THE NATIONAL PHYSICAL LABORATORY

OPEN DAYS

ABOUT 3,500 visitors saw the scientific work on display at the National Physical Laboratory during May 9–10. They came from industry, Government Departments, universities and national boards. Lectures were given in Glazebrook Hall by Dr. A. M. Uttley on "Learning and Recognizing" and by Dr. N. P. Allen on "The Work of Metallurgy Division". As many as 150 items from the research programme of the Laboratory were exhibited and a necessarily small selection of these is described here. Those selected are new to the programme of the National Physical Laboratory or show significant new developments.

Of the work on display, an item which attracted great interest was the research on optical masers being carried out in the Light Division. Effort is being concentrated on the development of improved solid-state optical masers for the photomultiplier region of the spectrum and on the application of these in experiments which require extremely high intensity or spectral purity. In one of the Laboratory's high-power ruby masers the rod of synthetic ruby is 4 in. long and ⅜ in. in diameter; it operates at room temperature with one end unsilvered. Several joules of red light are emitted in a nearly parallel beam during an output flash lasting less than one ten-thousandth of a second. An experiment was demonstrated to show how extremely high temperatures could be produced by focusing such a beam on to a small spot. In such circumstances the time is too brief for heat to leak away by conduction and a single flash melted a hole several thousandths of an inch in diameter through a steel razor blade.

Visitors to Light Division also saw the new 2-m photometric integrating sphere which enables precision photometric measurement to be carried out more rapidly. Made of aluminium alloy it opens on hinges so that lamps can be changed simply by walking in without the use of steps or drawbridge. Its diameter is sufficient to enable tubular fluorescent lamps up to 5 ft. long to be accurately measured.

The Applied Physics Division is dealing with the problem of noise and in particular that caused by aircraft. Experiments have been carried out to determine limits within which the so-called 'perceived noise-level' scale is a suitable criterion for comparison of aircraft noises. This scale has already proved satisfactory for comparing noise from piston-engined aircraft, normal jets and helicopters: it is now being applied to noise from ducted-fan jet engines. The Division staged a display of drawings, graphs and photographs which showed how the scale was established. Visitors were also asked to co-operate in the research itself by acting, in groups, as juries for the subjective assessment of various recorded noises to which they listened. The ultimate aim of this work is to decide the highest noise-levels, allowing for frequency of occurrence, which people can accept during various activities of living and to relate these to the least practicable noise-level that may be expected from aircraft now being developed when operating under economic conditions and with strict flight control.

The Division also displayed its newly developed high-precision inductively coupled double-ratio bridge which is to be used in particular for the measurement of temperatures to the highest possible accuracy, using platinum resistance thermometers. In this instrument the ratio of voltage division, to the first order of error, does not depend on the properties of the materials used but on the turns ratio, which is constant. The very high input impedance of the bridge reduces to negligibly small proportions errors in measurement due to the resistances of the potential leads of the thermometers used.

In the Ship Division Hydrodynamics Laboratory at Feltham an experiment was staged to demonstrate the measurement of forces on a surface-piercing hydrofoil. This was mounted on a National Physical Laboratory six-component balance capable of measuring large forces, up to 4,000 lb. lift and 1,000 lb. of drag or side force. The balance is of advanced design and is simple in principle because of the use of very sensitive semiconductor strain gauges. The gauge outputs are automatically recorded in digitized form on punched tape or on an electric typewriter. This is essential because of the short time available for recording data at the high carriage speeds which have to be used in this work. As the speed of a submerged hydrofoil increases it reaches a critical value above which cavitation occurs, this value being dependent on foil shape, attitude and submergence. When the foil pierces the surface the cavity forming on it often spreads to penetrate to the atmosphere and then fills with air at atmospheric pressure. The forces acting on the foil under this 'ventilation' condition are different from those which occur when it operates in a totally wet condition. Recent investigations have indicated that it should be possible to design hydrofoils to be as efficient when vented as when completely wet. If such designs can be achieved then considerable increases in operating speeds of hydrofoil ships would be possible. The experiments being carried out in the Ship Division with various types of foil units are to determine the conditions which control the inception of ventilation and their performance when ventilation has occurred.

The Ship Division also exhibited some of the research on hovercraft which is being carried out for the Ministry of Aviation. The main objective is to study the fundamental principles of the hydrodynamic aspects of hovercraft. Visitors saw a model designed for studying the wave-making qualities of a circular planform which was mounted on a general purpose static rig for testing (Fig. 1). A comb of wave probes was also shown; these are used to measure the wave-pattern generated by the model. It is hoped to establish the correlation between wave resistance and energy flux in the measured wave-pattern.

