Large-scale Chemistry at the Imperial College of Science and Technology.

IT is now generally recognised that a student in chemistry who wishes to rise to any position of prominence in his profession, either in the industry or in academic life, must first obtain a thorough grounding in his subject by passing through a recognised honours school, and that he must then devote one or two years to training in the methods of research. It is usually during the third year of his honours course that the student first comes in contact with the realities of organic chemistry, and a considerable portion of his time during this period is devoted to a series of preparations in the organic laboratory. The organic laboratory is generally fitted with every type of glass and porcelain apparatus necessary for the student's needs, and he learns here the usual operations and requirements involved in the preparation of a number of typical organic substances. This training is undoubtedly of the greatest value, yet, because someone at some time ordained that there should be two kinds of chemistry, namely, that carried out in glass vessels and that effected in vessels of metal, the unfortunate student, who must needs satisfy a board of examiners who have passed through the same course as he, is instructed in the former kind of chemistry, and left either to imagine the fundamental conditions underlying the latter kind or to learn them in sorrow and tribulation under the more exacting conditions of the factory.

Owing possibly to his early training as an engineer, the present writer has always felt acutely the anomaly of this position, and has sought for an opportunity to erect a laboratory which should contain, like the ordinary small-scale laboratory, types of appliances suitable for all purposes—reduced replicas of those used on the industrial scale, but sufficiently large to render the usual industrial operations essential. This opportunity has now arisen owing to the generosity of an old student of the Imperial College of Science and Technology, Mr. W. G. Whiffen.

A laboratory of this kind will serve several purposes. It will, for example, enable the student, and especially the research student, to familiarise himself with operations carried out in vessels into which he cannot see and the contents of which he cannot transport by hand. He will become acquainted with factors, such as heat transference, cost of production, etc., fundamental in large-scale work, but which are of minor importance in ordinary laboratory practice and usually ignored. He will learn, moreover, in the small fitting-shop attached to the laboratory how to make the necessary metal connections and to erect plant of metal in the same way as he is taught to build up apparatus of glass in the small-scale laboratory. Knowledge of this kind cannot fail to be of the greatest service both to students intending to enter industry and to those who have decided to follow an academic life. Indeed, the laboratory is not a "technical laboratory" in the strict sense of this much misused term, but rather the logical outcome of any adequate system of training in chemistry, and ought, therefore, to find a place in the equipment of every chemical school of university standing

Again, the advantage to the research student will be very great, because he will be able to prepare his initial material on the large scale, and it will be possible for him to carry out, if necessary, any new preparation which he may have discovered on a scale approaching that required for its commercial production.

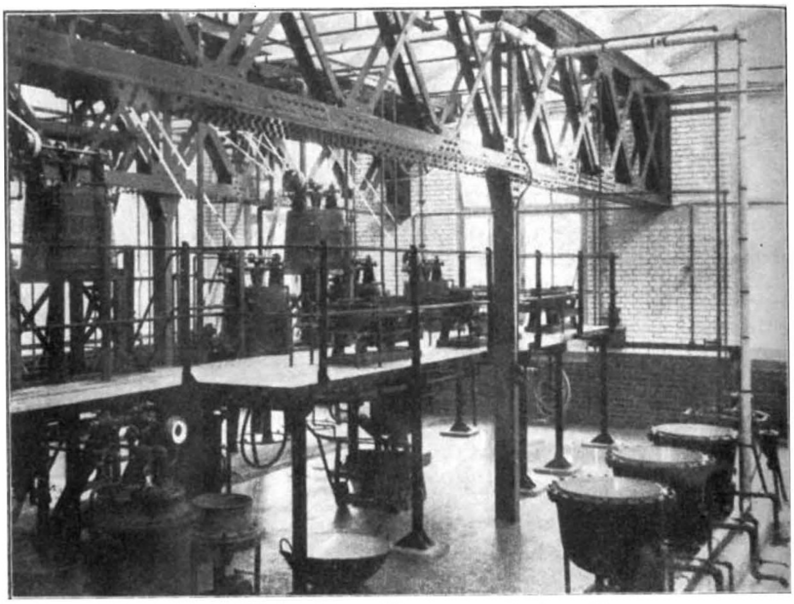
FIG. 1.—Staging showing filter presses and mixing tubs.

