition section, with some suggested questions is included. Such guides are of considerable value in giving the teacher planning a visit some sense of direction in a museum which is overwhelming in its content.

The Cranbrook Institute of Science has tried a novel approach by making, and offering free, a 15 minute film entitled 'So you are going to visit the Institute'. Judging by the following comment from Doris McMillan, an Instructor at the Museum, it seems to be successful.

'Our film is in almost constant use and we feel it is very worthwhile....The children seem delighted to recognise in the museum things which they have previously seen in the film. In some cases, where even the teacher has not visited the museum before the field trip, the group has a much better idea of what they may expect to see'.

9.9 ORGANISED MUSEUM VISITS

Every museum education administrator encouraged teachers to bring their classes to the museum and use the exhibits both as a talking point and as a means to adding reality to the childrens science lessons. The Franklin Institute Science Museum, however, has encountered difficulty with this type of visit. This museum found it necessary to exclude the general public from the area being used by a class receiving instruction in order to reduce the number of distractions and give the teacher some degree of privacy. The reaction of the public was usually one of understanding but it did mean that any teacher using the museum was discouraged, by the museum, from giving lengthy lessons in any one section.

In order to avoid imposing limitations on teachers, ways and means are being sought to increase the use of museum classrooms so that the unique character of a museum lesson can be retained. Attempts are being made to mobilise the exhibits so that a museum classroom lesson can still be directly related to a specific exhibit.

Three museums avoided this particular difficulty by closing their display areas to the public every morning and reserving them for
teachers accompanying school parties; the public were re-admitted in the afternoons.

The most popular type of museum visit is the conducted tour. Table 5 lists the data that was available for school group attendance in 14 museums during 1967 and 1968. The figures reveal that the highest percentage of official school visitors came from the primary age group.

Fifteen museums provided guides for visiting classes. These guides were either members of the regular museum staff, volunteers, or university students. The organisation and training of such volunteer guides varied considerably with, I was told, corresponding degrees of success.

Without exception the museums considered in this study believed that the 'quick walk round' type of visit was of little educational value, but schools continued to request the larger museums to provide 'Cooks Tours'.

The Boston Museum of Science is in the course of adapting itself to the tendency of visitors to wander through sections of the museum chosen at random. The director, Mr. Bradford Washburn, stated 'we have now decided to make a formal and deliberate break away from the time honoured technique of systematic text-book type halls which have always been at the heart of science museum displays'. Mr. Washburn believes that the segregation of exhibits is unsound and is developing an integrated method of presentation that will attempt to clarify the inter-relationship between the sciences.

9.10 CLASSROOMS

Sixteen of the museums in this study have at least one classroom. They range from converted basement storerooms to comfortable teaching rooms equal to or better than those found in many schools. Fig. 3.

Table 6 shows the number of classrooms in each museum and indicates their average weekly use.

The Chicago Museum of Science and Industry has no classrooms but does possess several excellent lecture theatres which are used frequently for
<table>
<thead>
<tr>
<th>Museum location</th>
<th>No of students in school group</th>
<th>Total Museum Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K - 6</td>
<td></td>
</tr>
<tr>
<td>Boston</td>
<td>- -</td>
<td>149,197 158,237 - -</td>
</tr>
<tr>
<td>Buffalo</td>
<td>23,634 26,743</td>
<td>383,811 322,316 - -</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>2,228 8,000</td>
<td>47,300 49,800 - -</td>
</tr>
<tr>
<td>Charlotte</td>
<td>44,500 50,900</td>
<td>210,000 260,000 - -</td>
</tr>
<tr>
<td>Chicago</td>
<td>5,152 3,821</td>
<td>3,333,242 3,160,429 - -</td>
</tr>
<tr>
<td>Concord</td>
<td>8,000 200</td>
<td>35,200 38,000 179,000 -</td>
</tr>
<tr>
<td>Morristown</td>
<td>5,152 3,821</td>
<td>35,200 38,000 179,000 -</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>8,000 200</td>
<td>35,200 38,000 179,000 -</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>108,900 53,100</td>
<td>45,000 49,500 - -</td>
</tr>
<tr>
<td>Portland</td>
<td>- -</td>
<td>45,000 49,500 - -</td>
</tr>
<tr>
<td>Rochester</td>
<td>- -</td>
<td>37,740 43,828 - -</td>
</tr>
<tr>
<td>St. Louis</td>
<td>39,000 44,000</td>
<td>Very few - - 80,000 85,000</td>
</tr>
</tbody>
</table>

**TABLE 5**
SCHOOL GROUP ATTENDANCE

*Unspecified figures refer to museums that were unable to supply an analysis of children's attendance by grades.*
Figure 3  One of the small but comfortable classrooms in the Fortworth Children's Museum.

Figure 4  A lecture theatre in the Museum of Science and Industry, Chicago, used for presenting scientific demonstrations to children.
### TABLE 6
USE OF MUSEUM CLASSROOMS

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>Number of Classrooms in regular use</th>
<th>Average Hours Weekly Use Per Room (1969)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Summer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltimore</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>2</td>
<td>*</td>
</tr>
<tr>
<td>Boston</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>5</td>
<td>3 rooms 14 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 rooms 36 hours</td>
</tr>
<tr>
<td>Buffalo</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Charlotte</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Chicago</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Concord</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Houston</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Morristown</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Newark</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Portland</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rochester</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>St. Louis</td>
<td>3</td>
<td>1 - 2</td>
</tr>
<tr>
<td>San Jose</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Washington</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

* no data available
lectures or special demonstrations. Fig. 4.

In 1963 the Cranbrook Institute of Science opened a lecture room, seating 35 people, called 'The Atomarium' dealing exclusively with atomic and nuclear physics. This was followed in September, 1964 by a unique laboratory, 'Experiments in Physics'. The purpose of this laboratory is to focus children's attention on important physical principles by means of 36 carefully planned experiments which a child can perform himself by pressing buttons. Fig. 5. In addition to the experiments the room contains a demonstrations bench and a small reading area. All the experimental arrangements were designed using the philosophy that anything loose may disappear, parts not over strengthened may be broken by untrained hands and each experiment must always be in working order.

The Institute expects a minimum of 150,000 children to visit this laboratory each year.

The American Museum of Atomic Energy has a 'Participation Room' where young visitors can inspect exhibits designed to give information about the atomic energy programme and have a dime made radioactive as a souvenir.

Both the Boston Museum and the Fort Worth Museum have excellent libraries that are capable of serving children of all ages, including senior high school students. Fig. 6.

9.11 SPECIAL DEMONSTRATIONS

Museums sometimes offer special half hour demonstrations utilising equipment which is not readily available in the schools.

The Museum of Science, Boston, offers one such demonstration topic per school year, for school parties. Past topics have included, sound, air, and the laws of motion. Regular demonstrations are given also with the 2.5 million volt Van de Graff generator and unique closed circuit television system for enlarging micro-organisms nearly a billion times.

The Franklin Institute Science Museum offers about 12 similar demonstration topics throughout the year and helps teachers by preparing
Figure 5 Children performing an experiment in the Cranbrook Institute of Science. (Museum Photograph).

Figure 6 One corner of the library in the Fort Worth Children's Museum.
brief descriptions and suggested questions.

9.12 MUSEUM MEMBERSHIP PROGRAMMES

Several museums had direct contact with members of the public through their membership programmes.

The Charlotte museum offers workshops for children and adults and advertises its activities as 'suitable for people between the ages of 5 and 85'. They arrange 20 workshops and field trips each quarter which have the emphasis on natural history.

The Cranbrook Institute of Science organises a club designed to encourage boys and girls to pursue in depth their special interest in science. This club functions on Saturdays and during the school week in vacation time. Membership of the club provides free admission to the museum at all times.

Entire families are encouraged to join the Boston Museum at fees ranging from £15 for a family to £5 for a single person. Payment of this fee entitles family members to free admission, a Newsletter, use of the library service and discount in the shop.

The Fort Worth Museum actively encourages families to participate in varied programmes of activities. Tuition within the museum classes costs £1 per hour.

9.13 MUSEUM LOAN SCHEMES

The lending of exhibit material to schools was another educational service offered by eight of the museums. Table 7. The purpose of this activity is to permit a teacher to have in the classroom material which is directly connected with the topic being studied, and which a school cannot afford to acquire on a permanent basis. Most of the material, related to natural history.

The Newark Museum had the most extensive lending collection of the museums in this study, comprising over 10,000 items and administered by six full-time staff. Most of the items were designed to be handled and they ranged from stuffed birds, to a sundial or a model of Independence Hall.
TABLE 7

MUSEUM APPARATUS LENT TO SCHOOLS

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>Number of Items Lent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1967</td>
</tr>
<tr>
<td>Baltimore</td>
<td>1,091</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>0</td>
</tr>
<tr>
<td>Buffalo</td>
<td>11,050</td>
</tr>
<tr>
<td>Charlotte</td>
<td>205</td>
</tr>
<tr>
<td>Concord</td>
<td>50</td>
</tr>
<tr>
<td>Newark</td>
<td>40,969</td>
</tr>
<tr>
<td>Portland</td>
<td>154</td>
</tr>
<tr>
<td>Rochester</td>
<td>4,351</td>
</tr>
</tbody>
</table>

* no data available
A few museums maintained libraries of films and film strips for loan to schools. This service is offered to fill local needs when no nearby source of such visual aids is available. The Oregon Museum of Science and Industry, Portland, lend expensive science equipment such as incubators, microprojectors, and Geiger counters on a short-term basis.

Loan services such as these are generally free of charge, and when fees are required they are quite nominal. At the Newark Museum, the loan exhibits are delivered free to all Newark public schools. Teachers outside Newark pay one dollar a year to borrow materials, and have to provide their own transportation.

Two museums operate travelling units to provide demonstrations for schools whose students cannot readily visit the museum. The Atomic Energy Centre at Oakridge, Tennessee, has twelve of these units in operation throughout the country, co-ordinated by a central office at the museum. The programme which they offer is novel, in that the lecturer not only presents a 40 minute demonstration for each school, but is available also to meet with individual science classes throughout the day.

9.14 MUSEUM COURSES FOR CHILDREN

The purpose of these courses, most often mentioned by the museums, was to supplement the normal school curriculum. Pamphlets describing the courses showed that the subjects offered were consistent with this aim. Typical topics included were telescope construction, amateur radio and palaeontology.

Courses in the field of chemistry and physics were provided by some museums but were generally aimed at children who were too young to meet these subjects at school. For example, The Franklin Institute organised classes for children in grades 5-7 in the hope that they would get an opportunity to explore, and satisfy their curiosity. One such series of classes at the Franklin Institute entitled 'Introduction to.....' Chemistry (three levels), Physics (two levels), Electricity (two levels), Air and Weather, and Space Science were reported to be in great demand.82

ORGANISATION OF THE COURSE    The typical pattern for these courses
involved a 'workshop' activity. The education director of the Oregon Museum stated 'Classes are designed to let the students participate actively in the doing aspect of the subject rather than playing the passive role of a listener'.

Personal observation of several classes showed that the proportion of 'doing' to listening varied greatly from one museum to another.

ENROLLING FOR A COURSE Registration for courses was usually on a first come first served basis, no special qualifications were demanded except for the more advanced courses. In these cases students were expected to have taken the previous course. Table 8 shows the enrolment figures in 13 of the museums in this study.

There was no consistency in the fees charged.

EVALUATION OF COURSES As with most museum education programmes, evaluation was largely subjective. The fact that every museum offering courses reported that they were operating at full capacity is probably the best evidence of the need for this kind of activity. The Oregon Museum reported turning away several hundred prospective students.

Further evidence of students' interest was cited by The Franklin Institute Science Museum, which maintained cumulative records for each student. These indicated that thirty per cent of the students had taken more than one course, with some having enrolled for as many as eight over a period of years.

Evidence of the effect of these courses on students' educational goals and careers was largely lacking. However the Brooklyn Children's Museum, which has been offering such courses longer than any of the other museums (since 1902), observed that a considerable number of its students did pursue careers in science. Whether this indicates that the museum exerted any influence, or if these children took museum courses because they were already interested, cannot be shown.

9.15 MUSEUM PROGRAMMES FOR GIFTED STUDENTS

In recent years a number of museum activities have been directed specifically towards students who have shown high achievement levels in their science studies at school. These activities have been stimulated,
### TABLE 8

**STUDENT ENROLMENT IN MUSEUM CLASSES**

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>1967</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>600</td>
<td>*</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>147</td>
<td>143</td>
</tr>
<tr>
<td>Boston</td>
<td>1,402</td>
<td>1,678</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>592</td>
<td>2,115</td>
</tr>
<tr>
<td>Buffalo</td>
<td>*</td>
<td>699</td>
</tr>
<tr>
<td>Charlotte +</td>
<td>5,600</td>
<td>7,280</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>2,427</td>
<td>2,522</td>
</tr>
<tr>
<td>Morristown</td>
<td>210</td>
<td>220</td>
</tr>
<tr>
<td>Newark +</td>
<td>12,900</td>
<td>12,700</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>1,100</td>
<td>1,000</td>
</tr>
<tr>
<td>Portland</td>
<td>2,140</td>
<td>2,217</td>
</tr>
<tr>
<td>Rochester</td>
<td>1,564</td>
<td>1,712</td>
</tr>
<tr>
<td>St. Louis</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

* no data available

+ these figures represent the number of students attending rather than the number enrolled
in part, by the National Science Foundation's financial support of programmes for high ability secondary school students. The Museum of Science and Natural History, St. Louis, has an annual grant of $12,000 - 14,000 for this work. The purpose of some of these activities is best described by quoting directly from the museum's own publications:

To unite a talented high school student with a research scientist in a research team (Museum of Science and Natural History, St. Louis). To give high ability secondary school students an otherwise unavailable programme of intensive work and study which will include actual participation in scientific work. (Brooklyn Children's Museum). To bring together outstanding high school students and famous scientists to give students an insight into new knowledge and theory at a level seldom available to their age group. (Boston Science Museum).

Programmes of this type were generally directed towards students of high school age. In some cases, the recommendation of a teacher was the only requirement for entry. In others, usually the more extensive programmes, personal interviews and tests such as essays were required as well. The Museum of Science, Boston dropped their teacher recommendation after a few years as they realised that no teacher ever refused to sign the card presented by the prospective student. The process was not one of true selection.

The California Museum of Science and Industry and the Brooklyn Children's Museum offer summer courses ranging from four to eight weeks which are directed particularly towards gifted students. Topics in programmes of this length include, observational astronomy, electronics and biochemistry.

The Franklin Institute, The Maryland Academy of Science and the Boston Science Museum conduct seminars for selected High School students. These are held during the school year, either on Saturdays or after school hours. All three programmes involve a series of ten meetings for each group of students; topics included semi-conductors and solid state physics, physical aspects of astronomy, and modern in-organic structure. These programmes enabled also outstanding scientists to address large gatherings of school children.

Opportunities for gifted students to perform research under the guidance of scientists was made available by the museums at St. Louis.* Each student receives approximately $25.
and Los Angeles. The museums merely served as agencies to sift the applicants and place them in contact with scientists whose specialities matched the interests of the students.

In both cases the students were required to submit research papers to the museum at the completion of their projects, with a view to publication.

EVALUATION Probably a good indication of the effectiveness of these activities is the financial support from the National Science Foundation, which scrutinize very carefully any activity involving their funds. The interest shown by teachers and students, and some of the tangible results indicated by the student papers, also give evidence of the value of this type of activity. Table 9 summarizes the enrolment in programmes for gifted students offered by the museums in this study.