An experiment demonstrated by the Basic Physics Division is the measurement, by a guest worker from the University of Oxford, of molecular quadrupole moments by an analogue of the Kerr effect. The importance of these in the theory of electronic

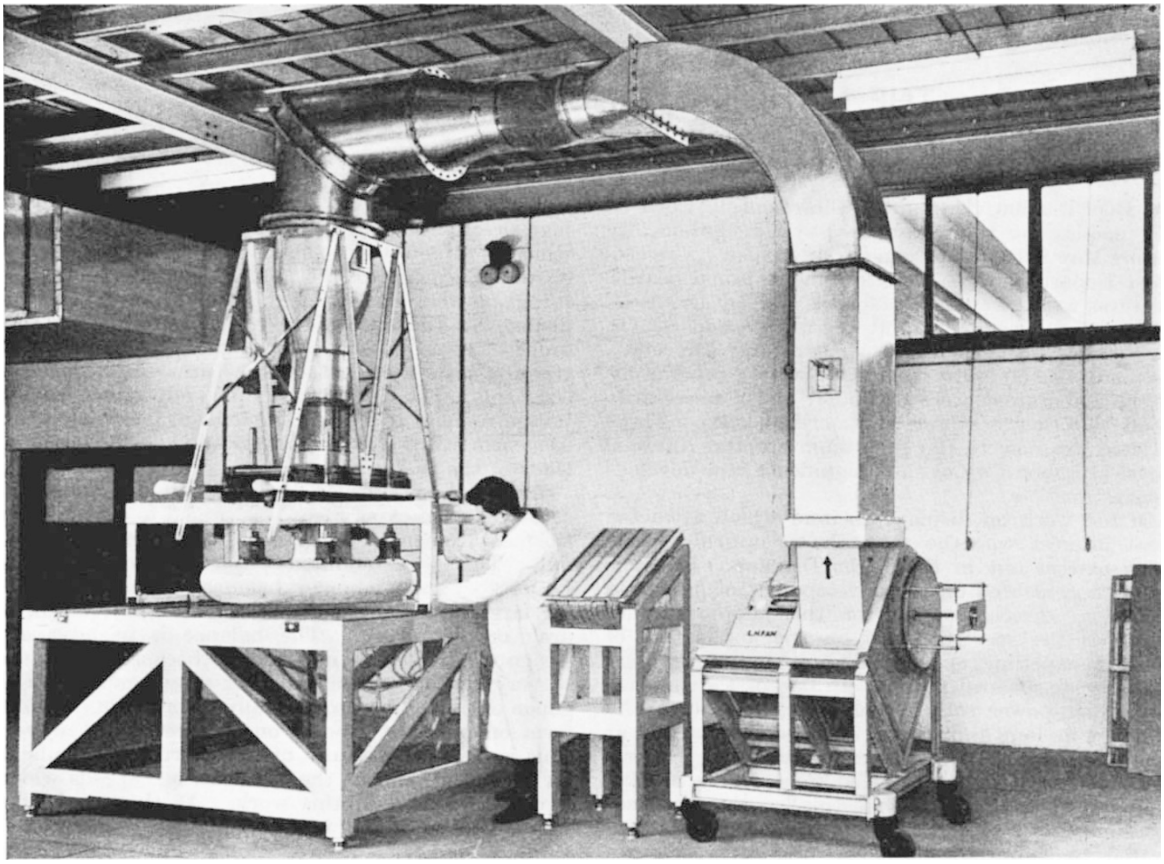

Fig. 1. Hovercraft model under test on static rig in the Ship Division Hydrodynamics Laboratory

structure of molecules is greater than that of dipole moments. Their values are also important in physical phenomena involving intermolecular potentials. Accurate values of molecular quadrupole moments have not been available in the past. Estimates of them have had to be made, based on indirect methods which have depended on poor approximations and doubtful assumptions. In the experiment shown an inhomogeneous electric field, produced between two parallel spring steel wires, is applied to a gas and this leads to a birefringence as a direct result of orientation by the field gradient of molecular quadrupole moments. The value of the molecular quadrupole moment is obtained from the measure of the depolarization of linearly polarized light which has been directed as an intense parallel beam along an axis midway between the two wires. Since the birefringence induced by the inhomogeneity of the field is an odd function of the applied voltage, for axially symmetric molecules not only the magnitude but also the sign of the molecular quadrupole moment can be determined. Since also the ordinary Kerr effect birefringence is an even function of the applied voltage its contribution can be 'tuned out' in an a.-c. experiment thus allowing direct measurement of quadrupole moments even in molecules with permanent dipole moments.

A combined exhibit by the Metallurgy and Basic Physics Divisions demonstrated the value of having different fields of research within the same organization as at the National Physical Laboratory. Investigation of the structure of polymers may indicate ways of improving the properties of industrial plastics. Crystalline samples of polythene can be made by precipitation from a 4 per cent xylene solution; during crystallization the long chain molecules apparently fold into short ribbons, the crystallites consisting of successive layers of the folded molecules. It is thought that similar effects occur, in an irregular manner, in the less crystalline commercial materials. Even for the crystalline samples the full details of the molecular folding are not known, but the fold-length is approximately constant for precipitations from a given temperature and is about 100 Å. The regular spacing of the fold planes gives rise to X-ray scattering in the form of a halo at low angles while the diffuse scattering at low angles which accompanies it gives a more general indication of the structure of the material. The special X-ray camera developed in the Metallurgy Division enabled a study of this scattering to be made. The investigation of metals by means of this camera led to an interpretation of the results with polythene in terms of classical metallurgy. Visitors were told that for the polymer work the camera had been improved by the addition of radiation counters. The intensity of the diffuse scattering could therefore be measured.