Two questions have frequently been asked, namely: (1) How will it be possible to initiate a large number of students into operations such as those which it is proposed to carry out in this laboratory? and (2) How can the material prepared be disposed of? The answer to the first question is that the third-year students will work in batches of six or eight under the direction of one student as foreman, and, of course, under the general control of the demonstrator in charge of the laboratory. Each batch will carry through one complete preparation, say nitrobenzene—aniline—acetanilide—*p*-nitroacetanilide—*p*-nitrophenol, and will obtain the pure product. It will be possible, if necessary, for five or six such batches to work at the same time, and it can be arranged that students from the main laboratory will, during their organic course, pass for a week at a time into the larger-scale laboratory.

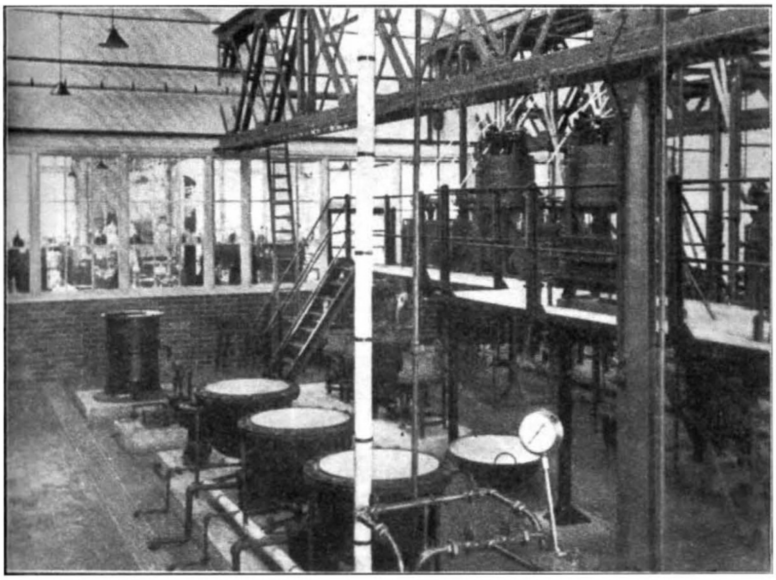

FIG. 2.—View towards S.E. showing evaporating pans, centrifuges, and box filters. Research laboratory through screen.

Regarding the second question, the operations carried out will lead to the production of material which can not only be used for further work on the intermediate scale, but will also be utilised in the small-scale laboratory for the ordinary students' preparations. It is more, however, in connection with the preparation of initial material for research that the new laboratory will be of the greatest service from both instructional and utilitarian points of view. No one who has conducted a school of research containing twenty or more research students can have failed to realise the waste of time entailed by having to go back to the beginning every time the supply of material is exhausted. It is evident that much time will be saved if large quantities of the initial material can be prepared as soon as the conditions for its preparation have been ascertained. The general design of the laboratory has been worked out in conjunction with the late Dr. J. C. Cain, after consultation with Mr. F. H. Carr, then in charge of Messrs. Boot's research laboratories at Nottingham. The general erection of the plant has been due to the skill and interest of Mr. James Robinson, of Messrs. Mather and Platt, Ltd.

Description of the Laboratory.

The laboratory occupies a floor-space 50 ft. by 47 ft., exclusive of the adjoining fitting-shop and research laboratory. It is 22 ft. high, and is covered by an asphalted ferro-concrete roof arranged for semi-indirect north lighting, the light being transmitted through safety (armoured) glass and reflected from the white ceilings and from the white glazed surface of the walls. The advantages of this type of lighting are well known, and in the present instance the success of the arrangement is complete, a clear, steady light being obtained throughout the day. The floor is water-tight and acid-proof. It is paved with red tiles laid in such a way as to shed into the two main drains (Figs. 1 and 2), which run parallel to each other throughout the length of the room. With this arrangement—a most necessary one in a laboratory of this kind—it is a simple matter to give the floor a wholesale wash-down with fire-hoses, six of which are situated at various convenient points.

The centre of the laboratory is occupied by a platform (Figs. 1 and 2), approximately 6 ft. by 40 ft., supported on stanchions 5 ft. above the floor. On and above this, fixed on suitable steel structures, are types of apparatus, such as open-top tubs, which, in general, are most conveniently emptied through a bottom run-off by gravity.