9.16 MUSEUM EDUCATION COURSES AND SERVICES FOR TEACHERS

A number of museums offer inservice courses for teachers, occasionally with college credit being given. The majority of these courses are directed towards teachers of the elementary grades, the feeling being that this group is likely to have the weakest background in science. The Museum of Science in Boston, for example, has offered 'Science Projects for Elementary Teachers' each year since 1950. The course meets once a month for eight months during the school year and is designed to give confidence to the non-science orientated teacher by featuring new teaching techniques and unusual classroom demonstrations. The museum usually has no difficulty filling the 108 places even though each meeting lasts 2 hours and the course costs $45.\(^{80}\) (This includes a $25 materials fee).

The Oregon Museum of Science and Industry holds inservice classes for elementary teachers of the Portland area and plans to extend them throughout the Oregon and South-West Washington areas at the request of the school districts. This Museum sponsors also monthly field trips for school teachers. The purpose of these trips is to enrich the teachers' scientific knowledge by giving them industrial experiences.

Courses for teachers at other grades are also offered, the most common subject being astronomy. The emphasis is always on aiding the teacher to present the subject matter effectively.
TABLE 9

ENROLMENT IN MUSEUM PROGRAMMES ORGANISED FOR GIFTED STUDENTS

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>1967</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>x 570</td>
<td>*</td>
</tr>
<tr>
<td>Boston</td>
<td>41</td>
<td>37</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Buffalo</td>
<td>666</td>
<td>623</td>
</tr>
<tr>
<td>Charlotte</td>
<td>240</td>
<td>160</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>35</td>
<td>*</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>x 1,000</td>
<td>*</td>
</tr>
<tr>
<td>Portland</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>St. Louis</td>
<td>75</td>
<td>50</td>
</tr>
</tbody>
</table>

x includes attendance at seminars
* no data available
TABLE 10

ENROLMENT IN MUSEUM PROGRAMMES ORGANISED FOR TEACHERS

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>1964</th>
<th>1967</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloomfield Hills</td>
<td>140</td>
<td>35</td>
<td>73</td>
</tr>
<tr>
<td>Boston</td>
<td>79</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>80</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Charlotte</td>
<td>90</td>
<td>62</td>
<td>*</td>
</tr>
<tr>
<td>Portland</td>
<td></td>
<td>155</td>
<td>169</td>
</tr>
<tr>
<td>Rochester</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>St. Louis</td>
<td>-</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Baltimore</td>
<td>400</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>800</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>200</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Washington</td>
<td>50</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

* no data available
Several different types of one day programmes were provided for teachers by the museums in this study. The purposes of these programmes includes acquainting teachers with new developments in science curricula, updating their knowledge and showing them methods for improving science instruction in the classroom.

The Oregon Museum of Science and Industry organises a membership scheme for elementary and junior high teachers at a cost of $7.50 per year. This membership entitles teachers to free admission, participation in field trips and the chance to receive 'Membership Packets'. These packets contain useful information on teaching science, scientific publications and drawings for making simple equipment.

Table 10 lists enrolment figures for teachers courses organised by museums in this study.

9.17 SUMMARY AND CONCLUSIONS

SUMMARY OF FINDINGS

The following are seen as major findings in this study:

(1) Scope and purpose of museum education. The purpose stated most often by these museums was that they offered their educational programmes as a supplement to science education in the schools. The museums indicated consistently that local needs determined what types of programmes they offered. In some cases these needs were observed and acted upon by the museums themselves. In other, needs were made known to the museums by the schools and colleges in their communities.

(2) Administration. Sixteen out of eighteen museum education administrators in this study had had classroom teaching experience before entering the museum profession. Five had had close contact with museums during their years as a teacher. (Appendix 1)

(3) Physical facilities. The museums utilized both exhibit areas and classrooms for their educational activities. Classrooms varied in number from zero to fourteen, and average hours weekly use ranged from zero (either during the school year or in the summer, but not both) to 40. These rooms generally were well supplied with both laboratory and visual aid equipment.
Public relations. Various methods were used by the museums to inform the schools and general public of educational activities. Mailed announcements to principals were used by 18 museums. Twelve addressed announcements to individual teachers, while in only two cases did the school districts distribute them directly. Relations with news media depended on local circumstances.

Museum education activities. The most common educational activity found in these museums was the class visit, which sometimes involved a lesson on a specific topic. The highest percentage of official school student visitors came from the primary age group. Many types of courses were offered, both for students in general as well as those considered to be particularly gifted. Annual enrolment in these courses ranged from 30 to over 2,000. Programmes for teachers were also conducted, with annual participation ranging from 50 to 800. A variety of other educational activities was found, dependent largely upon what services the museum education staffs felt were needed in their particular communities. Methods of evaluating the effectiveness of these various activities were almost nonexistent.

CONCLUSIONS

The only evaluation which the museums had made of their educational activities was through attendance figures and the accomplishments of a few individual students. It was felt generally by the museums that acceptance and demand of these educational programmes implied that they were accomplishing their purpose. While success in terms of attendance may be indicative of success in achieving purpose, it cannot be construed as an adequate measure of effectiveness. Other methods are necessary.

None of the museums could cite any specific improvements which they had effected in the overall teaching of science within the schools. A number of them, however, had developed unique ways of presenting certain limited topical areas, either through exhibits or special demonstrations.

It was evident that many of the latest exhibits had been designed more as educational devices than as simple displays. The complexity and cost of these exhibits placed most of them (as well as equipment for many of the special demonstrations) beyond the means of the usual school.
Consequently, the museums are performing a useful supplementary service by making them available to teachers and students.

Reports of students being turned away from museum courses for lack of facilities were not uncommon. This, perhaps, implies that financial support to provide space for museum education activities is not always adequate, and in fact a few museum education administrators stated that they felt their programmes were limited by lack of funds.

Finally, it can be concluded that the museums studied are making a significant contribution to the teaching of physical science, at least insofar as is indicated by the demand and response of the schools and students. Through their variety of programmes the museums are making available to school children and teachers a large number of science activities which so far, at least, have not been offered by the schools themselves.
### Appendix 1

#### Backgrounds of Museum Education Administrators

<table>
<thead>
<tr>
<th>Museum Location</th>
<th>Field of Study</th>
<th>Years of Classroom Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>Business Adm.</td>
<td>12</td>
</tr>
<tr>
<td>Bloomfield Hills</td>
<td>Geology</td>
<td>5</td>
</tr>
<tr>
<td>Boston</td>
<td>Zoology</td>
<td>7</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>Education</td>
<td>6</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>History</td>
<td>2</td>
</tr>
<tr>
<td>Buffalo</td>
<td>Anthropology</td>
<td>0</td>
</tr>
<tr>
<td>Charlotte</td>
<td>Botany</td>
<td>2</td>
</tr>
<tr>
<td>Concord</td>
<td>Biology</td>
<td>0</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>Child Devp.</td>
<td>26</td>
</tr>
<tr>
<td>Morristown</td>
<td>Art</td>
<td>1</td>
</tr>
<tr>
<td>Newark</td>
<td>Fine Arts</td>
<td>1</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>Educ. Supv.</td>
<td>9</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>Educ. Adm.</td>
<td>4</td>
</tr>
<tr>
<td>Portland</td>
<td>Education</td>
<td>6</td>
</tr>
<tr>
<td>Rochester</td>
<td>Home Econ.</td>
<td>4</td>
</tr>
<tr>
<td>St. Louis</td>
<td>Botany</td>
<td>3</td>
</tr>
<tr>
<td>San Jose</td>
<td>Zoology</td>
<td>10</td>
</tr>
<tr>
<td>Washington</td>
<td>Early American Culture</td>
<td>6</td>
</tr>
</tbody>
</table>
Private Investigation by G.C. Sneed into Educational Facilities provided by American Science Museums

Please complete and return this questionnaire to:

G.C. Sneed,
University of Surrey,
Institute for Educational Technology,
Guildford,
Surrey, England.

NAME OF MUSEUM ________________________________

1. Please give the following dates and information

<table>
<thead>
<tr>
<th>Year Administrative Position established for education.</th>
<th>Administrator's Specialist Field.</th>
<th>Approximate Year Educational Emphasis began</th>
<th>Year Museum Founded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Please state the number of teachers that enrolled for the educational programmes your museums provided especially for teachers during:

1967   [ ]
1968   [ ]

Please indicate, if possible, how many of these teachers taught science:

3. Please state the number of students that enrolled for any special programmes you provided for 'gifted' science students during:

1967   [ ]
1968   [ ]

4. Please state the total number of students that enrolled for your museum classes during:

1967   [ ]
1968   [ ]
5. Please state the number of children attending your museum in official school groups during 1967 and 1968 in grades K-6 and 7-12.

<table>
<thead>
<tr>
<th>Grades</th>
<th>K - 6</th>
<th>7 - 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please state the total number of your museum visitors, for the same years, in the boxes below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td></td>
</tr>
</tbody>
</table>

6. Please complete the following table showing the Utilisation of Museum Classrooms:

<table>
<thead>
<tr>
<th>Number of classrooms in regular use</th>
<th>Average hours weekly use per room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer</td>
</tr>
<tr>
<td></td>
<td>School Year</td>
</tr>
</tbody>
</table>

7. Please state the number of pieces of equipment or apparatus your museum lent to schools during:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td></td>
</tr>
</tbody>
</table>

Please indicate the kind of apparatus that you could provide relevant to lessons in physics or applied science (technology).
Please complete this questionnaire, by placing ticks or information in the appropriate boxes, and return it to:

G.C. Sneed,
Director,
Shell School Technology Programme,
University of Surrey,
Guildford,
Surrey, England.

NAME OF MUSEUM

1. PUBLICITY

a) Does your museum employ any public relations staff? 
   YES  NO

   If YES please outline their duties.

b) Does your museum engage in any educational radio or TV activities?
   YES  NO

   If YES please elaborate and indicate if you have a full time member of staff for this purpose.

Then
1) State the average number of hours of radio programming per month. 
2) State the average number of hours of TV programming per month.

   YES  NO

c) Do you try to get the work of the museum described by the local newspapers?

   YES  NO

Please state the average number of newspaper articles per month, that relate to the museum.
d) Does your museum produce promotional material or notices describing forthcoming educational activities?  

- YES -  
- NO -  

If YES, are such notices sent direct to  
Teachers by name  
Teachers by title  
Schools by name (not a person)  
Principals  

OR by  
Personal contact with teachers  
Distribution by School Districts  
Distribution by School 'Museum Representatives'  

e) Does your museum try to keep some form of updated educational mailing list?  

- YES -  
- NO -  

f) Do you think these systems of distribution are successful?  
Please comment.  

______________________________________________________________________  
______________________________________________________________________  
______________________________________________________________________  

2. PREPARATION FOR A MUSEUM VISIT  

a) Please state what means you have for informing schools and teachers about the educational services offered by your museum.  

______________________________________________________________________  
______________________________________________________________________  
______________________________________________________________________  

b) Do you operate any form of museum membership programme for:  
Adults  
Families  
Children  
Teachers  
If YES please send me details.  

- YES -  
- NO -  

c) Do teachers receive a special admission rate to the museum?  

- YES -  
- NO -  

If YES is it free?  


d) Do you encourage teachers to make a preliminary visit to the museum before bringing a party of children?  


3. MUSEUM VISITS

a) Does your museum permit the "Cook's Tour" (no specific purpose) type of visit?  


If YES do you expect the school concerned to provide their own guide?  


IN EITHER CASE  
Do you consider that this type of visit has any real educational value?  

CONSIDERABLE □  VERY LITTLE □  NONE □

b) Does your museum provide an official guide service?  


If YES are the guides:  

PROFESSIONAL □  VOLUNTEERS □  OTHERS □

Are the 'Volunteers' and 'Others' given any training?  


c) Does your museum provide any printed material describing the exhibits?  


If YES,  
1) Do the visitors have to buy the material?  


2) Does any of this material reach schools before they make a visit?  


Please elaborate:
d) Are special demonstrations provided other than those connected with the exhibits?  

If YES, how often: ____________________________

Please describe briefly the nature of these demonstrations: ____________________________

4. **EDUCATIONAL SERVICES**

a) Does your museum operate a loan scheme whereby schools can borrow exhibition material?  

If YES please send me details.

b) Does the museum provide any courses for children?  

If YES please send me details.

c) Does your museum provide special programmes for gifted students?  

If YES please send me details.

d) Does the museum provide any courses for teachers?  

If YES please send me details.

THANK YOU
AIM

To identify and examine the factors that influence young boys and girls to study technology at University level.
CHAPTER 10

AN INVESTIGATION INTO THE TEACHING OF TECHNOLOGY IN
JAPANESE SECONDARY SCHOOLS

10.1 AIM

To identify and examine the factors that influence young boys and girls to study technology at University level.

10.2 THE JAPANESE EDUCATIONAL SYSTEM

At the conclusion of the second world war the principal aim of the Japanese with regard to education was the expansion of secondary and higher education. They reorganised their pre-war educational pattern on the American system and it became known by the numbers 6, 3, 3, 4. This means that children from the age of six attend an elementary school for six years (which for some children is preceded by a short pre-school period in a kindergarten) followed by three years in a junior secondary school. After this some continue for a further three years in an upper secondary school, and of these those who have the ability proceed to a university for a further four years. Although only the first nine years of this programme are compulsory - that is to the age of 15 - over 70% of Japanese children now stay on at school to around the age of 18. Of these some 16% go on to Junior Colleges or Universities (Table 1).83

Under the new educational system opportunities have been provided for pupils with ability to advance to the higher places of learning by expanding the scholarship system. According to a survey taken in 1963 by the scholarship giving organisations a total of 1,625 organisations were found to be providing scholarships to under-privileged students. The biggest of these organisations the Nippon Ikuei Kai (Japanese Scholarship Society) was established by a special law and loaned out the equivalent of £14 million to some 300,000 students in 1966. This Society estimates that at the present time 1 in every 27 high school students, 1 of every 5 university students and 1 out of every 3 post-graduate students are holding awards from the scholarship funds of Japan.84

The national budget for the fiscal year 1967 allocated a total of the equivalent of £620 million - approximately 12-13% of the budget general account - for education and the promotion of science and
### TABLE 1
THE PERCENTAGE OF AGE GROUPS ENROLLED IN VARIOUS LEVELS OF EDUCATION

<table>
<thead>
<tr>
<th>Type of Education</th>
<th>Age Range</th>
<th>Percentage of Age Group Enrolled</th>
<th>1960</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>6-15</td>
<td></td>
<td>99.8</td>
<td>99.9</td>
</tr>
<tr>
<td>Upper Secondary</td>
<td>15-18</td>
<td></td>
<td>55.8</td>
<td>74.7</td>
</tr>
<tr>
<td>Higher *</td>
<td>18-21</td>
<td></td>
<td>9.7</td>
<td>16.0</td>
</tr>
</tbody>
</table>

* Junior Colleges - provide upper secondary school graduates with two or three year courses

Universities - provide four year undergraduate courses and facilities for postgraduate studies.
## TABLE 2
JUNIOR SECONDARY SCHOOL CURRICULUM REQUIREMENTS

### COMPELLARY SUBJECITS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of Hours Each Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Year</strong></td>
<td></td>
</tr>
<tr>
<td>Japanese Language</td>
<td>5</td>
</tr>
<tr>
<td>Social Studies</td>
<td>4</td>
</tr>
<tr>
<td>Mathematics</td>
<td>4</td>
</tr>
<tr>
<td>Science</td>
<td>4</td>
</tr>
<tr>
<td>Music</td>
<td>2</td>
</tr>
<tr>
<td>Fine Arts</td>
<td>2</td>
</tr>
<tr>
<td>Physical Education</td>
<td>3</td>
</tr>
<tr>
<td>Industrial Arts, Homemaking</td>
<td>3</td>
</tr>
</tbody>
</table>

### ELECTIVE SUBJECTS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of Hours Each Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Year</strong></td>
<td></td>
</tr>
<tr>
<td>Foreign Language</td>
<td>3</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2</td>
</tr>
<tr>
<td>Trades &amp; Industries</td>
<td>2</td>
</tr>
<tr>
<td>Business</td>
<td>2</td>
</tr>
<tr>
<td>Fishery</td>
<td>2</td>
</tr>
<tr>
<td>Homemaking</td>
<td>2</td>
</tr>
<tr>
<td>Mathematics</td>
<td>-</td>
</tr>
<tr>
<td>Music</td>
<td>1</td>
</tr>
<tr>
<td>Fine Arts</td>
<td>1</td>
</tr>
</tbody>
</table>

3 hours each week are spent on elective subjects made up either as a foreign language or from two other subjects totalling 3 hours of instruction.
At the junior secondary school level I studied very carefully the aim and contents of a subject called 'Industrial Arts' which was introduced into the curriculum in 1962. The aim of this subject is to keep the curriculum abreast of the rapid post-war developments that have taken place in Japanese science and technology. Industrial Arts is compulsory for all boys throughout their three year stay in the junior secondary school and is taken while the girls are studying a subject called 'Home Making'. Three hours each week are devoted to Industrial Arts - which is based on the workshop, Figure 1 - during which time it is hoped to give each boy the chance of gaining some basic technical knowledge and also to help him form a mental attitude towards modern life in which technology plays a major role.

