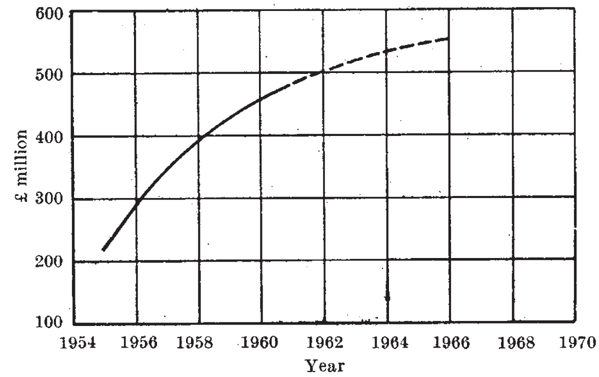

Fig. 1. Total British research expenditure (adjusted to take account of the fall in the value of the £)

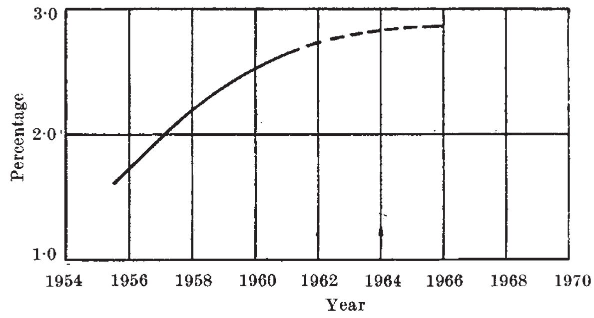

Fig. 2. Research expenditure as a percentage of the 'gross domestic product'

wisdom of this is further demonstrated by the graph of total expenditure on research and development, since 1955, which, as can be seen from Fig. 1, seems to be levelling off at £550 million per annum, and also this expenditure expressed as a percentage of the 'gross domestic product' where the graph suggests a levelling around 2·8 per cent (Fig. 2).

In the second half of his address, Dr. Rotherham was concerned with the prospects for metallurgists in the future and the part to be played by the professional institutions. The enhanced status of metallurgy, in which the universities have played a major part, is indicated by the fact that in 1962, despite the recession, only six men who graduated that year in the subject were known to be still looking for jobs six months later. The immediate outlook is for about a 9 per cent increase per annum in the demand, even apart from increased employment in institutions of higher education and the special research expansion called for in the iron and steel industries.

A pressing need is seen by Dr. Rotherham in effecting a better and more realistic image of the applied sciences to school children, their teachers and parents, and the public generally. In this the professional institutions can play a major part, especially since their function, with the increase of university graduates, will become less and less concerned with their own examinations.

It is concluded, therefore, that the numbers of men qualifying in science and engineering are increasing and will continue to increase within the foreseeable future. Membership of professional institutions is showing a corresponding growth. The full employment of these men is governed by industrial expansion and modernization, or putting it another way, commercially successful industries will need more qualified men to design, install and manage new plant. These industries will also provide the money, either directly or from taxes paid to the Exchequer, for increasingly expensive research and technological development. In contrast, any falling off in productivity will lead to a slowing up of plant modernization and research effort. Present indications are that industry will want all the qualified men it can get. F. C. THOMPSON

FUNCTION OF AN INDUSTRIAL RESEARCH LABORATORY

THE above title poses questions which will always be controversial between scientists whether 'pure' or applied—since there are no precise answers. The points at issue will always hinge round the query whether an industrial laboratory should rightly embark on problems of academic interest, and vice versa. Can these two extremes be combined without detriment to both? The principal arguments are familiar. On one hand is the alleged ivory-tower complex of the academic scientist, isolating him from the practical realities of what he is investigating. On the other hand is the severely practical approach of the technologist, who is not allowed time or opportunity to wander into the by-ways of his subject, thereby perhaps missing new vistas which could lead to important discoveries. The giant industrial companies can, of course, afford to set up as independent establishments laboratories for fundamental research akin to those of the universities. At the other end of the scale the small company can afford to cater only for its day-to-day problems, and these inevitably are purely practical.