All fixed chemical apparatus, except that on the central platform, is set in concrete foundations carried to a height of 6 in. above the floor-level, whilst the motor, air compressor, and vacuum pumps are bedded in concrete blocks raised to 15–18 in. above the floor.

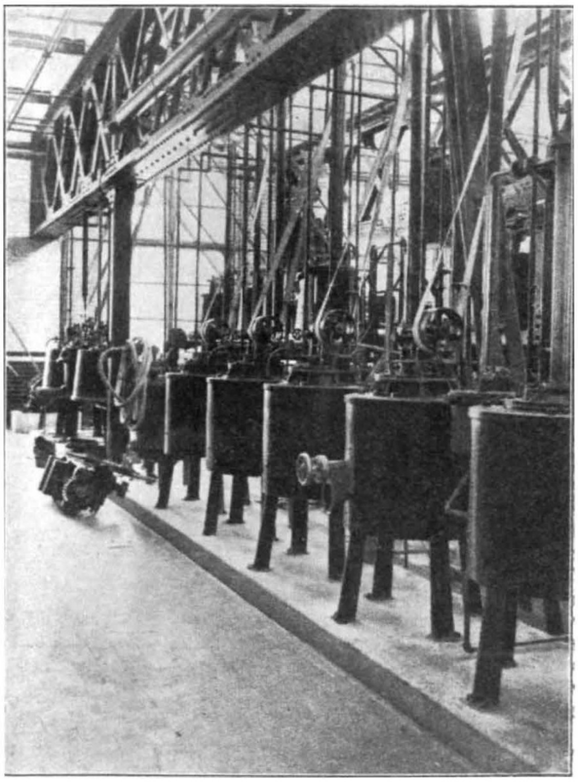

FIG. 3.—Series of general reaction pots.

The power for stirring, air compression, etc., is obtained from a 15-b.h.p. totally enclosed and ventilated acid-proof motor, and is transmitted by two parallel lines of shafting hung in ball-bearings along the whole length of the laboratory and in the fitting-shop beyond. Resting on the shaft-brackets are the main pipes (showing through the lattice girder in Fig. 4) of the seven principal services:—Steam, 80-lb. air, 10-lb. air, vacuum, hot and cold water, and gas.

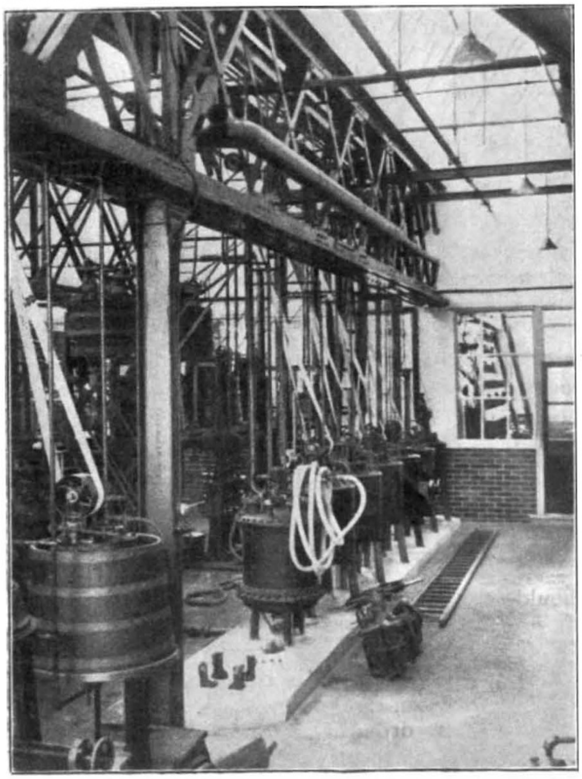
FIG. 4.—View showing distribution of high- and low-pressure air, hot and cold water, steam, vacuum, and gas services, with fitting-shop at back.

Both high- and low-pressure air are obtained from the same compressor (Fig. 5), which, by an appropriate arrangement of blow-off and reducing valves, delivers into two separate receivers at the required pressures. From these the air is led through high- and low-pressure mains to all parts of the laboratory, the former main being in permanent connection with the mild steel (lead lines) liquor receivers from which the filter-presses are charged, and the latter with most of the other apparatus in the laboratory; for it is the low-pressure air which is put to such general uses as blowing liquor from one vessel to another, stirring where mechanical stirring is inconvenient, blowpipe work, and so on.