The Metallurgy Division demonstrated apparatus for the preparation of single crystals of niobium and tantalum by electron bombardment of a vertical rod, and also for the horizontal zone-refining of iron on a water-cooled copper hearth. The latter technique has proved to be the most promising method for the preparation of iron of very high purity in quantities of a few pounds, since those impurities which are of greatest interest from a metallurgical point of view, for example, carbon, sulphur and phosphorus, are those with the most favourable distribution coefficients. The water-cooled hearth obviates contamination from the crucible and is more readily adaptable to a large scale than floating-zone refining. A 3-lb. ingot of iron was shown with a carbon content of 4 parts per million over most of its length. By further purification of the gas atmosphere over the specimen it is hoped to reduce this to 1 per million. Such iron will have considerable interest for the study of the movement of dislocations, using transmission electron microscopy.

The provision of a highly stable frequency standard by optical pumping of a cæsium gas cell was demonstrated by the Standards Division. Stabilities of ± 4 parts in 10^{11} have been obtained over a few hours and ± 1 part in 10^{10} over six months. Cæsium vapour is contained in a small cylindrical glass cell. The illumination of this with resonance spectral lines from a cæsium lamp causes a redistribution of the energy states of the atoms (optical pumping) with some absorption of the light, detected by a photocell. When a microwave field at the cæsium hyperfine transition frequency is applied to the cell more light is absorbed since the energy-level distribution tends to return to normal. As the microwave frequency passes through the hyperfine transition value, therefore, a small but sharp decrease occurs in the transmitted light. Frequency modulation of the microwave field, at a low frequency-rate, produces a low frequency output from the photocell, the phase of which is dependent on which side of the transition the mean microwave frequency lies. This phase-sensitive signal can be applied to pull a quartz oscillator the multiplied frequency of which gives the microwave frequency. The frequency stability of the system is determined by the constancy of various factors affecting the shift of the hyperfine transition frequency; these are the buffer gas in the cell, the light intensity, the temperature and the magnetic field.

The Standards Division also displayed an infra-red monochromator and specially designed furnaces to show how monochromatic radiation in the infra-red could be used to realize the thermodynamic scale between 200° C and 1,063° C by means of Planck's law of radiation. This has been rendered possible by the development of sensitive photo-conductive detectors of infra-red radiation, such as the lead-telluride cell.

The Aerodynamics Division exhibited a general cross-section of its basic research in relation to flight of aircraft. Much of the recent work has been concerned with stability and flutter properties of new aircraft shapes and their structural strength under severe conditions of flight at supersonic speeds. The Division displayed a series of experiments dealing with slender wings in unsteady motion. Knowledge is being gained of the aerodynamic forces relevant to the transient effects of a gust and of possible structural deformation of wing surfaces linked with oscillatory behaviour. The work shown included a water-tunnel study of the flow under certain conditions of transient motion and the measurement of oscillatory forces and surface pressures on rigid and deforming delta wings in a low-speed wind tunnel. On display also was a newly designed apparatus for the measurement of oscillatory forces on sting-mounted models in transonic, supersonic and hypersonic flow.

Apparatus on view in the Autonomics Division demonstrated an attempt to develop a high-speed character recognition machine capable of reading the results printed out by normal cash registers and listing machines. The operation of the machine is based on multiple auto-correlation techniques devised in the Division. It uses a novel combination of scan displacement and video signal delay to obtain a multitude of copies of any character placed before a flying spot scanner. Groups of copies are correlated in a manner which defines and measures the amount of distinctive features present in the character scanned. The character can then be identified from the statement of features present. It is anticipated that the reading speed will exceed 1,000 characters per sec.

Because of the inherent difficulty of displaying their work the Mathematics Division listed the main items of their research and visitors were invited to discuss those of interest to them with members of the Division. Specific demonstrations were also arranged if required.

The staff of the Laboratory welcome the opportunity during the open days of showing the latest developments in their work to other scientific workers and to technical staff from industry. In particular, these occasions offer industrial firms a chance to discover in what ways the work of the National Physical Laboratory may be of interest to them. The open days in 1963 will be held during May 15–16 and applications for invitations should be addressed to the Director, National Physical Laboratory, Teddington, Middlesex. J. R. ILLINGWORTH

MARINE SCIENCE LABORATORIES, MENAI BRIDGE

By DR. D. J. CRISP

Director

THE opening of the Marine Science Laboratories of the University of Wales on June 5 by Sir Harry Melville marked the end of the first ten years of growth of the Marine Biology Station and the beginning of further developments in oceanography. In his opening address Sir Harry referred to the fruitful areas of research lying between established disciplines and congratulated the University College of North Wales on its foresight in planning for the integration of marine biology with a new department soon to be established in the cognate subject of physical oceanography, so that effective collaboration in all aspects of oceanography—physical, chemical and biological—would be encouraged. The buildings have therefore been renamed the Marine Science Laboratories.