speed than reciprocating engines, the necessity of seeing that the propellers were suitable not only as regards form, but also as regards their being in proper mechanical balance, has received considerably more attention. Experiments have been carried out in two destroyers and a Town class cruiser built at the Commonwealth Naval Dockyard at Sydney. The paper describes experiments made by rotating the propeller at speed on spring bearings, noting the vibration and removing material from certain parts of the blade and even the boss. From subsequent observations on the ships it was apparent that there was a decided improvement. The problem to be solved is by no means easy, since removal of material from the blades of a propeller has the effect of altering the pitch, and naval architects, as a rule, have very stringent specifications regarding the exactitude of the pitch of a propeller.

Sir George Greenhill contributed a paper on the theory of wave-motion on water. In this paper the author discusses mathematically the trochoidal wave as treated by Rankine. Mr. John H. Macalpine gave particulars of marine applications of reduction gears of the floating-frame type. The success of this type of gear appears to be very marked. The first floating-frame gear was installed at Granite City, Illinois, in 1911; when examined on April 30, 1916, the scraper marks were still visible on the gear teeth. Originally these marks were of imperceptible depth.

Messrs. P. A. Hillhouse and W. H. Riddlesworth presented a paper on launching. This paper contains an account of some interesting experiments made at the Fairfield Shipbuilding Yard. A model of the ship was constructed and arranged in all respects to be a reduced copy. Model ways were constructed and a tank arranged with water at proper tide level. By these means valuable information was obtained regarding the motion of the ship during launching. The authors make an interesting suggestion whereby an accurate record of the complete motion of the actual vessel from start to finish might be obtained by means of the kinematograph. Two machines would be required, one placed near the stern of the vessel when on the slip, and the other somewhat less than the length of the vessel further aft. Both would stand at a convenient distance away from the vessel's side, and would have their axes at right angles to the middle line of the berth. In the field of view of each, two uprights would be placed as near to the vessel's side as possible, and on each upright a vertical scale of feet would be clearly marked in black and white. On the ship's side would be painted a continuous longitudinal white line crossed by short vertical lines numbered in succession from either end. As the vessel moved the cameras would record continuously the movements of the white line in relation to the ship and to the water level and ground ways, and the whole motion could be reconstructed. If, in addition, there could be placed in front of each camera a large clock-face with seconds pointer, the two sets of photographs could be correlated and a record of velocities obtained.

BRITISH FILTER-PAPERS.

AS is well known to laboratory workers, in pre-war days the better kinds of filter-paper used in chemical operations were not produced in this country. They were imported chiefly from Germany and Sweden. In particular, the so-called "ashless" filters, from which most of the mineral matters have been extracted by treatment with hydrochloric and hydrofluoric acids, had made the name of one German firm familiar in probably every chemical laboratory of importance throughout the kingdom. The outbreak of war, however, stopped the supply of German filters, and British paper-makers turned their attention to meeting the demand.

The qualities required in filter-paper depend upon the purpose to which it is to be applied. Thus for certain technical operations, such as the filtration of oils and fruit juices, a soft paper of open texture is desirable. Further, as such paper is often used for filtration under pressure, a high degree of elasticity is required in it to prevent fracture. In analytical work, on the other hand, whilst a paper with open texture which filters rapidly is preferable for flocculent precipitates like ferric hydroxide, a close-texture paper is required for the retention of fine precipitates such as barium sulphate. Moreover, the proportion of mineral matter is important. Compounds of calcium and iron, frequently with a little copper, and sometimes silica and alumina, are the chief mineral impurities found in filter-paper; and for accurate quantitative work the amount of these should be small. Indeed, it should preferably be so small as to be negligible except where a high degree of exactitude is required. In any case, it should be definitely known, and ought always to be stated on the packets of filters by the makers.

The ability to retain fine precipitates, a minimum proportion of ash, and reasonable rapidity of filtration are thus the chief desiderata in the best filters for chemical laboratory purposes. The last alone is sufficient in many technical operations. Discussing this question in the *Analyst* some months ago, Messrs. Bevan and Bacon indicated that for paper required to filter with moderate rapidity the ratio of the volume of the paper to that of its constituent fibres should be about 3·5 to 1. It does, in fact, as a rule vary between the limits 3 and 4·5 to 1. "Pin-holes" are sometimes found in paper having this ratio or "bulk" (as the technical term goes); they are attributable to faults in the milling.

Some time ago specimens of the filter-papers now produced in this country were supplied to us by three manufacturing firms, namely, Messrs. W. and R. Balston, Ltd., Maidstone; Messrs. J. Barcham Green and Son, Maidstone; and Messrs. Evans, Adlard and Co., Ltd., Winchcombe. Judging by the reports furnished with certain of the papers, supplemented by tests applied in actual working practice, a number of the samples compare quite well with the foreign filters which they have replaced. It is evident that a serious endeavour is being made to produce filters which will compare favourably in quality with even the best of those hitherto imported, and the efforts appear to have met already with a considerable measure of success. Naturally, it will take time and careful study completely to outvie the foreign articles, which are the result of long specialisation. Uniformity of product is an important point to aim at, so that the user may know that he can rely upon the constancy of the quality. There is no obvious reason why British paper-makers should not, with proper technical advice, compete successfully with foreign manufacturers in this branch of industry, and, in fact, there is good reason to believe that they will do so. In this matter, as in so many others, we ought not to have to revert to the *status quo ante bellum.*

COMPULSORY CONTINUATION CLASSES.