For the first two years the boys are given instruction and practice in the use of hand tools - for wood and metal - together with lessons in technical drawing, design, elementary mechanics and horticulture, with the introduction at the beginning of the second year of simple power tools. In the third year one-third of the available time is spent on further practice with tools, while the remaining time is devoted to instruction in the mechanics of the internal combustion engine and electricity as applied to radios, motors, heating and lighting.

One school that I visited had several small motor-cycle engines available for the boys in the third year to dismantle in addition to a number of home-made demonstration units for teaching the function of the various parts. However, I understand that this was an exceptional school with regard to equipment but still had great difficulty in finding suitable teachers for the subject. The standard of equipment in each school that I visited varied both in quality and quantity.

The junior secondary school provides also a vocational elective subject known as Trade and Industry; but this subject is not very popular at the moment. The vast majority of children choose either additional mathematics or foreign languages from the electives available (TABLE 2) because they want to enter a university. During visits to two junior secondary schools I looked at the science

* Kojimachi School, Tokyo
+ Hitotsubashi, Imagawa, Kojimachi
@@ Imagawa
Fig. 1. The workshop in the Kojimachi Junior Secondary School that is used for lessons in the subject, Industrial Arts.

Fig. 2. A science laboratory in the Kojimachi Junior Secondary School.
### TABLE 3

PERCENTAGE OF JUNIOR SECONDARY SCHOOL GRADUATES
PROCEEDING TO UPPER SECONDARY SCHOOLS OR TECHNICAL COLLEGES (1969)

<table>
<thead>
<tr>
<th></th>
<th>Boys &amp; Girls</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior Secondary School Graduates</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>(1,737,000)</td>
<td>(886,000)</td>
<td>(851,000)</td>
<td></td>
</tr>
<tr>
<td>Percentage who applied to upper</td>
<td>81.6</td>
<td>81.9</td>
<td>81.2</td>
</tr>
<tr>
<td>secondary schools or technical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>colleges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of successful applicants</td>
<td>79.4</td>
<td>79.2</td>
<td>79.5</td>
</tr>
</tbody>
</table>
Fig. 3. The front of the physics laboratory in the Tamagawa Upper Secondary School.

Fig. 4. The back of the physics laboratory in the Tamagawa Upper Secondary School showing the students tables and the apparatus cupboards.
laboratories and found them to be rather short of apparatus for class experiments and demonstrations, although I did see some interesting sectioned working models of diesel engines and turbines. I was told by the science teachers that the emphasis was placed on the theory and very little practical work in physics, if any, was undertaken by the students. (Figure 2)

In order to help children gain some ideas about their future career they assemble by form each week in their home room where teachers talk to them and a number of small career booklets are available for them to read. With regard to future high level engineers, it seems that the Industrial Arts course is not considered as guidance for this profession although it may have some small effect. Generally, any boy with ability who wishes to become a top level engineer - and there are many - is immediately recommended to proceed to the academic secondary high school and then to attempt to gain a place at a university. The less able boys who wish to consider some aspect of engineering as a career are recommended to attend a three year technical high school where they can qualify as a technician.

10.4 ADMISSION TO UPPER SECONDARY SCHOOLS & TECHNICAL COLLEGES

All the children who have graduated from junior secondary schools are entitled to apply for admission to upper secondary schools or technical colleges. Due to lack of places, all graduates of junior secondary schools may not be admitted. Admission is usually obtained on a competitive basis.

Table 3 shows the percentage of junior school graduates proceeding to upper secondary schools or technical colleges in 1969.83

10.5 THE UPPER SECONDARY SCHOOL

ACADEMIC When I visited an academic secondary high school+I found that there was no 'Industrial Arts' in the time-table and that all the effort was devoted to preparing boys for the very difficult university entrance examinations. No technology is taught in these schools and the physics laboratories that I saw seemed more like ordinary classrooms. (Fig. 3 & 4) There was very little of the normal school laboratory equipment available and mains services to students' benches was either minimal or non-existent. However, I

+ Tamagawa, Tamagawa Gakuenmae
did see more facilities for practical work in the chemistry and biology laboratories.

Upon talking through interpreters, to science teachers and the Government school inspectors responsible for upper secondary science education I learnt that it was customary, although not considered ideal, to reduce practical work to almost nil and concentrate on the theory. The reason for this policy by the school teachers was that the entry examinations to the university were extremely difficult and entirely theoretical. The results of these examinations are vital not only to the students taking them, but are also very important to the schools providing the preparation. The reputation of a school and its staff in Japan hinges on how many boys succeed in gaining places at the better universities.

**TECHNICAL**  I visited the Karasuyama Technical High School which was one of the new technical high schools established by Tokyo City to help counteract the shortage of high grade technicians in Japan. This particular school was founded in 1959 and is one of ten similar new technical high schools in Tokyo which make up the total of 27 such public schools within the City. (There are also 20 private schools of the same type). These schools accept boys leaving the junior high schools and offer them a normal secondary high school curriculum containing languages, mathematics, social studies, etc., for 23 hours a week, with the remaining eleven hours devoted to professional training in mechanics, electricity or electronics. I was told that the mechanics course was the most popular as the boys feel that this offers the best preparation for the jobs awaiting them in Industry.

The workshops at the school were large and well equipped with machine tools, welding apparatus and casting facilities while the laboratories enabled both theoretical and practical work to be undertaken (Fig. 5). Much of the apparatus used for teaching was full size although some small scale electrical equipment has been installed.

At the conclusion of the three year course this school aims to have given every student a thorough grounding in workshop practice, electricity and electronics, provided them with the chance to become familiar with industrial equipment, and also to have helped them to

* Mr. Ohashi and Mr. Ito
Fig. 5(a) A spot welder in the workshops of the Karasuyama Technical High School.

Fig. 5(b) One of the laboratories in the Karasuyama Technical High School. This one is used for teaching the basic principles of electrical engineering.
acquire a respect for the manual worker.

10.6 TECHNICAL COLLEGES

Technical Colleges came into existence in 1962 for the purpose of training the large number of high grade technicians that were required by industry. These Colleges provide a five year course the successful completion of which entitles the candidate to apply for a place in the upper part of a university, but the Ministry of Education say very few make such an application.

Table 4 gives data concerning the number of technical colleges and student enrolment.

10.7 UNIVERSITY ENTRY

At the present time there are nearly 400 universities in Japan. Table 5 shows the number of universities in each of three categories for the year 1969.

The State universities expect their students to qualify for entry by passing examinations in the following subjects: mathematics, general science (this means one of several sciences), social studies, Japanese language, and English language, irrespective of which faculty they may wish to enter. In the case of students attempting to enter a faculty of technology, physics and chemistry are compulsory (no choice of a science is allowed) and are weighted, together with mathematics in relation to the other subjects.

Table 6 shows that Technology is the second most popular course being studied within Japanese Universities.

Parents and teachers help boys and girls to realise that the 'name' or 'reputation' of the university that they attend decides the kind of Company in which they can hope to find employment at the completion of their four year technology course. It is for this reason that the competition is so keen for the places at the leading universities and why these universities are making the entrance examination more and more difficult. Japanese people talk about the two wars still raging in peaceful Japan, one of these is the traffic war (10,000 annual deaths on the roads) and the other is the fight for success in entrance examinations.
TABLE 4

NUMBER OF TECHNICAL COLLEGES AND STUDENT ENROLMENT FIGURES.

<table>
<thead>
<tr>
<th>Type of College</th>
<th>Number in Existence</th>
<th>Student Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
<td>1969</td>
</tr>
<tr>
<td>National</td>
<td>43</td>
<td>49</td>
</tr>
<tr>
<td>Public</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Private</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
TABLE 5

NUMBER OF UNIVERSITIES IN JAPAN
OFFERING UNDERGRADUATE COURSES*

<table>
<thead>
<tr>
<th>Type of University</th>
<th>Number of Universities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
</tr>
<tr>
<td>National</td>
<td>73</td>
</tr>
<tr>
<td>Public</td>
<td>35</td>
</tr>
<tr>
<td>Private</td>
<td>209</td>
</tr>
<tr>
<td>Total</td>
<td>317</td>
</tr>
</tbody>
</table>

National Universities are established by the State
Public Universities are established by local authorities
Private Universities are established by private foundations.

* Data provided by the Ministry of Education, Japan.
<table>
<thead>
<tr>
<th>Course</th>
<th>Percentage of Students Studying the Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>41.0</td>
</tr>
<tr>
<td>Technology</td>
<td>19.5</td>
</tr>
<tr>
<td>Humanities</td>
<td>15.5</td>
</tr>
<tr>
<td>Education</td>
<td>6.4</td>
</tr>
<tr>
<td>Agriculture</td>
<td>4.0</td>
</tr>
<tr>
<td>Medicine</td>
<td>4.0</td>
</tr>
<tr>
<td>Science</td>
<td>3.0</td>
</tr>
<tr>
<td>Home Economics</td>
<td>1.5</td>
</tr>
<tr>
<td>Other Courses</td>
<td>5.1</td>
</tr>
</tbody>
</table>

* Data provided by the Ministry of Education, Japan*
As can be expected, many students each year fail to gain entry to the university of their choice and so on leaving the academic secondary school they enter special preparatory schools to continue their studies until retaking, they hope with success, the university entrance examination the following year. There are approximately 200000 students filling the places in these schools, many of whom will re-sit the university entrance examination two, three or even more times (Table 7).

Education is not free at State universities even though it is much cheaper than at the private university. I was told that the cost of entry to a private university could be as much as the equivalent of £400 with the additional fees each year. Many parents make great sacrifices to give their children the benefits arising from a university education.

Tuition fees per annum

<table>
<thead>
<tr>
<th>National University Undergraduate</th>
<th>£14.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Technical College</td>
<td>£11.60</td>
</tr>
</tbody>
</table>

10.8 OBTAINING A PROFESSIONAL APPOINTMENT

Towards the end of their university course students do not apply for an engineering appointment in response to an advertisement by the large Companies, but wait to be invited. A powerful and popular State owned organisation, such as the Japanese National Railways or a private company, such as 'Shell' invite the professors of engineering at a number of leading universities to select four or five students whom they can fully recommend to sit their Company's entrance examination. The selected group of students then attend at the Company's offices for perhaps as long as a week, during which time they are required to take written examinations in engineering as well as in general culture and languages, followed by a series of interviews. On the result of these examinations and interviews the Company selects the small number of new engineers it wishes to employ. The success rate for these selected examinations may be only 1 in 6 or 8. From this employment pattern it is quite clear that unless a student attends a good university and makes a success of the course it is quite impossible for him to gain employment as a graduate engineer with one of the leading Japanese industrial organisations.
TABLE 7

NUMBER OF STUDENTS ADVANCING TO HIGHER EDUCATION (1969)*

<table>
<thead>
<tr>
<th>Number of applicants for admission to Higher Education</th>
<th>Total</th>
<th>Upper Secondary Graduates of 1969</th>
<th>Upper Secondary Graduates of 1968 or before</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>706,189</td>
<td>502,951</td>
<td>203,238</td>
</tr>
<tr>
<td></td>
<td>464,797</td>
<td>339,147</td>
<td>125,650</td>
</tr>
</tbody>
</table>

* Data provided by the Ministry of Education, Japan.
It is no good a student adopting the view that he will start with a small organisation and then transfer to one of the more famous concerns when he has gained experience, for it is still quite common for staff to spend their entire working lives with one Company. The reputation acquired by an engineer with a Company seems to be more important than his reputation within the profession. The public judge an engineer, I was informed, by his position in a specific Company, because this will immediately reveal his background and his worth.

10.9 THE STATUS OF THE ENGINEER

During my stay in Japan I was granted an interview with Professor Numera, who is head of the educational section of the Japanese Society of Mechanical Engineers. Through an interpreter the Professor told me that Japanese Companies employ more technologists than scientists and that this employment policy is reflected in the applications to the various faculties of the university. He did not think that boys reasoned that by becoming technologists they would immediately have a better chance of a job and a safer career, although such feeling is held now by many members of the general public. The Professor did not consider that Japanese boys and girls in upper secondary schools really appreciated the content of a university technology degree course or fully grasped the work of a technologist - he wished they did - but felt that there was a 'mood' in Japan which gave technologists a high social status and a position of respect. The Professor also told me that 30% of top level industrial management now was filled by men with an engineering background.

I was also able to spend considerable time talking with the Managing Director of J.N.R. (Japanese National Railways), who confirmed for me that boys at school have very little understanding of technology. He told me also that 10 - 15 years ago the majority of them wanted to be business men. He believed that the reason for the change was due to the developments in Japanese technology that have occurred, thus creating a feeling that the technologist is a very important person and necessary for the economy. He also expressed the view that boys realise - perhaps with the help of their parents - that a good education is essential for getting a good job in industry and that higher salaries are available for university
graduates.

This high status of the technologist again was made clear to me while I was watching a Japanese T.V. programme. With the help of an interpreter I was able to follow the remarks being made by a panel of young people, about 20 years of age, when questioned about their views on everyday matters. When a question was asked concerning the kind of husband they wanted, the young ladies were quick to nominate technologists, doctors, and lawyers as being the most eligible.

When I visited Tamagawa University I was invited by the Professor of English to address his final year English class. While he was introducing me to them, in Japanese, I was suddenly aware of being regarded as the centre of attraction by the young ladies in the group. The Professor explained to me that this spontaneous reaction was due to the fact that he had said that I was a bachelor and concerned with engineering.

An Emeritus Professor of Engineering from Ibaraki University with whom I had a long interview also expressed the view that the popularity of engineering among young students was due to the status and the challenge offered by the very high academic standards demanded in order to gain entry to any university engineering department. This Professor also told me that some universities are now offering a general first-year to the technology degree course so that boys and girls may defer their choice of specialisation until the second year; but the majority of universities still begin their specialist instruction as soon as their students start the four year course.

10.10 THE POSSIBILITY OF INTRODUCING TECHNOLOGY INTO THE SCHOOLS

When I visited the Ministry of Education in Tokyo and talked through interpreters with several inspectors concerned with scientific education* I learnt that a group of people within the Ministry are at present busy examining the existing educational system with the idea of modifying it and incorporating all the latest ideas that have been evolved and tested in other parts of the world. Methods which encourage teachers to incorporate more practical and experimental work into school science lessons -

* Mr. Muchizuki and staff.
especially physics - are receiving considerable attention. Also the idea of introducing some kind of pre-university technology course into both the upper and lower high school curriculums is thought to be a worth while and much needed addition. It seems very likely that in years to come the Japanese Educational system will include provision for teaching school physics more on English or American lines, together with the inclusion of technology for the more able students in the academic high schools.

