Chapter 4

The Ceramic Laboratory

Scientific methods of testing and research are finding ever-increasing application in the ceramic industry in a number of different forms. There are three main fields of application, which, however, overlap considerably.

1. **Pure Research**, the investigation of the nature of ceramic materials and their reactions and the nature and cause of their properties. The results of such work lead to the descriptions given in Chapters 1 and 2 and are an important aid to development.

2. **Development**, the systematic improvement of ceramic products towards a desired end.

3. **Control**, the checking of properties of materials, processes and products to achieve uniform results of the kind indicated by development projects, and the tracing of sources of trouble.

The methods used may be applicable to one or more of these fields. Some are simple and may be described in detail here; others require costly apparatus and/or skilled technicians, and for these only the principle will be described.

Throughout the work in ceramic laboratories there is frequently the need to make up samples on lines similar to those used in the works. Small-scale equipment for preparing these is therefore required, *e.g.* crushing rolls, rotary crushers, jaw crushers, edge runner mills, jar mills; mixers, blungers, sieves, magnets, filter presses, pugmills; extruding augers, hand presses; drying ovens, small kilns; masonry saw and grinders for preparing samples for tests. The manufacturers of full-size equipment often also produce a laboratory model. German (G27) gives an outline of the type of small-scale equipment required in a works laboratory.

**RECORDING OF LABORATORY TESTS**

The need for adequate recording of methods, samples and results cannot be over-emphasised. Whereas research tests may be adapted to the sample, control tests, which are very frequently purely comparative *must* be done by standard methods which are laid down in writing.

It is also essential that accurate record be kept of every sample entering the laboratory with its date, its origin, any treatment it has already undergone in
the works and in which machines, followed by the test results. It is only in this way that any systematic error will be detected (W62).

WIDELY APPLICABLE TESTS

CHEMICAL ANALYSIS

Chemical analysis has very wide applications in research, development and control, even though the nature of ceramic raw materials and their reactions necessitates the use of many other methods besides analysis. Knowledge of the chemical composition of raw materials, bodies, glazes and ceramic products is frequently very useful, but because complete analyses of silicate materials by ‘classical’ methods take a week to perform, they were not formerly used as routine control measures. Sometimes only one or two components must be checked, and quick chemical methods were evolved for them. Instruments now greatly speed up chemical analysis so that it can be used increasingly for control purposes.

Methods of carrying out complete or ‘ultimate’ chemical analyses of silicate materials and any other raw materials required in the ceramic industry have been described in the detail which is their due in books devoted entirely to the subject, e.g. Hillebrand, *Analysis of Silicates* (1919) (H91), Groves, *Silicate Analysis* (1937) (G92), Jakob, *Chemische Analyse der Gesteine und Silikatschen Mineralien* (1952) (J16). We will therefore not enter into the subject here. The classical method of complete analysis is mainly gravimetric, occasionally assisted with colorimetric measurements. It relies on previous knowledge of the elements present and takes from six to ten days to complete.

For speedier work microchemical techniques are frequently very suitable. The field has become too wide to be dealt with here. There are numerous works on the subject, e.g. Emich, *Microchemical Laboratory Manual* (E16).

There are also, many specific tests for individual components. These generally involve specific chemical reactions followed by gravimetric, volumetric, or colorimetric estimation. This last has been developed to give quick and accurate results by the use of physical instruments instead of the human eye.

Bennett, Hawley and Eardley (B37) describe in detail a method of carrying out a complete analysis of silicate materials by rapid methods for the individual constituents, using normal chemical laboratory equipment plus a flame photometer. The following oxides can be determined: SiO₂, Al₂O₃, Fe₂O₃, TiO₂, CaO, MgO and the alkalies. Interference to the methods is found if phosphates (e.g. bone, or bone china body) and vanadates are present, or the magnesia content is high, e.g. in magnesite. A complete analysis can be carried out in one day and individual determinations in four hours.

*Colorimetric Analysis*

Colour tests in qualitative analysis are widespread. The use of colour for quantitative work is possible when there is only one coloured substance