The main vacuum pump (Fig. 5, at back), which exhausts a 40-gallon vacuum chamber to the vapour tension of water in about two minutes, is used not only for "sucking" the contents of open-top vessels into the liquor tanks, but also for vacuum distillation and for exhausting the vacuum drying ovens, which, however, are connected in addition to a small pump capable of maintaining a vacuum, once established in the ovens, for any length of time.

Steam, gas, and cold water enter the laboratory from without. Hot water is obtained by passing water and steam through Mather and Platt unit heaters, which raise the water to the boiling point as quickly as the pressure in the mains is able to force it through the delivery pipes.

The types of apparatus permanently fixed in the laboratory are intended to render possible on the greater scale all ordinary chemical operations. The digestors, for example (Figs. 3 and 4), include vessels suitable for nitration, sulphonation, fusion with alkalis, acid and alkaline reduction, acid and alkaline hydrolysis, esterification—in fact, almost every operation which in an ordinary laboratory one associates with a flask on a sand-bath. Heating under pressure is performed in gas-fired heavy mild steel autoclaves. The stills include an apparatus for distillation in a current of saturated or superheated steam, a gas-fired still with a Young's column, a vacuum still with an arrangement of receivers equivalent in its use to the Perkin triangle, and a pan for vacuum evaporation. The redwood tubs on the platform are fitted with stirring gear, and arranged suitably for such operations as diazotisation and coupling and for washing solid precipitates and oils; they are the beakers and separating funnels of the laboratory. Apparatus for the three chief methods of filtration, under pressure by filter-presses (on platform, Fig. 1), by vacuum in box-filters (Fig. 1, left), and by centrifuging (one small and one larger machine appear on the left in Fig. 2), is installed, and the principal operations involved in the later treatment of a filter-press cake—for instance, squeezing in a hydraulic press (Fig. 2) or in a screw press (Fig. 4, lying on floor), drying in evacuated steam-ovens, and grinding in an edge-runner mill (not shown)—are all provided for.

A word should be said regarding the steps which have been taken to solve the problem of ventilation. General ventilation is provided by a 36-in. fan working in an aperture in the wall. In addition, however, a main draught trunk, operated by a separate

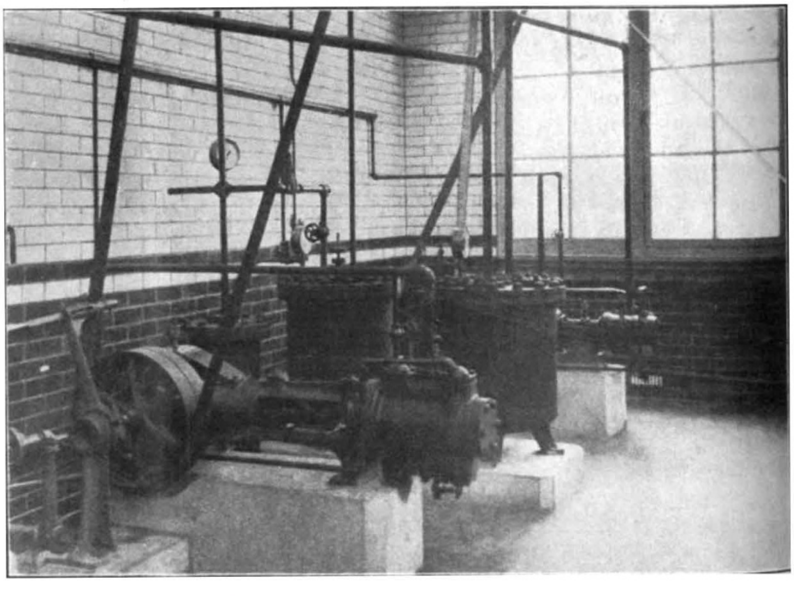
FIG. 5.—Vacuum and air-pressure services.

fan, has been arranged to pick up vent-pipes and gas-flues from all digestors, as well as the exit pipes of the counterpoised draught-hoods which are pulled down over the evaporating pans when evaporations are in progress.