With the knowledge that Japanese educators were at least interested in the idea of providing technology courses in the academic secondary upper high schools I visited a leading Japanese manufacturer of school science apparatus to see if this company would be able to supply suitable equipment, or whether new apparatus would have to be designed and built. From the conversation I had with an English speaking salesman, and from what I saw in the catalogues I formed the opinion that there was no technology equipment at present built especially for experimental work in the schools, but that in the event of the Japanese Government making technology a standard school subject then the company very quickly would design and build whatever apparatus was needed. The possibility of Japan importing any equipment for use in school technology programmes seemed very unlikely.

10.11 INDUSTRY AND THE SCHOOLS

While I was visiting the Ministry of Education I made enquiries concerning any links between Industry and the schools. I was told that on the whole Industrial companies did not give much help to the schools, but one notable exception was the Honda Motor Company who had given a large number of motor cycles for demonstration and dismantling. I learnt also that it was not customary for Industry to pass on to schools any unserviceable or out-dated equipment. Some Industrial organisations however did give prizes to schools so that they could buy either books or some additional apparatus for science teaching.

By having some pamphlets translated I discovered that the Honda Motor Company had established an engine school for the benefit of students attending either a junior or academic upper secondary school. In practice however it seemed that the majority of the students attending came from the junior secondary schools. This

*Shimazu Manufacturing Co. Ltd., Tokyo
engine school was created because the Company realised that very little practical work was done in the schools and that in a few years time these students would be potential customers for the Company's products. By offering these courses the Company hoped to supplement work undertaken in the state schools syllabus and indirectly familiarise students with the Company's motor cycles. With the help of the Shell Petroleum Company I obtained an invitation to attend the Honda engine school - situated in the suburbs of Tokyo - and observe one of the courses in progress. The room in which the lecture course was given was tiered and large enough to accommodate comfortably 200 students (Fig. 6). The Company had supplied 100 special engines so that every two students could share one engine between them. This special engine was designed and built solely for these courses and was an extremely neat and efficient power unit. The lecture course lasted either 90 or 120 minutes according to the extent of dismantling that was to be attempted. Throughout the dismantling of the engine, which was carried out under step by step instruction, projected drawings or diagrams were displayed and interesting pieces of theory included (Fig. 7). For example, when the sparking plug was removed a little time was spent discussing and explaining the formation of the high voltage and the factors governing the magnitude of the voltage required. I formed the opinion that the course was extremely well presented and was not just a disguised sales talk. It is not surprising therefore that the lecture course which is given at least twice a day for five days a week is very popular among the schools, and explains why students are brought considerable distances by coach to attend. At the beginning of each academic year a similar lecture course is organised for the benefit of teachers, so that they will have advance knowledge of what the Company is offering for the students.

10.12 TELEVISION LESSONS FOR SCHOOLS

In order to try and help me find out something about the T.V. programmes presented to the schools in the field of science and technology, the British Council made arrangements for me to visit NHK (Nippon Hoso Kyokai). During an interview, through an interpreter, with three gentlemen who were connected with scientific broadcasting I learnt that the committee responsible for deciding the nature and content of these programmes had some members who were practising teachers, and that the person who actually gave the lesson in front of the T.V. camera was on occasions, also a practising teacher.
Fig. 6. The tiered lecture room at the Honda Engine School showing the small engines which are dismantled by students attending the lecture.

Fig. 7. The lecturers rostrum at the Honda Engine School showing some of the apparatus available for illustrating the engine dismantling lecture.
These T.V. lessons are based on the normal school science syllabus with demonstrations using only very simple apparatus although, I understand, Industry is prepared to lend material for certain experiments or illustrations.

In addition to presenting programmes for day schools NHK transmit educational programmes in the evenings for the benefit of youths and adults who left full time education at the earliest age permitted and now wish to continue their studies. The programmes, known as correspondence courses, include mathematics and physics and are presented in conjunction with specially prepared text books. Serious students formally enrol for these courses knowing that they have to submit written exercises and attend direct schooling for 20 days a year. A minimum of four years is needed to complete the course, with the majority of students taking longer.

These programmes may have some affect on the normal full time school boy but teachers with whom I spoke, with the aid of an interpreter, thought the Japanese youths would be more interested in the cartoons when they returned home in the evening.

10.13 INSERVICE TRAINING FOR TEACHERS

In 1953 the Science Promotion Law was passed in Japan. The aim of this law is to further science education as science is considered important in the creation of a cultured nation populated with capable citizens. The law made it clear that the State should, in addition to making an effort itself, encourage local bodies to promote science education. Among the methods suggested was the provision for the improvement of facilities and equipment for science education and the setting up of a programme for the 'in service' training of science teachers in addition to the normal preparation given to prospective science teachers.

At the same time it was suggested that a Science Education Council within the Ministry of Education - should be established which could deliberate on important matters relating to science education and carry out any research that seemed necessary. Among the reports prepared by this Committee was one that pointed out that the decisive factor in improving science education was the quality of the teacher. This led to the Ministry of Education and the local education councils of each prefecture and metropolis in Japan starting (in 1958) a five
I visited two of these centres, one of which was situated in Tokyo and the other in Sapporo (Hokkaido). I was most impressed with the physical facilities which consisted of a separate laboratory for each of the sciences, preparation rooms, stores, workshops, lecture theatres and a library in addition to the normal administrative offices. Each laboratory was large enough to accommodate 20 - 24 students and was fitted with benches carrying all normal services. (Fig. 8) The preparation rooms, which were adjacent to the laboratories, were large enough to enable research to be undertaken as well as to store apparatus needed for forthcoming lessons. Every effort was made by the staff to maintain a collection of equipment and material superior to that found in the majority of schools so that the visiting teachers could become aware of the latest developments and never get complacent about the state of their own facilities.

The teaching staff at these 'in service' centres were appointed - from the ranks of the classroom teachers - because they had excellent individual records and high reputations for good teaching. (Fig. 9) While working at the Centre the staff try and divide their time between educational research in the field of science, the evaluation and devising of new equipment, and the preparation and presentation of courses to practising teachers. At the moment the staff spend the major part of their time on the presentation of courses but in the very near future it is hoped to offer higher salaries for this work and so attract sufficient well qualified and experienced teachers to join the centres. When this occurs the staff will be able to devote more time to research into teaching techniques and also take long periods of study leave in order to investigate educational advancements in other countries.

One of the difficulties connected with the enrolment of practising teachers to the courses provided at these centres is the supervision of the classes they have 'abandoned' in their school. When the courses last for one day, or less, every week their classes are supervised...
Fig. 8. A science laboratory in one of the 'in service' Teacher Training Centres in Tokyo.

Fig. 9. One of the teaching staff who had been appointed because of his excellent teaching ability.
by their colleagues, but for longer periods it is very difficult to find a temporary substitute teacher. The reason for this is partly the shortage of teachers and partly the lack of money available to finance a group of 'floating' teachers. Some improvement may be forthcoming in this direction very soon as the prefectures are keen for their teachers to attend 'in service' courses. The evidence supporting this is that they pay all travelling expenses together with room and board when necessary. Another future improvement suggested is for the centres to become residential and so economise in the money spent on daily travel and hotel accommodation.

The Japanese Ministry of Education I was told, want many more of these science centres to be built and so provide an ever increasing number of teachers who will be well informed on scientific and technological matters and capable of helping able students to select a career in these fields, based on wise reasoning.

10.14 SCIENCE MUSEUMS

Four science museums and a transport museum were visited in order to assess the interest value and teaching potential of their exhibits for children in upper secondary schools who were interested in the physical sciences.

TOKYO

THE OLD SCIENCE MUSEUM - UENO PARK - ENTRY FEE 10p

This museum displayed exhibits in all branches of science, but devoted most floor space to natural history. One section however contained approximately 20 small experiments concerning the basic principles of electricity, arranged so that the visitor was able to perform the experiments himself. (Fig. 10) Although the apparatus was of the older type it was excellent from the teaching point of view as it's 'openess' enabled every connection and link wire to be traced.

This range of small self-teaching experiments is very similar to those presented in the physics section of the Deutsches Museum, Munich; the main difference is that the Japanese collection of experiments use older equipment and cover the very simplest principles
Fig. 10. A visitor operated experiment showing the relationships between the current flowing through and the voltage across, varying lengths of a uniform resistance.

Fig. 11. Familiar domestic electrical appliances wired to instruments that provide a visual indication of how appropriate factors such as temperature and current vary with change of load.
because the Japanese children have not had the chance of seeing them demonstrated in school.

Parties of school children are taken to the museum and encouraged to perform the experiments and ask the attendants or their teachers if they require further instruction.

THE NEW SCIENCE MUSEUM - KITANOMARU FOREST PARK
ENTRY FEE - ADULTS 15p - CHILDREN 10p

This museum was founded in April, 1964 and is a unique star shaped building five stories high. All sixteen exhibition rooms are windowless and house modern industrial materials, working models and experimental devices covering the fields of physics, chemistry and technology (Figs. 11, 12, 13). Unlike the National Science Museum, South Kensington, none of the exhibits have been installed because of their historical interest. There is a complete absence of internal combustion engines and other static equipment.

This museum has mastered the technique of linking simple physical principles with industrial apparatus and presenting the result as an interesting and instructive working model. In this respect the museum is ahead of science museums in Britain, America and West Germany.

A very large number of the models are designed to be operated by the visitor whilst several of the more elaborate exhibits can be used with the help of assistants, who are readily available.

In order to make the visit as profitable as possible each visitor is given a magceiver. This instrument picks up tape recorded commentaries that provide detailed descriptions about the exhibits when you stand close to them. At the moment commentaries in English are only available on the fifth floor; but it is expected to extend this 'foreign' service to all floors in the near future.

THE MUSEUM OF TRANSPORT - ENTRY FEE 10p

This museum was dominated by a large sectioned steam locomotive
Fig. 12. A working demonstration of fibre optics.

Fig. 13. A tank in which three model ships are each towed along by the same applied force. Each ship offers a different resistance to the water, because of variations in the shape of its hull, so causing them to take different times to reach the end of the tank. The instruments on the wall record the speed and journey time of each ship.
standing in the central hall (Fig. 14). Leading off from this hall were smaller rooms containing models and working exhibits relating to Japanese rolling stock. Among the many historical exhibits was an Emperor's railway coach, while the modern aspect of Japanese railways was represented by a full size mock-up of the front section of a new Tokaido line train.

The upper floors of this museum were devoted to exhibits concerning air and sea travel through the ages (Fig. 15).

The contents of this museum gave it specialised interest value but the minimum of immediate teaching potential with regard to the applications of school physical science in the modern world.

THE MODERN SCIENCE MUSEUM - TOYKO TOWER - ENTRY FEE - ADULTS 20p
CHILDREN (OVER 15) 10p - CHILDREN (UNDER 15) 7\(\frac{1}{2}\)p

This tower - 333 metres high - was built for the purpose of supporting radio and T.V. aerials and offers a great attraction to the Japanese people. The tower straddles a five storey building whose contents seemed to be a strange mixture of fun fair and trade fair, hardly justifying the title 'Modern Science Museum'.

The fifth floor chiefly housed studios and transmission facilities for various T.V. broadcasting companies, but there was also a large number of slot machines for the benefit of the visitors.

The fourth floor was used partly as a showroom for broadcasting and receiving equipment and partly as a recreational centre.

The third floor was divided into sections, each of which was filled with the products of one or other of the leading industrial organisations in Japan. Among the exhibits were sectioned models of trains and ships but the young people present on the Sunday I visited seemed more interested in using the personal electrical vanity items manufactured under the title 'The Dandy Series'.

The second floor contained a shopping centre and restaurant while the first floor (ground floor) housed the ticket desks and entrance to the elevator for the observation platform.

The educational objective of this museum seems to be to give
Fig. 14. The large sectioned steam locomotive standing in the central hall of the Museum of Transport, Tokyo.

Fig. 15. A sectioned model of an early Japanese trading ship.
young people the chance to realise that modern Japan produces every conceivable type of electrical gadget and that science and technology are playing a large part in everyday living. No doubt, children from the poorer outlying parts of Japan would be delighted to see electrical appliances which are almost taken for granted by children in the towns.

NAGOYA

THE NEW SCIENCE MUSEUM - ENTRY FEE 10p

This museum has the best exhibition of apparatus concerned with the teaching of fluid flow that I have ever seen anywhere in Europe or America or elsewhere in Japan (Figs. 16, 17). It is arranged so that anybody would be attracted to the display and want to learn more.

There were literally hundreds of carefully designed exhibits covering many branches of technology that could be operated by the visitor, all of which demonstrated very clearly either a physical principle (Fig. 18.) or its application in industry. On each floor there was an attendant (an attractive young lady) who upon request would give more information about any exhibit (Fig. 19.).

The first floor housed a well equipped chemistry laboratory which was open on Sundays for the benefit of local boys and girls who wished to undertake some supervised practical chemistry experiments.

Although this museum contained more large size exhibits than the New Science Museum, Tokyo, it did not possess any equipment merely of historical interest nor any apparatus that only worked at certain times of the day such as a static discharge demonstration commonly found in American and European Science Museums.

The Japanese Ministry of Cultural Affairs recommended this science museum to me as the best in Japan, and in my opinion, must rank among the six leading science museums in the world at the moment.
Fig. 16. One corner of the large water tank displaying a venturi tube and jets issuing from different levels in a reservoir.

Fig. 17. Two demonstrations: one showing a wheel rotating by means of water issuing from jets and another providing an example of stream line and turbulent flow around shaped pieces of wood.
Fig. 18. A working model demonstrating the principle of mutual induction and its application in a transformer.

Fig. 19. One of the young lady attendants who either explain the exhibits to visitors or answer their queries.
CONCLUSION

The leading science museums try to restore the balance of theoretical/applied school science teaching by offering a large number of well-presented exhibits showing how theoretical science, comprehensible to secondary school children, is used in industry.

These self-operated models and demonstrations give children and adults the chance to participate in a very large number of self teaching situations that are individually complete, yet short enough to prevent loss of interest.

Almost every field of technology is represented in the museums and personal observation showed that a high percentage of the visiting school children seemed to find something that held their attention.

SUGGESTION

The best science museums should be encouraged to equip and operate large travelling exhibition units that could visit outlying areas or employ a lecturer who is able to present interesting talks and demonstrations in schools, using some of the museum exhibits. Such a service would help those children who are unable to reach cities like Tokyo or Nagoya, to benefit from the experience of seeing science working for them.

10.15 OVERALL CONCLUSION

The stimulus to study technology is not created in Japanese children by any form of technological course or activity provided in the schools but is largely due to an appreciation by the community of the important contribution made by technologists to industry, and in turn the country. As a result of this appreciation the status of the technologist is very high among the people and from an early age boys and girls are made to realise that to qualify as a technologist it is essential that they are competent in their academic studies and possess special interest and ability in mathematics and physics.

The quantity of student practical work and class demonstration provided in upper academic secondary school physics classes is much less than that offered in corresponding English secondary schools. The reason for this is that the entry examination to a Japanese university is entirely theoretical and the prestige of the school depends upon the
number of its students gaining places in the better universities. This concentrated effort on teaching examination material presumably helps students to pass the difficult entry examinations, but how much the students really understand about the world of technology is another matter.

Science museums and one or two industrial organisations are doing their best to fill the gap in the applied/practical aspect of school science teaching until, perhaps, the developments in technological education contemplated by the Japanese Government materialise.
AIM

To develop techniques and material whereby schools throughout the country can introduce applied science to their boys and girls, between the ages of 14 and 18 years, in the immediate future.
CHAPTER 11
THE SHELL SCHOOL TECHNOLOGY PROGRAMME

11.1 AIM

To develop techniques and material whereby schools throughout the country can introduce applied science to their boys and girls, between the ages of 14 and 18 years, in the immediate future.