The problem therefore becomes of real significance with companies somewhere between these two extremes, and there are many in this category. The opening of New Butler's Court, Beaconsfield, Bucks, the Research Centre of the Wiggins Teape Group of papermakers, on March 20, 1963, following a visit of inspection by the Duke of Edinburgh on the previous day, directs attention to a particular case of this kind. Butler's Court, as purchased by the Company in 1956 on the site of Edmund Burke's former home, provided 13,500 ft.^{2} of laboratory space. Since then a further 19,000 ft.^{2} of laboratories and pilot plant buildings have been erected, and the above occasion was the inauguration of these by the chairman, Mr. L. Farrow.

Wiggins Teape are papermakers and paper converters operating, in the United Kingdom alone, 15 actual paper mills and 15 factories where associated manufactures are carried on. Although the general research requirements of the paper industry are handled by the British Paper and Board Industry Research Association which the Wiggins Teape Group supports, the Company has perhaps more specialized problems than any other of its kind, since it manufactures speciality papers and in particular the so-called 'industrial papers'. Examples are: papers for impregnation with plastics, photographic base papers, leather papers, photo-copying and other copying papers, and chart papers resistant to water and oil. These, of course, are in addition to the usual types of high-grade writings and printings, and speciality wrappings such as vegetable parchment and glassine.

With a wide and varied production of this nature the interface between pure and applied science becomes increasingly diffuse. However, Dr. H. F. Rance, technical director, recently summed up the policy of his company quite unambiguously by pointing out that research and development are regarded as a business activity which must show returns commensurate with expenditure. Since they exist to promote change, in the interest of the

Company, they must themselves be flexible and adaptable. For this reason Butler's Court has been built, item by item, to meet specific needs.

Such a policy does not of necessity exclude fundamental research. Thus a basic approach has been made to the investigation of the structure of paper with special reference to the statistical geometry of the arrangement of fibres in a sheet. This has enabled the arrangement of the fibres during the formation of the sheet to be predicted mathematically, and thence it should be possible to predict also many of the physical properties of the finished paper. Such work has a natural practical sequel in the possibility of designing papers with special properties, and in the subsequent mill control necessary to ensure that these properties are achieved continuously in practice. Hence the existence of a printing room and a pilot plant aqueous coater, solvent coater and an extrusion laminator which, together with the papermaking pilot plant area, workshop and electricity substation, cost £235,500 for building and equipment. The coating plant is a special feature, since it can run at 3,000 ft. per min and can be operated with air knife or blade coater methods.

Finally, the implementation of all this development work involves an effective system of mill control to ensure that the papers are manufactured to the correct standard of quality, and, of course, profitably. Quality control in the form of factory instrumentation, the development and application of testing instruments, and a system of routine testing, is a major activity directed from Butler's Court.

This, briefly, is one Company's general conception of the function of an industrial research laboratory. The recent opening of the extension to Butler's Court is at once full justification for the initial step taken in 1956, and a tribute to the direction of the laboratory in the intervening period.

JULIUS GRANT

POTASSIUM–ARGON AGES OF SLATES AND THEIR GEOLOGICAL SIGNIFICANCE

By C. T. HARPER

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A PROGRAMME of potassium–argon dating is being undertaken at Oxford on material from the British Caledonides, and during the course of this work the possibility of using whole-rock samples of slate for age determination was investigated. A few whole-rock slate ages have appeared in the literature[1–4] and recent work[5] has demonstrated the possibilities of using slates on a regional basis to date an orogenic (Hercynian) belt. In the Grampian Highlands of Scotland, a wide range of metamorphic grade allows whole-rock potassium–argon ages of slates to be compared with ages of muscovite and biotite from schists belonging to the same (Caledonian) metamorphic complex.