THE final report of the Departmental Committee on Juvenile Education in Relation to Employment after the War has just been issued (Cd. 8512, price 6*d.* net).

The terms of reference of the committee were:—To consider what steps should be taken to make

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provision for the education and instruction of children and young persons after the war, regard being had particularly to the interests of those (i) who have been abnormally employed during the war; (ii) who cannot immediately find advantageous employment; (iii) who require special training for employment. Among the twenty-three recommendations made by the committee are the following:—

(1) That a uniform elementary school leaving age of fourteen be established by statute for all districts, urban and rural and that all exemptions, total or partial, from compulsory attendance below that age be abolished.

(2) That steps be taken, by better staffing and other improvements in the upper classes of elementary schools, to ensure the maximum benefit from the last years of school life.

(3) That it be an obligation on the local education authority in each area to provide suitable continuation classes for young persons between the ages of fourteen and eighteen, and to submit to the Board of Education a plan for the organisation of such a system, together with proposals for putting it into effect.

(4) That it be an obligation upon all young persons between fourteen and eighteen years of age to attend such day continuation classes as may be prescribed for them by the local education authority, during a number of hours to be fixed by statute, which should be not less than eight hours a week, for forty weeks in the year, with the exception of: (*a*) Those who are under efficient full-time instruction in some other manner; (*b*) those who have completed a satisfactory course in a secondary school recognised as efficient by the Board of Education and are not less than sixteen; (*c*) those who have passed the matriculation examination of a British university, or an equivalent examination, and are not less than sixteen; (*d*) those who are under part-time instruction of a kind rot regarded as unsuitable by the Board of Education and entailing a substantially greater amount of study in the daytime than the amount to be required by statute.

(5) That all classes at which attendance is compulsory be held between the hours of 8 a.m. and 7 p.m.

(6) That it be an obligation on all employers of young persons under eighteen to give them the necessary facilities for attendance at the statutory continuation classes prescribed for them by the local education authority.

(7) That where there is already a statutory limitation upon the hours of labour, the permitted hours of labour be reduced by the number of those required for the continuation classes

(8) That the curriculum of the continuation classes include general, practical, and technical instruction, and that provision be made for continuous physical training and for medical inspection, and for clinical treatment where necessary, up to the age of eighteen.

(9) That suitable courses of training be established and adequate salaries be provided for teachers of continuation classes.

(10) That the system of continuation classes come normally into operation on an appointed day as early as possible after the end of the war, and that the Board of Education have power to make deferring orders fixing later appointed days within a limited period, where necessary, for the whole or part of the area of any local education authority.

(11) That the State grants in aid of present as well as future expenditure on education be simplified and very substantially increased.

RECENT PROGRESS IN SPECTROSCOPY.[1]

TEN years ago the subject of Prof. Crew's vice-presidential address was "Facts and Theories in Spectroscopy." Since that time some notable discoveries have been made and some remarkable theories have challenged attention. It is my purpose to review a few of the more important experimental results and to discuss the relations of some of them to theories brought before you in two recent vice-presidential addresses on "Atomic Theories of Radiation" and "The Theory of the Nucleus Atom." Inasmuch as it will be necessary to refer to them, I will restate the salient features of the theories which have attracted the most attention.

Planck derived an expression for the spectral energy distribution of black-body radiation from the assumption that the radiation was emitted and absorbed by electric oscillators in definite quanta, each equal to the frequency of the oscillator multiplied by a universal constant, h, the wirkungsquantum. Later he modified this theory so far as absorption is concerned. Einstein and others went farther in assuming that these quanta preserve their identity in their propagation through space, thus reviving a form of corpuscular theory. This extreme view has been generally abandoned, but it has been found impossible to explain away the wirkungsquantum h. It appears in too many relations to be the result of chance. The work of Millikan in particular proves the exact validity of Einstein's relation $Ve=h(\nu-\nu_0)$ in the photoelectric effect, in which Ve is the measure of the emission energy of the electrons, ν the frequency of the incident light, and ν_0 the minimum frequency which will cause emission of electrons. A similar relation appears to hold good in many cases of X-ray and light spectra. It seems probable that this constant depends upon atomic structure only, and affects radiation through space only in so far as emission and absorption are determined by atomic structure.

The theory of the nucleus atom is likewise of fundamental importance in spectroscopy. The work of Rutherford and others leaves no escape from the conclusion that the nucleus of the atom is a concentrated group of positive charges and electrons, with an excess of positive elementary charges approximately equal to half the atomic weight, while the same number of electrons circulate about the nucleus in rings. The spectroscopist must try to fit his theories to these probable facts, but he is met at the outset with apparently insuperable difficulties in accounting for the stability of such atoms and for the manifold complexity of spectra according to accepted electrodynamical laws. Bohr cut the Gordian knot by supposing that the classic laws apply only to conditions of stability, when no energy is radiated, and that radiation attends the transition of an electron from one state of stability to another, the frequency being determined by the relation that h multiplied by the frequency is equal to the difference between the energies of the system in the two stable states. In the case of hydrogen, to which he assigns one radiating electron and one nucleus charge, it is difficult to account for the existence of so many stable states, for the failure to radiate while subject to uniform radial acceleration, and for monochromatic radiation while passing between two positions of stability. Nevertheless, Bohr derived an expression like that of Rydberg which locates accurately not only the Balmer series, but also an infra-red and an ultraviolet series predicted by Ritz and found by Paschen

[1] Address delivered to Section B—Physics—of the American Association for the Advancement of Science at the New York meeting, December, 1916 by the chairman of the Section, Prof. E. P. Lewis.

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