11.2 INTRODUCTION

During the last 10 - 15 years industrialists and school teachers have spent considerable time and effort discussing the need for introducing applied science into the schools, both from the educational viewpoint and from the national need for recruitment of able people into the world of technology.

In 1967 The Schools Council's Project Technology, was set up to try and encourage more schools to introduce technology and to offer some suggestions on methods to be adopted.21

At much the same time HRH Prince Philip, through his connection with the Association for Science Education and the Council of Engineering Institutions, took the initiative which led to the establishment of the School Science and Technology Committee. This Committee, with Prince Philip as Chairman, sought to promote interest in and encouragement for schools introducing technology.

As a direct outcome of this royal initiative Shell International gave a grant of £27,000, over a period of three years, to the University of Surrey for the purpose mentioned above.

In September 1968 I joined the University to carry out the necessary research under the title of 'The Shell School Technology Programme'.

11.3 FORMULATING A POLICY

The Page Report showed that the major obstacles preventing schools in Great Britain from introducing applied science, in order
of severity, were the ones listed below.

Lack of accommodation.

Lack of equipment.

Lack of staff know-how.

Finance in general.

Lack of technical assistance.

Demands of university entrance.

Lack of time.

(These obstacles have been verified, 1971, as still current by 200 of the teachers wanting to start an applied science activity who have expressed an interest in the material produced by this research programme). Appendix 1. Question 3.

Some of the special applied science schemes and equipment devised by the pioneer schools in England have proved workable and successful but have been slow to spread for the reasons mentioned above.

Taking parties to visit industry overcomes some of the obstacles but is not very satisfactory because the children see far too much 'end product' and have little or no opportunity to link school science lessons with the machines in the factory.

Experience obtained by serving on the committee that devised the new `A' level N U J M B 'Engineering Science' syllabus showed that this approach takes considerably longer than three years to develop and does not receive the unanimous approval of the teaching profession, partly because it still needs space, equipment and staff know-how.

If some new approach was going to prove satisfactory then it would have to be capable of overcoming all the usual obstacles encountered by teachers.

EXPERIENCE GAINED ABROAD A first hand study of educational activities in Europe, America and Japan, undertaken between 1966 and 1968 showed me that several other countries were facing a similar problem but none of them had devised a satisfactory solution. It was interesting to discover that the large number of technologists working in Japanese industry were not the end product of an exciting school applied science programme but originated from
Facilities outside the schools gave some assistance. Science museums in America, Germany and Japan were modernising their exhibition areas and installing self operated demonstrations that made science more fun to learn as well as attempting to show the industrial application of the fundamental principles.

Unfortunately the science museums in Great Britain are extremely short of money and staff, so similar developments were unlikely to occur, on a large scale, for the immediate benefit of British children.

11.4 POLICY - FOR A THREE YEAR PROGRAMME

With this background knowledge and experience in mind I decided to devise material that would enable physics teachers', using existing 'O' and 'A' level syllabuses, to demonstrate how the fundamental principles they taught are used in industry to solve simple, interesting but carefully selected problems. It seemed essential to me that each problem discussed should involve only the principle being taught in the current lesson, otherwise the ingenuity of the solution and the relevance of the theory to life outside the classroom would be lost.

If such a technique was implemented, initially, by words and pictures in approximately 10 minutes of a timetabled 40 minute theory lesson, the immediate difficulties would be overcome as shown below.

<table>
<thead>
<tr>
<th>DIFFICULTY</th>
<th>HOW DIFFICULTY IS OVERCOME BY NEW APPROACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of accommodation</td>
<td>No special accommodation needed.</td>
</tr>
<tr>
<td>Lack of equipment</td>
<td>None needed.</td>
</tr>
<tr>
<td>Lack of staff know-how</td>
<td>Provided by a new booklet.</td>
</tr>
<tr>
<td>Finance in general</td>
<td>Only £2 - £3 needed.</td>
</tr>
<tr>
<td>Lack of technical assistance</td>
<td>None needed.</td>
</tr>
<tr>
<td>Demands of university entrance</td>
<td>No new 'unapproved' subject suggested.</td>
</tr>
<tr>
<td>Lack of time</td>
<td>10 minutes twice a week can be found.</td>
</tr>
</tbody>
</table>
Once a teacher has introduced applied science by this method it is likely that the students will ask for more; I would then suggest visiting the exhibition of working models each showing how school physics has solved an industrial problem - mounted within the University of Surrey (or taken to a local centre), trying a series of experiments devised by the combined efforts of several departments of the University of Surrey, or using the new material as a source for open-ended project work involving some design and construction.

11.5 ACCOMMODATION

Initially I shared a small office with four other staff.

In September 1969 my technician and I were able to move into a temporary building having a floor space of 1,000 sq. ft. which I decided to divide into two offices, a combined secretarial office and store, small workshop and combined exhibition and lecture area. Fig. 1. This latter area now houses a permanent exhibition arranged in such a way that 25 visitors can be seated at any one time.

Facilities for projecting still and moving film have been installed in one of the offices so that there is a minimum of disturbance for the visitors watching the screen mounted on one wall of the main lecture area.

11.6 METHODS OF FINDING HOW INDUSTRY UTILISES PRINCIPLES TAUGHT IN SCHOOL PHYSICS LESSONS

During the first year of the Programme’s life I read many professional and technical journals before approaching 63 selected industrial organisations and research establishments in the hope of finding some simple but interesting applications of the principles included in a typical ‘A’ level physics course.

Each firm approached was sent a letter explaining the purpose and aims of the School Technology Programme and asking for specific help or advice. Included with each letter was a sheet showing the format in which their help would be of maximum benefit together with a list of the principles taught in school physics lessons.
In 97% of the cases replies were received expressing great interest in the work and offering either to retain the papers and circulate them amongst their staff, or inviting me to discuss the matter with them in person.

Retention of the papers usually provided some relevant information but frequently took a minimum time period of six months to be completed and returned to me.

Personal visits to organisations generally resulted in discussion with senior members of the staff followed by a conducted tour around the works. Sometimes during these tours of the factory I would see, or be told about, some piece of equipment that immediately suggested a school physics principle. Further discussion would then complete the technical background thus enabling me to present the information to the world of education either as a data sheet or a working model as described in the next section.

CONCLUSION Industrialists find it hard to appreciate the limited knowledge possessed by school boys and girls, even at sixth-form level.

In these days of specialisation it is becoming increasingly difficult to find individuals who can both use equipment and discuss its fundamental working principles. Nevertheless simple and interesting examples of applied science, suitable for presentation in school, can be found providing one is prepared to use their eyes, ask questions and look at every suggestion offered through the combined eyes of a science teacher and engineer.

11.7 TEACHING MATERIAL PRODUCED

All the information collected from industry and research establishments has been carefully sifted so that the material finally chosen was, in my opinion, suitable for helping either teachers or school children to familiarise themselves with some of the interesting ways in which school physics is used in industry.

By presenting the material in the five forms described below I believe that it will interest and educate a large number of people spread over a wide area of the country.
1. An exhibition of 22 working models (designed and built by the Programme staff) each of which demonstrates how one principle has been used to solve an industrial problem. Great care has been taken to select these examples so that only one principle is dealt with at a time, otherwise, it is felt, the pupil may become overwhelmed with understanding the theory and fail to appreciate the ingenuity of the application. A typical one is shown in Fig 2. This exhibition is permanently on view at the University of Surrey. (Fig 3.) The 15 display stands have been designed (by the staff) in such a way that they and the models can be transported on a three-ton lorry to any school, teachers' centre or college of education throughout the country that may wish to avail itself of this service. Fig. 4.

Each stand is assembled from six sections, namely, two end panels, back panel, roof, display surface and fascia. The end and back panels are of hollow ply sandwich construction while the roof and display surface are of particle board. The sections are assembled by the location of metal dowels in pre-drilled holes. The end panels have a matt slate grey finish with white 'Formica' edging. The back panel is finished in mustard hessian wall covering and the display surface in black expanded vinyl.

Electric power reaches the exhibits from a 13 amp plug connecting the mains supply to pre-wired outlets in the rear panel. Illumination for the display and the white opal perspex fascia is provided by a roof mounted 60w fluorescent tube.

Dimensions of the stand units are given in Fig. 5.

2. An illustrated lecture given by myself describing, with the aid of slides and a selection of the models, how school physics is applied in industry. This lecture is available for science teachers or pupils.
Fig. 2. A typical model. This one demonstrates how a potentiometer is used to convert the length of carrots into voltages for analysis by a computer.

Fig. 3. A section of the permanent exhibition, mounted by the School Technology Programme.
Fig. 4. One of the backboards of the display stands being loaded into a lorry in preparation for a demonstration at a centre situated somewhere in England.
3. A loose-leaf book entitled 'Science Serving Society'. This booklet contains 63 data sheets which show science teachers how the physical principles that they teach have been used to solve problems in industry. A typical sample is shown in Fig. 6. Each sheet outlines one problem and gives details of the solution. Where applicable there are diagrams of the apparatus that is being used and a photograph showing the apparatus at work in industry. This booklet is deliberately offered in loose-leaf form so that as the School Technology Programme writes further data sheets and sends them to the schools, teachers will be able to file them and so build up a useful collection of technological information.

4. A series of 60 slides has been prepared to be used as visual aids in conjunction with the data booklet mentioned above. All the explanatory drawings which appear in the data booklet are also available as slides or in the form of transparencies that can be used with overhead projectors. At the present time these slides can be purchased at a cost of £1.50 for 20 and overhead projector transparencies at 15p each.

5. A 16mm film loan scheme has been established containing approximately 50 films.

Considerable time has been spent searching the archives of the BBC for industrial films that can be offered as short (6 minutes) pieces of illustrative material relevant to a school science lesson.

If these pieces of 16mm film prove popular amongst the schools the BBC have agreed to transfer the material onto 8mm film and package it as continuous running cassettes for use in daylight viewing projectors.

11.8 AN OPEN DAY

The Shell School Technology Programme held its first Open Day on the 11th June, 1970, which was attended by 40 ladies
TOTAL INTERNAL REFLECTION

Principle. Total Internal Reflection.

The Problem. To monitor the surface of a liquid, for purposes of control or measurement of container contents, here conventional techniques are unsuitable due to fire risk, chemical action or extremely low temperatures.

The Solution. The problem has been solved by using an optical dipstick. This instrument consists of a perspex probe with a prismatic tip. At the upper end of the probe are mounted an illuminator lamp and a cadmium selenide photocell (Fig. 1). The lamp sends a beam of light down the probe, this is totally internally reflected twice at the prismatic end—when the surrounding medium is air—and passes back up the rod to the photocell (Fig. 2). When the tip becomes immersed in a liquid the critical angle changes, total internal reflection no longer takes place, the beam no longer passes up the rod to the photocell which therefore receives less light. Under these conditions its electrical resistance rises and a signal is passed to the control box to be amplified and utilized as necessary.

Application. The optical dipstick has been used in this form for the detection of the level of many liquids particularly liquid oxygen, liquid nitrogen, liquid air, acids and alkalis. N.A.S.A. uses this technique for monitoring liquid oxygen levels in spacecraft.

With the substitution of a heat resisting glass probe the device may be used with hot liquids or solvents which attack perspex.
An optical dipstick in use to control the gasoline level in the fuel bowl of a C.F.R. (Co-operative Fuel Research) Engine that is comparing the knock intensity of reference and line gasoline samples.

Photo by courtesy of Associated Ostel Co. Ltd.
and gentlemen representing Shell, the SSTC, the ASE, The British Association for the Advancement of Science, CEI, DES, Local Education Authorities, Ministry of Technology, Project Technology, The Royal Society and the Women's Engineering Society.

The day was arranged so that the guests had the chance to hear a lecture describing the policy of the Programme, followed by a guided tour around the working models.

PUBLICITY Very shortly after this Official Open Day a Press Day was held which resulted in articles concerning the work appearing in the following journals.

<table>
<thead>
<tr>
<th>Journal</th>
<th>Volume</th>
<th>Issue</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Scientist</td>
<td>Vol.48</td>
<td>No. 721</td>
<td>1st October, 1970</td>
</tr>
<tr>
<td>New University</td>
<td></td>
<td></td>
<td>May/July, 1970</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
<td>25th September, 1970</td>
</tr>
<tr>
<td>Faculty</td>
<td></td>
<td></td>
<td>10th October, 1970</td>
</tr>
<tr>
<td>University Equipment</td>
<td></td>
<td></td>
<td>December, 1970</td>
</tr>
<tr>
<td>The Teacher</td>
<td></td>
<td></td>
<td>2nd October, 1970</td>
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</table>

The author also wrote an article, describing the work, that was published in School Technology, Bulletin 16, Vol. 4, January, 1971.

Since the formal Press Day further related articles have appeared in:

<table>
<thead>
<tr>
<th>Journal</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Times Educational Supplement</td>
<td>12th March, 1971</td>
</tr>
<tr>
<td>The Teacher</td>
<td>26th March, 1971</td>
</tr>
<tr>
<td>Ophthalmic Optician</td>
<td>1st May, 1971</td>
</tr>
</tbody>
</table>

In the world of sound radio the BBC External Services Talks and Features (General Programmes) used the material in a form entitled 'Making Technology Attractive' and on 3rd March, 1971 I was interviewed by BBC Radio Brighton and asked to discuss the School Technology Programme and Exhibition Unit, on a lunch time magazine programme.

OBSERVATION The article I wrote in 'School Technology'
produced the greatest follow-up from school teachers in England, in the form of requests for copies of the booklet, while the greatest response from abroad came as a result of the paragraphs written in 'University Equipment'.

11.9 EXHIBITIONS ATTENDED

Eight of the models and four of the portable display stands were taken to the Annual three day meeting of the ASE held at the University of Sussex, in December, 1970. This gave me the opportunity to meet almost 200 practising science teachers many of whom have since used our material or are planning to incorporate it into their 1972 teaching arrangements.

In April, 1971 the Programme displayed 3 models at the 4 day Physics Exhibition, held at Alexandra Palace. Fig. 7. Considerable interest was shown in the work but the number of visitors directly engaged in education who reached the stand, and identified themselves, was lower than expected; the exact number was 38.

**OBSERVATION** Attending exhibitions undoubtedly helps to get the new material known to a wide audience and, on the whole, is time and effort well spent.

11.10 THE MOBILE EXHIBITION UNIT

When the visiting lecture/exhibition service was first started the working models were displayed on the special portable exhibition stands. This technique was found to involve a considerable amount of physical labour, as well as time, because advance promises of help with the assembling and dismantling failed to materialise when they were most needed.

To ease this task I decided to build a mobile Exhibition Unit which could be parked at any school or centre to which we were invited and made operational within 20 minutes of arrival.

This mobile Exhibition Unit was made from a secondhand 22 ft. caravan. When purchased the interior contained bedraggled facilities for sleeping and the remains of a kitchen. All this unwanted
Fig. 7. Visitors to the 1971 Physics Exhibition taking an interest in the models and printed material presented by the Shell School Technology Programme.
furniture was removed and the interior stripped back to the aluminium shell. A new interior layout was designed and my technician, Mr. A.E.W. Tessier, made the caravan shell into a purpose built Exhibition Unit. It contains horizontal display surfaces around the sides and one end, for supporting the models, 12 13amp sockets for driving the models, 2 electric heating points and 30 ft of fluorescent strip lighting. All the display surfaces, walls and ceiling are finished in 'Old Gold' coloured hessian while the floor is covered with brown cord carpet. Fig. 8.

The external surfaces of the Exhibition Unit are finished in 'Limestone' cellulose with the appropriate titles displayed in black lettering; the complete Unit is towed by a Land-Rover painted in a similar style. Fig. 9.