The metamorphic rocks south of the Great Glen consist of two major units, the Central Highland Granulites, similar to the Moine Series to the north, and the Dalradian Series. The Dalradian Series is divided into two structural and stratigraphic groups, the Ballapel Foundation and the Iltay Nappe Complex, each characterized by a distinct stratigraphic succession. The succession in the Iltay Nappe Complex can be divided into Upper, Middle and Lower Dalradian[6,7]. Slates and schists were collected for age determination from the Upper and Middle Dalradian of the Iltay Nappe, and from the Ballapel Foundation. Schists were also collected from the Central Highland Granulites.

The Dalradian slates are characterized by fine-grained muscovite–chlorite–quartz assemblages, the amount of muscovite relative to chlorite and quartz being directly proportional to the K_2O content of the rock. Although it was not possible to separate micas from any of the slates, X-ray diffraction analysis confirms the presence of muscovite, and shows that in all cases it possesses a high degree of crystallinity. Basal (001) muscovite peaks show no tendency to asymmetry, and the overall diffraction pattern is indistinguishable from that of completely recrystallized muscovite in the schists. Paragonite–muscovite–chlorite–quartz assemblages have been found in three slates[8]. The Middle Dalradian slates collected from the Iltay Nappe Complex have a characteristically strong strain-slip cleavage superimposed on the main slaty (flow) cleavage, while Upper Dalradian slates from the Nappe Complex commonly show little or no strain-slip cleavage. Strain-slip cleavage is particularly strong in slates collected from the Ballapel Foundation, and in some cases becomes the main cleavage in these rocks.

All samples for age determination were crushed and sieved to $-40 + 80$ mesh. Muscovite and/or biotite in the schists were separated by conventional methods. The $-40 + 80$ mesh fraction obtained from the slates was used for analysis without further treatment, the -80 mesh fraction being discarded owing to the possibility of argon loss from this finely ground material. Potassium was determined by flame photometer; argon was measured on a Reynolds-type, bakeable, mass spectrometer by isotope dilution with enriched argon-38; ages were calculated using the following constants:

Isotope abundance:	$^{40}K = 0{\cdot}0119$ atomic per cent
Decay constants:	$\lambda\beta = 4{\cdot}72 \times 10^{-10}$ yr.$^{-1}$
	$\lambda e = 0{\cdot}584 \times 10^{-10}$ yr.$^{-1}$

The calculated ages are summarized in Fig. 1. Each point represents the potassium–argon age at one locality. Samples are divided into 4 classes, and the isotope ages of the samples in each class are arranged in numerical order and plotted in cumulative frequency. The mean age and standard deviation ($2\bar{\sigma}$) for each class is as follows:

Mica	
(1) Muscovites (from Central Highland Granulite and Dalradian mica schists)	436 ± 9 m.y.
(2) Biotites (from Central Highland Granulite and Dalradian mica schists)	424 ± 6 m.y.
Whole rock	
(3) Slates (from Middle Dalradian and Ballapel Foundation)	431 ± 6 m.y.
(4) Slates (from Upper Dalradian)	461 ± 8 m.y.

The mean ages of muscovites, biotites and Middle Dalradian and Ballapel Foundation slates are equal within the limits of error, and taken together give a weighted mean of 429 ± 4 m.y. (compare averages obtained from Moine schists[9–11]). The mean age for the Upper Dalradian slates is significantly higher.

The observed similarity between Middle Dalradian and Ballapel Foundation slate and mica ages suggests that preferential loss of argon from the slates has not occurred and that whole-rock potassium–argon ages obtained from slates are equivalent to those obtained from metamorphic micas. Ages obtained from the Upper Dalradian slates, however, fall outside the range shown by the other slates and the micas, with two exceptions (Fig. 1). A Macduff slate from the north-east Dalradian, the only dated Upper Dalradian slate which does not come either from the