The surroundings of the laboratory are shown in some of the photographs. In Fig. 2 appears the adjoining research laboratory, whilst Fig. 4 shows a corner of the fitting-shop and engineering store. This invaluable adjunct contains a stock of pipes, fittings, and tools, some small power-driven machines, including a screw-cutting lathe, and working places for carpentering, fitting, and soldering. The chemical store, which is arranged to contain casks, drums, and carboys, as well as Winchesters, does not appear in the photographs.

With regard to the question of slinging and heavy work generally, the numerous overhead principals provide so many points from which a lifting block may be hung that it was not considered necessary to install a travelling crane. Two rubber-tyred bogeys, one of which has been specially designed, suffice for the carriage of all the heavier objects which we are likely to have to handle J. F. T.

Great British Droughts.

By CHAS. HARDING.

IT is fortunately seldom that such persistent dry weather has to be chronicled as that which has now continued for several months. A more complete history of the drought will doubtless be written when all possible facts have been collected.

At Greenwich Observatory the records show that the rainfall has been less than the normal for nine consecutive months, from October, 1920, to June, 1921. The total measurement for the whole period is 9·78 in., which is 7·74 in. below the average for the 100 years ending 1915, and only 56 per cent. of the normal. This is the driest period from October to June in the last 105 years; the next driest corresponding period occurred in 1879–80, when the measurement was 10·50 in. There is only one longer period at Greenwich—November, 1846, to January, 1848, a period of fifteen consecutive months—with the rainfall below the normal. The controlling factors of the weather have commonly been a low barometer in the north of the British Isles, and a relatively higher barometer with anticyclonic conditions in the South of England.

In addition to the Greenwich observations, those at Eastbourne have been chosen to represent the more southern portion of the kingdom. The drought at Eastbourne is scarcely so severe, since the rainfall for each of the months December, 1920, and January, 1921, was in excess of the average for the period of thirty-five years ending 1915, chosen as the normal by the Meteorological Office. The total rainfall for the nine months from October, 1920, to June, 1921, inclusive, is 15·62 in., which is 7·95 in. in defect, and 66 per cent. of the average fall. This is 10 per cent. of the average more than at Greenwich.

Attempts have been made from time to time to detect a weather cycle, but so far these have not been very successful. The favourite cycle with meteorologists is that corresponding with the periodicity of solar activity; but, so far as the general weather is concerned, it does not yield satisfactory results. Prof. Brückner, of Berne, has discussed the subject of periodic variations and changes of climate in detail, and his discussion is conducted on lines which perhaps might well be followed by others. For the fluctuations of rainfall he has made use of observations at 321 points on the earth's surface, and of these no fewer than 198 are in Europe. Prof. Brückner deals with averages for five years, and the period found for the cycle is thirty to thirty-five years. Continuing the cycle to the present time, a period of deficiency of rainfall is shown for the years 1921–25; the previous period of deficiency was 1891–95. The next period of excess should occur in 1936–40. The present deficiency of rain seems decidedly a fulfilment of Prof. Brückner's cycle.

An absolute drought is reckoned as more than fourteen consecutive days wholly without rain, and a partial drought is a period of more than twenty-eight consecutive days the aggregate rainfall of which does not exceed 0·01 in. per diem. No absolute drought has occurred at Greenwich this year, and the only partial drought was from February 1 to March 5, a period of thirty-three days during which the total rainfall was 0·24 in. The spring drought of 1893 is probably the most severe of recent years; the absolute drought continued for forty-four days, whilst the partial drought at Dungeness lasted for 127 days, and at North Ockenden, Romford, Essex, for 128 days. The abnormal summer of 1911 experienced three absolute droughts at Greenwich—April 11 to 24, fourteen days; July 1 to 23, twenty-three days; and August 2 to 18, seventeen days. There was an exceptionally long partial drought continuing for fifty days, from June 30 to August 18; the aggregate measurement of rain during the period was 0·33 in. As many as three absolute droughts occurred in London in the years 1868 and 1887, and four in the year 1858. In 1880 there was an absolute drought for twenty-eight days—from August 9 to September 5. In the year 1716 it is recorded that, in consequence of a long drought and a south-west wind, the River Thames became so low that thousands of persons passed across on foot under the arches of London Bridge.

There is a great diversity in the periodicity of rainfall, and two consecutive summers often differ widely from each other, as shown by the rains in 1920 and 1921. In 1903, a remarkably wet year, the aggregate measurement of rain at