If the Exhibition Unit can be parked within 50 yards of a building, the electric power is obtained by an extension cable, if not, a portable petrol driven generator is brought into action. This unit is placed approximately 20 yards from the caravan so that the noise is kept to an acceptable level.

Entry to the caravan is gained by mounting a two step staircase, which is carried inside and lowered out when needed. Fig. 10.

In order that visiting children, or teachers, can obtain the maximum educational value from each model on display 11 circuits have been built into the caravan so that a telephone handset may be mounted adjacent to appropriate models; Fig. 11. Upon lifting the handset an 80-90 second recorded commentary can be heard describing the exhibit. Each commentary is on a loop of tape so that it automatically returns to the beginning ready for the next visitor. This explanatory technique is adopted where short written placards are considered to be insufficient.

11.11 FEEDBACK FROM PRACTISING SCHOOL TEACHERS CONCERNING BOOKLET 'SCIENCE SERVING SOCIETY'

As a result of visiting various centres and answering requests triggered by published work, more than 250 copies of the booklet 'Science Serving Society' have reached practising teachers.
School Technology Programme mobile exhibition unit fig 8

1: Display surface
2: Divider
3: Commentary playback unit
4: Chair
5: Projector
6: Opening flap over back-projection screen

Display Area

1 2 3 feet
The School Technology Programme Exhibition Unit setting out from its base at the University of Surrey

(photos: T. Wilkie Co.)
Fig. 10. Girls from the County School Reigate entering the mobile exhibition unit by mounting the two step staircase.

Fig. 11. The inside of the mobile exhibition unit showing the wall mounted telephone hand sets that provide visitors with short verbal descriptions of the models.
In order to assess the reaction of these teachers to the new material I devised a questionnaire shown in Appendix 2 and sent a copy to 250 of them together with a covering letter asking for their co-operation in evaluating the material.

A 57% response was obtained by 143 teachers completing and returning the questionnaire. These replies divided themselves into two categories:-

a) Teachers who had used the material (50).

b) Teachers who had not used the material (93).

Further analysis of each group is given below.

A. TEACHERS WHO HAD USED THE MATERIAL

GENERAL COMMENTS I have received written comments from 48 of the 50 practising school teachers who have used the material in the classroom and found it to be of great value to themselves and their students. Six typical comments are given below.

'The presentation of the material is in a very suitable format as the desired page is easily selected and can be passed around. There is a lot of paper wasted today in publications advising teachers; your publication is worth its weight in gold'. - Hampton G.S.

'I found the material well presented and interesting as did those of my students who looked through it'. - Stoke-on-Trent Sixth-form College.

'A very interesting well prepared booklet - I hope there will be more'. - Catford Boys School, S.E.6.

'Excellent material'. - Leyton Senior High for Boys.

'More power to your elbow. Much more of this kind of material is needed to add interest and significance to science lessons, particularly physics'. - Shirley Secondary School, Croydon.

'The whole thing is excellently presented and a great asset to my less imaginative and unoriginal mind'. - F. Southern, The Secondary School, Poole.

A1 AGE AND ACADEMIC LEVEL OF CHILDREN EXPOSED TO THE MATERIAL

The material has been tried in 50 schools with children between 12 and 17 years of age studying at 'A', 'O' and CSE level, as well as with those participating in non-examination activities.
The table below shows the percentage of these schools that have used the material with specific age ranges and academic levels.

<table>
<thead>
<tr>
<th>AGE GROUP (IN YEARS)</th>
<th>PERCENTAGE OF SCHOOLS USING THE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 - 12</td>
<td>0</td>
</tr>
<tr>
<td>12 - 13</td>
<td>4</td>
</tr>
<tr>
<td>13 - 14</td>
<td>4</td>
</tr>
<tr>
<td>14 - 15</td>
<td>30</td>
</tr>
<tr>
<td>15 - 16</td>
<td>54</td>
</tr>
<tr>
<td>16 - 17</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACADEMIC LEVEL</th>
<th>PERCENTAGE OF SCHOOLS USING THE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>60</td>
</tr>
<tr>
<td>O</td>
<td>42</td>
</tr>
<tr>
<td>CSE</td>
<td>42</td>
</tr>
<tr>
<td>NON EXAMINATION</td>
<td>16</td>
</tr>
</tbody>
</table>

A2 METHODS OF USING THE MATERIAL

In addition to using the material to make physics lessons more realistic at 'A', 'O' and CSE level several schools have used it successfully in the following ways.

a) To update teachers own lists of practical applications of science.
b) As a sixth-form reference book for project work.
c) As background material for an Oxford Board 'A' level Engineering Science course.
d) As a source of titles for a non-timetabled voluntary project activity.
e) 'As an example in the aims of keeping a clear methodical log book'. - Cowes High School, I.O.W.

A3 CHILD REACTION TO THE MATERIAL

All the teachers said the material created interest and in some cases excitement amongst the children. As an indication that the material is not just written for boys I quote the observation made by the Physics Mistress at Reigate County School for Girls when she presented the material; 'Their faces lit up with interest and excitement'.
REACTION NOTED BY A TEACHER

<table>
<thead>
<tr>
<th>PERCENTAGE OF SCHOOLS NOTING THE REACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERESTED</td>
</tr>
<tr>
<td>EXCITED</td>
</tr>
<tr>
<td>BORED</td>
</tr>
<tr>
<td>NO REACTION</td>
</tr>
</tbody>
</table>

The reactions 'excited' and 'no reaction' were observed in children aged between 14 and 16 years studying physics at CSE level.

A4 THE MATERIAL CAUSED QUESTIONS TO BE ASKED

Ninety-three percent of the teachers using the material said they had to answer questions from children relating to it and 80% were able to report that the data they needed to give the answers was available in the booklet.

A5 CONTINUED USE OF THE MATERIAL

Every teacher who has used the material intends to continue using it in the future.

A6 THE MATERIAL ESTABLISHES AN INTEREST IN APPLIED SCIENCE

Seventy-two percent of the teachers who had used the material believed that it had helped their students and school to take an interest in applied science.

CONCLUSION The new material and its method of presentation are both considered to be valuable aids to teachers concerned with the education of students between the ages of 14 and 17 years. Several ways of utilising the material have been found and successfully tried, in addition to the intended one, but the primary use is still for making 'A', 'O' and CSE physics lessons more relevant to everyday life.

The material has been observed to create an immediate interest in boys and girls and appears likely to encourage schools to
B. TEACHERS WHO HAD NOT USED THE MATERIAL

GENERAL COMMENTS  I received 44 written comments (47%) from practising school teachers who have read the material and felt that it will be of use to them in the classroom in the near future. Six typical comments are given below.

'The material will be of great value in future lessons'. - Renfrew High School, Renfrew.

'The material is of great interest and we shall be glad to use it'. - Quarry Bank Comprehensive School, Liverpool.

'Older pupils should find this material most interesting and a source of inspiration'. - Bishop Ward Secondary School, Dagenham.

'I think the material will make the sixth-form physics course more interesting'. - Archbishop Tenison's G.S., Croydon.

'The material is interesting, clearly presented and useful'. - Cleeve Comprehensive, Cheltenham.

'I think the material is excellent and I hope to use it as a source of ideas for project work undertaken by the boys. Will also use it in the 'A' level Physical Science Course where appropriate'. - Hurstpierpoint College, Sussex.

B1 REASONS WHY SOME TEACHERS HAD NOT YET USED THE MATERIAL

The reasons put forward are considered in the next five paragraphs.

B1.1 STAFF SHORTAGE  Although 11% of the schools complained of staff shortage the problem seemed largely to have been caused by ill health as shown by two typical comments.

'My only qualified colleague having suffered a nervous breakdown two months ago, I find myself alone (at 62+) to cope with Physics for a school of 700 pupils'. - Ashton-in-Makerfield, G.S., Lancashire.

'I have been away from school on sick leave for the past three months and expect to be for the next three.
I intend to use the material next year'. - Brentwood School, Essex.

A few schools, however, appeared to be understaffed even when all appointed members were present as shown by the comment from The Mount School, Greenock. 'Shortage of science staff - one teacher only'.

B1.2 STAFF NEED TIME TO ABSORB NEW MATERIAL Six teachers mentioned the difficulty of absorbing new material and the time taken to consider the best way to include it into their teaching programmes. These points are illustrated by the typical comment shown below.
'I personally need time to absorb the material'. - King Edward VII Upper School, Leicestershire.

B1.3 INSUFFICIENT LABORATORY SPACE Only two schools mentioned the problem of insufficient laboratory space for the new approach, one of which was Catford County School, S.E.6., that stated 'we are recovering from 3½ years arson difficulties'.

B1.4 TIME NEEDED TO FEED THE MATERIAL INTO TEACHING SCHEMES Six schools (6%) indicated that they wanted to use the material but said that it had to be incorporated into future teaching schemes which could not begin until next year. This situation is summarised by a comment from Barrhead High School. 'The material is most interesting and will appeal to the pupils. It takes time to set up but I have incorporated it into the next years scheme'.

B1.5 REARRANGEMENT OF SCHOOLS Two schools indicated that changes in educational policy were imminent or had occurred. One of these thought the new arrangement would help them develop an Engineering Science Course and the other finds itself without any pupils of the appropriate ability range.

'With the 'comprehensivisation' of my school in September, '71 our sixth-form Engineering Science (JMB) will develop and I think your booklet will initiate good projects'. - Bishop Ward Secondary Modern, Dagenham.

'As yet we have not got pupils of sufficient ability to use the material'. - Droitwich High School, Worcestershire.
Almost without exception these teachers appreciate the material and are likely to incorporate it into their classroom schemes in the near future.

There is no one difficulty that prevents the material being used, such as say, shortage of money.

At a conservative estimate it seems likely that at least 50 of these schools will be using the material at the beginning of next year either for adding interest to physics lessons or as a source of ideas for projects. The remainder have no objection to the material but may not implement the new ideas until later in the year.

The constructive criticism received can be summarised by the comments given below.

'Would have liked more details about the equipment and its sources'. - Berwickshire High School, Berwickshire.

'Would like more technical details such as those you give for strain gauges. It is very difficult for the new Technical Studies (Craft and Engineering) departments to work with the Science departments when only theoretical information is available'. - Bishop Ward Boys Secondary Modern School - Dagenham.

'Size of print for 'Principle' could be larger'. - Girls Grammar School, Cleethorpes.

Twenty-three Colleges of Education or University Education Departments have requested and been sent copies of the booklet 'Science Serving Society', together with details of the lecture/exhibition service. The reaction of these education establishments to the material has been obtained by sending them copies of the questionnaire shown in Appendix 3.

A 60% response to this questionnaire, made up of eight Colleges
of Education and six University Education Departments, has enabled the following paragraphs to be written.

All 14 education establishments have approved the approach, booklet and visual aid material and have either recommended it, or will be doing so in the near future, to serving teachers and teachers in training.

Comments from lecturers in these establishments may be summarised by the following statement written by Dr. John Wilson, Principal Lecturer in Education, Moray House College of Education. 'I found it all most interesting, and although I am a non-scientist by training, the presentation was so clear and simple I could follow most of the items quite readily. I am sure that you will be successful in stimulating interest amongst teachers and pupils with this approach'.

SPECIFIC RECOMMENDATIONS Thirteen of these education establishments have, between them, recommended the material for use with children engaged in 'A' level, 'O' level and CSE studies as well as non-examination activities, as shown in the tables below.

Newman College, Birmingham, was the only College unable to offer specific recommendation as they felt 'it depends on the teacher'.

<table>
<thead>
<tr>
<th>AGE GROUP (in years)</th>
<th>PERCENTAGE OF COLLEGES RECOMMENDING</th>
<th>ACADEMIC LEVEL</th>
<th>PERCENTAGE OF COLLEGES RECOMMENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 - 12</td>
<td>0</td>
<td>'A'</td>
<td>92</td>
</tr>
<tr>
<td>12 - 13</td>
<td>7</td>
<td>'O'</td>
<td>53</td>
</tr>
<tr>
<td>13 - 14</td>
<td>7</td>
<td>CSE</td>
<td>23</td>
</tr>
<tr>
<td>14 - 15</td>
<td>37</td>
<td>NON EXAMINATION</td>
<td>15</td>
</tr>
<tr>
<td>15 - 16</td>
<td>69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 17</td>
<td>92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION Teacher Training Establishments feel that the material is most suited to the needs of children engaged in 'A' & 'O' level courses, with the possibility of it having also some use at CSE level, probably depending upon the quality of the teacher.
FEEDBACK FROM SERVING TEACHERS

As the booklet and slides are still very new, some of the teachers, to whom the training establishments recommended this material, have only had time to read it. Comments, therefore, are included from these teachers as well as from those who have tested the material in the classroom.

i) TEACHERS WHO HAVE TESTED THE MATERIAL IN THE CLASSROOM

'Very favourable - especially physics teachers'. - University of Leeds.

'Bridges the gap very effectively between theory and application'. - Trinity College, Dublin.

ii) TEACHERS WHO HAVE READ THE MATERIAL

'Very interested'. - Thomas Huxley College of Education.

'Excellent source of ideas for projects'. - Dundee College of Education.

REACTION FROM STUDENT TEACHERS WHO HAVE READ THE MATERIAL

'Enthusiastic about the approach'. - College of St. Mark and St. John.

'Consider it useful background information'. - Newcastle University.

CONCLUSION

Teachers who first met the new material through the recommendation of a Teacher Training Establishment have found it helpful, and future teachers are prepared to try it.

11.14 APPROVAL BY LOCAL AUTHORITIES

Twenty-two Science Advisers or representatives of Local Education Committees have requested and been sent copies of the booklet 'Science Serving Society' together with details of the Lecture/exhibition service.

The reaction of these authorities to the material has been obtained by sending them copies of the questionnaire shown in
Appendix 3.

A 45% response to this questionnaire has been obtained. A recent informal meeting with three Science Advisers, who had not returned their questionnaires, showed that these gentlemen had not forgotten the material, but had been unable to find sufficient time to read it.

One hundred percent of the completed questionnaires were in favour of the material; the only criticism was the omission of lists giving the names of suppliers of parts for some of the models.

The craft adviser for Redbridge who asked for details of the material has recommended it to teachers of 'A' and 'O' level students, because he thinks that it is 'more suited to the intelligent child who can apply his learning'.

SPECIFIC RECOMMENDATIONS

Eleven Local Authorities are known to have specially recommended the material for use with children engaged in 'A' level, 'O' level and CSE studies, as shown in the tables below.

<table>
<thead>
<tr>
<th>AGE GROUP (in years)</th>
<th>PERCENTAGES OF AUTHORITIES RECOMMENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 - 12</td>
<td>0</td>
</tr>
<tr>
<td>12 - 13</td>
<td>0</td>
</tr>
<tr>
<td>13 - 14</td>
<td>0</td>
</tr>
<tr>
<td>14 - 15</td>
<td>27</td>
</tr>
<tr>
<td>15 - 16</td>
<td>81</td>
</tr>
<tr>
<td>16 - 17</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACADEMIC LEVEL</th>
<th>PERCENTAGES OF AUTHORITIES RECOMMENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>'A'</td>
<td>90</td>
</tr>
<tr>
<td>'O'</td>
<td>81</td>
</tr>
<tr>
<td>CSE</td>
<td>27</td>
</tr>
<tr>
<td>NON EXAMINATION</td>
<td>0</td>
</tr>
</tbody>
</table>

FEEDBACK FROM TEACHERS

The Local Authorities have had very little feedback from their teachers concerning the material. Brief statements sent to me from the four authorities that have obtained some reaction from teachers may be summarised in the words of the Science Adviser from Paisley, 'Favourable comment as a source of ideas for projects'.

CONCLUSION

Local Authority Advisers have recommended the
material to their teachers primarily for use with children studying at 'A' and 'O' level, but have not found it altogether unsuitable for use at CSE level.

11.15 EFFECT OF LECTURE/EXHIBITION ON TEACHERS

I have been invited to present the material at six Teachers' Centres * (two twice) and in so doing have addressed 202 teachers.

The first hour of these presentations includes an outline of the philosophy behind the programme and a demonstration of the software that has been devised; the visit concludes with an inspection of the working models carried in the mobile Exhibition Unit.

Upon leaving the Exhibition Unit each teacher is asked to complete a questionnaire, Appendix 1 , so that I can assess their reaction to the new material.

PROFESSIONAL BACKGROUND OF TEACHERS ATTENDING Eighty-three % were science teachers and 17% were teachers of craft. Thirty-four % of these teachers claimed to have an applied science activity in their school, but only 45% of the claimants were prepared to supply details of the activity. A summary of the data obtained is shown in the table overleaf.

*Bournemouth, Coberley, Guildford, Poole, Renfrew and Southampton.
<table>
<thead>
<tr>
<th>TYPE OF APPLIED SCIENCE ACTIVITY</th>
<th>PERCENTAGE OF SCHOOLS HAVING THE ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science based, examined</td>
<td>0</td>
</tr>
<tr>
<td>Science based, unexamined</td>
<td>9</td>
</tr>
<tr>
<td>Craft based, examined</td>
<td>5</td>
</tr>
<tr>
<td>Craft based, unexamined</td>
<td>19</td>
</tr>
<tr>
<td>Part science, Part craft examined</td>
<td>43</td>
</tr>
<tr>
<td>Part science, Part craft unexamined</td>
<td>24</td>
</tr>
</tbody>
</table>

**REACTION TO THE SOFTWARE**

During the presentation I felt the teachers were appreciating the new material. The table below shows how they rated the examples of the industrial application of school science mentioned during the lecture.

<table>
<thead>
<tr>
<th>COMMENT</th>
<th>% RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interesting</td>
<td>62</td>
</tr>
<tr>
<td>Ordinary</td>
<td>0</td>
</tr>
<tr>
<td>Dull</td>
<td>0</td>
</tr>
<tr>
<td>Exceptionally interesting</td>
<td>38</td>
</tr>
</tbody>
</table>

Every teacher, except one, who rated the examples as 'exceptionally interesting' was a specialist in physics.

Ninety-seven % of the teachers thought that written sheets containing the information mentioned in the lecture would be helpful in the classroom and 61% thought that sets of 20 slides, costing £1.50 each, would be of assistance.
All the teachers of science and craft estimated that the material would be suitable for children engaged in 'O' and 'A' courses and aged between 13 and 18 years; the vast majority agreed on 15 - 16 years as the optimum age range. The possibility of limited use at CSE level was suggested also.

**REACTION TO THE EXHIBITION** Every teacher enjoyed visiting the exhibition and 95% found the recorded description helpful; 70% of these judged the description to be of exactly the right length. The remainder were almost equally divided between them being 'too long' or 'not long enough', with a slight majority thinking they were 'too long'.

Teachers were equally divided upon the provision of an attendant to explain the models in preference to the recorded descriptions.

Fifty-four % of the teachers expressed a wish for the School Technology team to visit their school, with 80% of these requiring both the lecture and the exhibition service. Only 9% wanted the lecture without the supporting exhibition.

**CONCLUSION** The vast majority of the teachers attending the meetings at which the new material has been presented are already convinced that applied science is a useful and necessary part of a school curriculum and are looking for ways to implement such work in their own school. Over half of them were especially interested in an activity involving the combined resources of the science and craft departments.

All these teachers, especially the physicists, were enthusiastic about the new material and thought its greatest value was for students studying at 'O' and 'A' level. They thought also that the printed data sheets, comprising the booklet 'Science Serving Society', would be of great assistance to them and were favourably inclined to illustrate their classroom presentations with the suggested slides, costing £1.50 for each set of 20.

The mobile exhibition held the interest of the teachers and inspired over half of them to try and arrange for it to visit their school. The special educational aid of recorded descriptions
beside the models was agreed almost unanimously to be a helpful feature.

11.16 EFFECT OF LECTURE/EXHIBITION ON SCHOOL BOYS AND GIRLS

Between March and June 1971 I received invitations from 13 schools and one centre to present the lecture/exhibition to boys and girls between the ages of 14 and 17 years. By accepting all these invitations I have had the chance to try the material in several classrooms and observe the effect it had on nearly 700 students. The table on the next page lists the schools visited.

An attempt to assess the effect the presentation had on these students has been made by using questionnaires, Appendices 4 & 5, and first hand observation. The findings are presented in the next five sections.

1. UPPER SIXTH SCIENCE STUDENTS

The lecture/exhibition has been presented to 102 upper sixth-science boys and girls studying in four schools.

ACADEMIC BACKGROUND Every student in my audiences was studying physics and at least one other 'A' level science subject with the hope, in 78% of the cases, of proceeding to a university.

Eighty-two% of these young people claimed to be interested in applied science but only 25% thought that their teachers 'often' told them about the industrial applications of school science.

CAREER OUTLOOK Visits to Brighton College and Ardingly College confirmed some recent data showing that a career in engineering was the most popular choice amongst boys leaving public schools. Thirty-three% of the boys from these two colleges indicated that they had decided to become professional engineers compared to 9% entering the world of pure science.

From the entire group 45% had considered becoming a graduate engineer and 67% felt that school lessons had failed to help them find out about the work of engineers.

In the opinion of these young people the prestige of an
## TABLE LISTING THE SCHOOLS VISITED BY THE SHELL SCHOOL TECHNOLOGY PROGRAMME


Alperton High School, Alperton.

Archbishop Tenison's School, Croydon.

Ardingly College, Haywards Heath.

Brighton College, Brighton.

County School for Boys, Woking.

County School for Girls, Reigate.

De Burgh School, Tadworth.

North East London Polytechnic, Dagenham.

- North Romford Comprehensive School, Romford.

Robert Haining C. S. School, Camberley.

Royal Grammar School, High Wycombe.


Weydon C. S. School, Farnham.

* Centre organising a presentation on behalf of several schools in the area.
engineer was rated fourth behind a doctor, lawyer and professor.

REACTION TO THE LECTURE/EXHIBITION

a) LECTURE Outwardly the students appeared to enjoy the presentation and 76% said they felt it had given them an understanding of how science is used outside the classroom. The lecture appears also to have assisted with career guidance; 30% of the students said the material would help them to give favourable consideration to a career in the world of engineering, and 6% decided that engineering was probably not suitable for them.

b) EXHIBITION Every student stated that they enjoyed visiting the mobile exhibition to inspect and operate the working models. Eighty-two % of these students indicated that they found the recorded descriptions helpful. Further examination of this group revealed that 56% of them were satisfied that the length of the recordings were 'just right'. Analysis of the 'dissatisfied' visitors showed that 70% of the girls would have like the recordings a little longer and 67% of the boys, a little shorter.

The presence of an attendant to explain the models would have been preferred by 34% of these sixth formers. This figure applied equally to boys and girls. Sixty % of the girls and 25% of the boys would have liked recorded descriptions and an attendant.

COMMENT Any school that invited me to provide the exhibition for a total of 20 children or less would automatically have found an attendant available because the children would have been divided into small groups. With most schools, however, the totals average 50 and it is too time consuming to divide the children into groups of six or eight in order to allow sufficient space in the caravan for an attendant to move around.

Irrespective of the number visiting the exhibition there was always an attendant in the reception area at one end of the caravan to ensure that the flow of students was orderly and to hand out questionnaires.
2. LOWER SIXTH SCIENCE STUDENTS

The lecture/exhibition has been presented to 177 lower sixth science boys and girls in seven schools.

The number of girls in this sample was so small that it would not be very helpful to try and identify any difference in outlook between boys and girls.

ACADEMIC BACKGROUND Every student in my audience was studying physics and in the majority of cases two other 'A' level science subjects as 100% of them hoped to continue studying at a university when they left school.

Fifty-one percent of these young people claimed to be interested in applied science but only 20% thought that their teachers 'often' told them about the industrial applications of school science.

CAREER OUTLOOK 83 said they had decided upon a career in pure science and 41 intended to enter the world of engineering. As a group exactly 50% had given consideration to becoming a graduate engineer while 67% felt that school lessons had failed to help them find out about the world of engineering.

In the opinion of these students the prestige of an engineer was rated fourth behind a professor, doctor and lawyer.

REACTION TO THE LECTURE/EXHIBITION

a) LECTURE The students appeared to enjoy the presentation and 68% said they felt it had given them an understanding of how science is used outside the classroom. The lecture appears also to have assisted with career guidance. Twenty-six % of the students said the material would make them give favourable consideration to a career in the world of engineering and 15% had been convinced that engineering was not suitable for them.

b) EXHIBITION Every student stated that they enjoyed visiting the mobile exhibition to inspect and operate the working models. Eighty % of these students indicated that they found the recorded descriptions helpful. Further examination
of this group revealed that 70% of them were satisfied that the length of the recordings were 'just right'. The 'dissatisfied' visitors were almost equally divided between finding them 'too long' or 'too short', but a very slight majority came out on the side of 'too short'.

The presence of an attendant to explain the models would have been preferred by 30% of these students and 40% would have liked recorded descriptions and an attendant.

**CONCLUSION**

A large number of sixth-form boys and girls are naturally interested in applied science but do not have their interest satisfied during normal school lessons.

The new material devised by the School Technology Programme helps to fill this gap in school science education by assisting intelligent sixth-formers, studying physics and specialising in science, to understand how some of the physical principles they learn are used in industry. The material seems also to assist with career guidance and in the very long term may make a contribution towards raising the status of the engineer.

3. 'NEW' SIXTH

The lecture/exhibition has been presented to 40 boys and girls in the 'new' sixth form of one school. This form had been created for the benefit of the young people wishing to stay at school but unlikely to proceed to college or university.

**ACADEMIC BACKGROUND**

Almost every student was engaged in studying 'O' level subjects either to retake them or to increase the number they had already passed. None of them expected to study at a college or university.

Eighty-eight % of these students claimed to be interested in applied science but only 22% thought their teachers 'often' told them about the industrial applications of school science.

**CAREER OUTLOOK**

Only two students, both boys, from this group had decided upon a career. One of these had chosen television
servicing and the other car body repairing. Success in a particular subject seemed to be the overwhelming factor that influenced the career they were likely to select. None of them had considered becoming a graduate engineer.

In the opinion of these young people the prestige of an engineer was rated fifth behind a doctor, professor, lawyer and technician.

**REACTION TO THE LECTURE/EXHIBITION**

a) **LECTURE** Within the first seven minutes it was apparent to me, from the looks on the students' faces, that the lecture would have to be kept to a purely descriptive presentation. The emphasis therefore, was placed on the large number of different branches of engineering that existed and the usefulness to them and their families of the equipment designed and produced by engineers.

Ninety % of the students said that the lecture had given them an understanding of how science is used outside the classroom. With respect to career guidance, 28% felt the material would make them more favourably disposed towards considering a career in the world of engineering.

b) **EXHIBITION** Only 90% of these students enjoyed visiting the mobile exhibition to inspect and operate the working models but 100% said they found the recorded descriptions helpful. The 'dissatisfied' 10% was equally divided between boys and girls. Further examination of the group revealed that 80% of the students thought the length of the recordings was 'just right' with the remaining 20%, all boys, unanimously agreed that they were 'too long'.

The presence of an attendant to explain the models would have been preferred by 40% of this group, and 30% would have liked an attendant and recorded descriptions.

**COMMENT** Observation of these students during their visit to the exhibition showed that the stroboscopic lamp attracted and held their interest mainly, I think, because they saw an application
for it in their youth club dance hall. The remaining models gave them pleasure, especially the bio-medical type, but I don't think they saw them as a natural extension to the science they learnt in the classroom.

**CONCLUSION** The 'new' sixth form student is extremely interested in practical and applied science but lacks the theoretical background to fully understand the ingenuity of solutions to industrial problems. The new material, it seems, can be used effectively with these students provided it is presented more in the form of a careers talk than solely as illustrative inserts to normal science lessons.

Short recorded descriptions are of value to these students but the presence of an attendant is really needed, not so much to offer helpful explanations as to discourage unnecessary exhuberance.

Students in this category were almost the only ones to consider the prestige of a technician to be higher than that of an engineer.

4. FIFTH FORMERS

The lecture/exhibition has been presented to 198 fifth form boys and girls studying in five schools.

To study the effect of the presentation I have divided the students into the two categories shown below.

1) LIKELY TO STUDY SCIENCE IN THE SIXTH-FORM

**ACADEMIC BACKGROUND** All the students in this category were studying physics and at least one other science subject together with mathematics for the 'O' level examination. Fifty-three % of them were hoping to continue studying at the university when they finally left school.

Learning science was an enjoyable task for 97% of them and 86% found that school science had a connection with real life despite the fact that only 25% indicated that their teachers 'often' mentioned industrial applications of science during lessons.

**CAREER OUTLOOK** Sixty-two % of the students in this group
thought they knew what career they wanted to follow. Twenty-seven % of them had considered becoming graduate engineers but only 20% of these thought that school lessons had helped them find out about the world of engineering.

In the opinion of students in this group the prestige of the engineer was rated fourth behind a doctor, professor and a lawyer.

**REACTION TO THE LECTURE/EXHIBITION**

a) **LECTURE** The lecture was enthusiastically received in all schools and 96% of the audiences said they felt it had given them an understanding of how science is used outside the classroom. The presentation appears also to have assisted with career guidance; 18% of the students said the material would help them to give favourable consideration to a career in engineering and 6% were now having second thoughts about following a career in this field.

b) **EXHIBITION** Every student stated that they had enjoyed visiting the mobile exhibition to inspect and operate the working models. Ninety-four % of these students indicated that they found the recorded descriptions helpful. Further examination of this group revealed that 68% of them were satisfied that the length of the recordings were 'just right'. Analysis of the 'dissatisfied' visitors showed that 87% of them felt they were 'too long'.

The presence of an attendant to explain the models would have been preferred by 21% of these fifth formers; just under 50% would have liked an attendant and recorded descriptions.

ii) **UNLIKELY TO STUDY SCIENCE IN THE SIXTH-FORM**

**ACADEMIC BACKGROUND** All the students were studying physics with the intention of entering the 'O' level examination. Half of them were hoping to stay on in a sixth-form with ideas of entering a university when they left school.

Learning science was a pleasure for 67% of them and 78% found the subject had some connection with real life despite the fact that
only 23% indicated that their teachers 'often' mentioned industrial applications of science.

**CAREER OUTLOOK** Forty-four % said they had already decided upon a career but only 22% of the whole group had ever considered becoming graduate engineers. School lessons had helped 30% to learn something about engineering.

In the opinion of students in this group the prestige of the engineer was rated fourth, behind a doctor, professor and lawyer.

**REACTION TO THE LECTURE/EXHIBITION**

a) LECTURE The lecture was well received and every student said that it had helped them to understand how science is used outside the classroom. The presentation failed to assist any of them to give favourable consideration towards a career in the world of engineering; in fact 10% felt that it had helped them to make a decision against entering engineering.

b) EXHIBITION Eighty-nine % of these students said that they had enjoyed visiting the mobile exhibition to inspect and operate the working models. Only 45% of this category found the recorded descriptions helpful, but of these 56% thought the length was 'just right' the remainder were equally divided between thinking them to be 'too short' or 'too long'.

The presence of an attendant to explain the models would have been preferred by 43% of these fifth formers; only 23% would have liked an attendant and recorded descriptions.

**CONCLUSION** The new material is suitable for use with fifth form students 'dedicated' to science, as well as with those who are likely to specialise in other fields. Almost all the 'dedicated' category found the material extremely interesting but every future non-science specialist considered it had helped them gain a better understanding of how science is utilised in real life. This new interest, however, was not strong enough to make them choose engineering as a career.

5. FOURTH FORMERS

The lecture/exhibition has been presented to 160 fourth form
boys and girls studying in five schools.

To study the effect of the presentation I have divided the students into two categories which are shown below.

1) LIKELY TO ENTER THE SIXTH-FORM

**ACADEMIC BACKGROUND**

All of them were studying physics in preparation for the 'O' level examination, and said they derived pleasure from their science lessons. Eighty-three% thought that school science had some connection with everyday life despite the fact that only 36% considered that their teachers 'often' mentioned industrial applications of science.

**CAREER OUTLOOK**

Even though 55% of this group were still trying to choose a career, almost 80% of them had not, so far, given any thought to becoming graduate engineers. In the opinion of 58% of these students school lessons had done very little to help them find out about engineering. It is interesting to note that 75% of the students who had considered becoming engineers, felt that their initial interest in this career had been created outside the school.

The prestige of the engineer was rated fourth behind a doctor, lawyer and professor.

**REACTION TO THE LECTURE/EXHIBITION**

a) LECTURE

It was impossible to judge the reaction of the lecture on these children while it was being presented because they were sitting amongst others who did not intend to enter the sixth-form.

Data obtained from the questionnaire showed that just over 90% of these students felt that the lecture had given them an understanding of how science is used outside the classroom and had influenced 30% of them favourably towards engineering.

b) EXHIBITION

Every student stated they had enjoyed visiting the exhibition to inspect and operate the working models. Ninety% of these students indicated that they found the
recorded descriptions helpful and 66% found the length of the descriptions 'just right'. The 34% who were 'dissatisfied' were equally divided between finding them 'too long' and 'too short'.

The presence of an attendant to explain the models would have been preferred by 30% of these fourth formers; while 80% expressed a wish to have recorded descriptions and an attendant.

ii) UNLIKELY TO ENTER SIXTH-FORM

ACADEMIC BACKGROUND All of them were studying either an 'O' level or a CSE science subject and 77% indicated that these lessons were enjoyable.

Despite the fact that only 28% of this group thought that their teachers 'often' mentioned the industrial applications of science in class, 65% said they found school science had a connection with real life.

CAREER OUTLOOK Seventy-seven % of children in this category had never considered becoming graduate engineers even though 60% of them had decided upon the career they were to follow.

Amongst the minority who had thought of becoming engineers 50% said they did not like learning school science. In the opinion of these students the prestige of an engineer was rated fourth behind a doctor, professor and technician.

REACTION TO THE LECTURE/EXHIBITION

a) LECTURE It was impossible to judge the reaction of the lecture upon these children while it was being presented because they were sitting amongst others who did intend to enter the sixth-form.

Data obtained from the questionnaire, however, showed that 73% of the group felt that it had given them an understanding of how science is used outside the classroom and had influenced 42% of them favourably towards engineering; only two students said that as a result of my visit they had now decided against a career in engineering.
b) EXHIBITION Every student stated that they had enjoyed visiting the mobile exhibition to inspect and operate the working models. Eighty-five% of these students indicated that they found the recorded descriptions helpful and 57% of these found the length of the descriptions 'just right'. Two thirds of those 'dissatisfied' with the length wanted the descriptions longer.

The presence of an attendant to explain the models would have been preferred by 65% of these fourth formers, while 60% expressed a wish to have a recorded description and an attendant.

SUGGESTION The high demand for an attendant amongst this age group may have resulted from the fact that fourth form students are unaccustomed to handling scientific equipment and therefore needed a little extra guidance.

CONCLUSION The vast majority of these students enjoyed learning science but were uncertain about the work undertaken by engineers and the study necessary to qualify; the latter was most noticeable amongst those unlikely to enter the sixth-form.

The new material appealed to all fourth form students and apparently helped many of them to realise how science is used to solve industrial problems, so filling a gap that appears to exist in their normal teaching programme.

The mobile exhibition was appreciated by all fourth year students, irrespective of their academic future. The recorded descriptions were considered to be very helpful but not a complete substitute for a knowledgeable attendant.
1) Just over 500 Educationalists have requested and received copies of the booklet 'Science Serving Society'; more than half of these were sent to practising teachers.

2) The material has received the approval of fourteen Colleges of Education or University Departments of Education.

3) Fifty schools are known to be using the material.

4) It is estimated that over 100 schools will be using the material in the academic year beginning September 1971.

5) The new material has been used successfully with children between 13 and 17 years of age engaged in 'A' level, 'O' level and CSE examination courses, as well as non examination activities.

6) The Shell School Technology Programme has presented the material personally, but, formally, to over 200 teachers and informally - at exhibitions - to a similar number.

7) The lecture/exhibition service has been presented in thirteen schools, by the staff of the Shell School Technology Programme, to almost 700 children aged between 14 and 17 years.
1) Very few schools that have studied the new approach have said that they are unable to implement it through shortage of staff, space, time or finance. It seems, therefore, that the suggested approach does overcome the difficulties originally identified as barriers to the introduction of applied science in schools.

2) The content and format of the booklet 'Science Serving Society' is appreciated in all branches of education, but especially by practising teachers of physics.

3) Practising science teachers desperately in need of information describing modern industrial applications of science appreciate helpful written data on this subject more than films or slides.

4) The new material, in addition to giving relevance to school science lessons, also causes students to consolidate or review their choice of career.

5) The provision of a recorded description, adjacent to working models, is considered to be a helpful teaching technique by all teachers and over 80% of students aged between 14 and 18 years.

6) A recorded description of 80-90 seconds duration completely satisfied over half of the students; girls tended to prefer slightly longer descriptions than boys.

7) Fourth and Fifth form students, interested in science and possessing some theoretical knowledge of physics, prefer to listen to recorded descriptions and operate related working models without human assistance whereas their less scientifically inclined colleagues prefer to receive guidance from an attendant.
8) All students, except those in the less academically inclined categories, consider the prestige of an engineer to be higher than that of a technician, but below that of a doctor, lawyer and professor.

11.19 OVERALL CONCLUSION

The technique and teaching material devised by the School Technology Programme appears to overcome the difficulties normally associated with the introduction of applied science into schools and has proved acceptable to practising teachers, administrators and teacher training establishments.

In addition to helping teachers relate classroom theory to the outside world, the new material provides a source of ideas for projects and could initiate applied science activities which quickly develop into ones offering pupil involvement. Once teachers realise that many students are naturally interested in applied science and organising such work is not unduly difficult with the continuing assistance of a central research body, such as the School Technology Programme, applied science could rapidly spread through the English educational system.
Please answer each question by means of words or a tick as appropriate.

1. Name of your School ____________________________

2. Your specialist teaching subject ___________________

3. Do you have any form of applied science activity in your school?  
   Yes [ ] No [ ]
   If Yes is it
   Science based [ ]
   Craft based [ ]
   Part science Part craft [ ]
   An examinable course [ ]
   An UNexaminable activity [ ]
   Some other form [ ] please elaborate

If No is it due to
   Insufficient money [ ]
   Insufficient space [ ]
   You do not consider it necessary [ ]
   Some other reason [ ] please elaborate

4. Do you consider that the boys and girls in your school understand the nature of the work undertaken by a graduate engineer?  
   Yes [ ] No [ ]
   If Yes what age group ________________

5. Do you normally include some industrial applications of science in your lessons?  
   Yes [ ] No [ ]
   If Yes please state the source of your information.
   If No is the reason
   You do not consider it to be necessary [ ]
   No time available [ ]
   You do not have the chance to find the relevant information [ ]
   Some other reason [ ] please elaborate
Science is used outside the classroom?

If YES do you think the examples are

| Very good | Uninspiring | Outdated | Trivial | Too difficult to appreciate | Adequate |

7. Did you find the industrial applications of school science mentioned in the lecture today?

| Interesting | Ordinary | Dull | Exceptionally interesting |

8. Would sets of slides (with notes) of the type shown today, sold at £1.50 for 20, be of assistance to you?

9. Would printed sheets giving the information presented today help with your classroom teaching?

If YES please state the age and ability range of children you would use the material with

<table>
<thead>
<tr>
<th>Age</th>
<th>Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>'A' level students</td>
<td>'O' level students</td>
</tr>
</tbody>
</table>

10. Did you enjoy visiting the Exhibition Unit?

11. Did you find the recorded descriptions helpful in understanding the models?

12. Were the recorded descriptions

a) too long
b) not long enough
c) just right

13. Would you prefer an attendant to explain the models to you?

14. Would you like the University of Surrey School Technology Team to visit your school to help your students by means of

a lecture
the Exhibition Unit
both

I would not want the team to visit our school
Please complete this questionnaire by writing the name of your school at the top and then placing ticks or comments in the appropriate boxes after each question and return it to G.C. Sneed, Director, Shell School Technology Programme, Institute for Educational Technology, University of Surrey, Guildford, Surrey.

Name of School

1. Have you received a copy of our booklet 'Science Serving Society'? [YES NO]

2. Have you read sufficient of the booklet to form an opinion about its contents? [YES NO]

3. Did you as a teacher find the material interesting? [YES NO]

4. Have you included any of the industrial applications of science that are described into your science lessons? [YES NO]

   Please name the lesson ____________________________

   If the answer to this question is YES please answer questions 5 & 7
   If the answer to this question is NO please answer questions 6 & 7

5(a) Please indicate the age(s) and academic level(s) of the children exposed to the material.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>11 - 12</th>
<th>12 - 13</th>
<th>13 - 14</th>
<th>14 - 15</th>
<th>15 - 16</th>
<th>16 - 17</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Academic Level</th>
<th>'A' level</th>
<th>'O' level</th>
<th>CSE</th>
<th>NON EXAMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
</tbody>
</table>

(b) Did the children appear interested [YES NO]

(b) Did the children appear excited [YES NO]

(b) Did the children appear bored [YES NO]

(b) Did the children appear no reaction [YES NO]

(c) Did the children ask questions relating to the material? [YES NO]

(d) Were the answers you needed in the booklet? [YES NO]

(e) Did you enjoy presenting the applications? [YES NO]

(f) Do you intend to continue using the material? [YES NO]

(g) Has the presentation of the material helped your students, and school, to take an interest in applied science? [YES NO]
6. Is the reason for NOT using the material:-

You do not consider it to be suitable?
The appropriate lessons have not occurred?
Some other reason - please state.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7. Please write any other comments you would like to make about the material in the space below.

________________________________________________________________________

________________________________________________________________________

THANK YOU
Please complete this questionnaire, by writing the name and address of your College, Education Department or Education Office at the top and then placing ticks or comments after each question, and return it to G.C. Sneed, Director, Shell School Technology Programme, Institute for Educational Technology, University of Surrey, Guildford, Surrey.

Name & Address of Organisation

________________________________________________________________________

1. Have you received a copy of our booklet 'Science Serving Society'? YES NO

2. Have you read sufficient of the booklet to form an opinion about its contents? YES NO

3. Did you personally find the material interesting? YES NO

4. For which age group(s) and academic level(s) of children do you consider the material suitable?

   Age Group
   11 - 12
   12 - 13
   13 - 14
   14 - 15
   15 - 16
   16 - 17
   NONE

   Academic Level
   'A' level
   'O' level
   CSE
   NON EXAMINATION
   NONE

5. Have you recommended the material to serving teachers or teachers in training? YES NO

If YES have you had any reaction from serving teachers/trainee teachers who have read the material used the material YES NO

Please outline the nature of their reaction.

________________________________________________________________________

________________________________________________________________________

If NO

a) Will you be recommending the material in the near future? YES NO
b) Did you consider the material to be unsuitable?  

YES  NO 

If YES please indicate why it is unsuitable.

__________________________________________

__________________________________________

c) Some other reason - please state.

__________________________________________

__________________________________________

6. Please write any other comments you would like to make about the material in the space below.

__________________________________________

__________________________________________

__________________________________________

THANK YOU
1. Indicate the subjects you are studying for the 'A' level examination.

<table>
<thead>
<tr>
<th>Physics</th>
<th>Pure Mathematics</th>
<th>Combined Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>Applied Mathematics</td>
<td>Geology</td>
</tr>
</tbody>
</table>

Any other (please state)

2. In which aspect of science are you most interested?
   i) Theoretical
   ii) Applied
   iii) Don't know

3. Are you hoping to continue studying at a university when you leave school?
   Yes
   No

If YES do you wish to study?
   i) a pure science course
   ii) an engineering course
   iii) an arts course
   iv) some other course

4. What has influenced your choice of course the most?
   School careers advice
   Your Headmaster
   Your Parents
   Your success in a particular subject
   The way in which a subject was taught at school
   Some other reason

5. What career do you hope to follow after leaving university?

6. Have you ever considered becoming a graduate engineer?
   Yes
   No

7. Have your school lessons ever helped you to find out what engineering is about?
   Yes
   No

8. Please number the following jobs in the order that you think carry the greatest prestige:
   Technician
   Teacher
   Doctor
   Lawyer
   Engineer
   Professor
10. Do you find the science that you learn at school has any connection with real life?

11. Has the illustrated lecture presented today given you an understanding of how science is used outside the classroom?

12. Do your science teachers tell you about the industrial applications of science?

13. Will the information you have heard today help you to make a career choice either in favour of, or against engineering?

14. Did you enjoy visiting the Exhibition Unit?

15. Would you have preferred the models to have been mounted in your classroom/laboratory instead of in the Exhibition Unit?

16. Did you find the recorded description helpful in understanding the models?

17. Were the recorded descriptions
   a) too long □
   b) not long enough □
   c) just right □

18. Would you prefer an attendant to explain the models to you?

19. Would you like both an attendant and recorded descriptions?

20. Are you □ MALE □ FEMALE
UNIVERSITY OF SURREY: SCHOOL TECHNOLOGY PROGRAMME

FORM: SCHOOL:

Please answer each question by ticking the appropriate boxes.

1. If you study any of the following subjects please indicate which ones.

<table>
<thead>
<tr>
<th>Physics</th>
<th>Biology</th>
<th>Woodwork</th>
<th>Technical Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>Mathematics</td>
<td>Metalwork</td>
<td>Domestic Science</td>
</tr>
</tbody>
</table>

2. Do you expect to stay at school and enter the sixth form?

| YES | NO | Don't know |

3. Are you hoping to study science in the sixth form?

| YES | NO | Don't know |

If NO is the reason:-

the subject seems to have no connection with everyday life
too difficult to learn
not very interesting
Some other reason - please state

4. Do you hope to go to university when you leave school?

| YES | NO | Don't know |

5. Have you decided what career you would like to follow?

| YES | NO |

6. Have you ever considered becoming a graduate engineer?

| YES | NO |

7. Have your school lessons ever helped you to find out what engineering is about?

| YES | NO |

8. Please number the following jobs in the order that you think carry the greatest prestige:

- Technician
- Teacher
- Doctor
- Lawyer
- Engineer
- Professor
10. Do you find the science that you learn at school has any connection with real life?

YES  NO

11. Has the illustrated lecture presented today given you an understanding of how science is used outside the classroom?

YES  NO  ONLY A LITTLE

12. Do your science teachers tell you about the industrial applications of science?

OFTEN  NEVER  SOME TIMES

13. Will the information you have heard today help you to make a career choice either in favour of, or against engineering?

YES FOR AGAINST

14. Did you enjoy visiting the Exhibition Unit?

YES  NO

15. Would you have preferred the models to have been mounted in your classroom/laboratory instead of in the Exhibition Unit?

YES  NO

16. Did you find the recorded description helpful in understanding the models?

YES  NO

17. Were the recorded descriptions
   a) too long
   b) not long enough
   c) just right

   YES  NO

18. Would you prefer an attendant to explain the models to you?

YES  NO  NO PREFERENCE

19. Would you like both an attendant and recorded descriptions?

YES  NO

20. Are you
    MALE  FEMALE
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