National Physical Laboratory, Teddington.

INSPECTION BY THE GENERAL BOARD.

ON Tuesday, June 23, the General Board of the National Physical Laboratory made its annual inspection of the laboratory. As is customary, a large number of visitors, including members of scientific and technical institutions, government departments and industrial organisations, were present and were received by Sir Gowland Hopkins, president of the Royal Society, chairman of the General Board, Sir Richard Glazebrook, chairman of the Executive Committee, and Sir Joseph Petavel, director of the Laboratory.

A comprehensive range of experiments and apparatus, illustrating the various activities of the Laboratory, was shown.

In the Aerodynamics Department, the compressed air wind tunnel, a model of which was shown in 1928, has nearly reached completion and was thrown open for inspection. This tunnel, which consists of a main steel shell 50 ft. in length and 17 ft. in diameter, enclosing the working tunnel of 6 ft. diameter, is constructed of rolled steel rings closed by hemispherical end castings, both made at the works of Messrs. John Brown, Ltd., Sheffield. The tunnel is of the open jet, return flow type and is capable of withstanding pressures up to 25 atmospheres. Three 400 h.p. compressors are housed in an adjoining room and can raise the pressure to its full value in about 80 minutes. The propeller for circulating the air is driven by an external 400 h.p. motor, the shaft passing through a stuffing box. It is anticipated that an air speed of about 90 ft. per sec. will be possible at the highest working pressure, corresponding to a speed of about 150 miles per hour in the case of an average aeroplane under normal atmospheric conditions.

In one of the four-foot wind tunnels demonstrations were given of the buffeting of aeroplane tails, a phenomenon revealed by tests subsequent to the Meopham accident. This phenomenon is due to the character of the airflow behind an aerofoil, when the latter approaches stalling incidence, particularly at high speeds. Under these conditions the airflow becomes periodic, and the eddies so formed may impinge on the tail, and in special circumstances may set up serious vibration. To demonstrate the phenomenon, an aerofoil was mounted in the tunnel at stalling incidence and means were provided of setting the tail in any desired position relative to it. The tail was provided with suitable flat springs to allow vibration to take place, the oscillations being projected by appropriate mirrors on to photographic paper. The investigation is directed to the study of the limits of the eddying wake produced by different wing sections at various angles of incidence, and to the buffeting effects on a tail placed at various positions inside and outside the wake.

Apparatus for the precise reproduction of the spinning motion of an aeroplane has been constructed in the Department. Hitherto, in wind tunnel tests relating to spinning problems, the model has been rotated about an axis through the centre of gravity. This does not take account of the fact that the latter moves in a helix. The new apparatus allows for this factor. The model is offset at any desired distance from the rotating axle by means of a radius arm, the rotation being effected by means of a motor and epicyclic gearing. The rolling moment is determined by measurement of the mechanical reaction on the gear system due to the model.

Of interest also was a method of rendering visible the airflow round a body placed in an airstream. Fine platinum wires, half an inch apart, are mounted on two vertical supports situated in front of the body and heated to redness by means of an electric current. Each wire gives rise to a band of heated air which persists for some distance downstream. These bands, owing to their decreased refractivity, cast a shadow on a screen when suitably illuminated and thus give a direct picture of the streamlines. These can be examined by means of a stroboscope if necessary. Such phenomena as the behaviour of an aerofoil at stalling incidence and of the Handley Page slot are clearly brought out.

In the Engineering Department an investigation was in progress for the Roads Department of the Ministry of Transport on the forces due to wheel impacts on a road. To determine such forces it is necessary to know the corresponding spring load and the linear accelerations of two points on the axle. To measure the latter, special accelerometers have been designed and constructed in the Department. These instruments depend on the variation of a mutual inductance by the impact. Alternating current of definite frequency is supplied to the primary coil and the secondary current, after rectification, is recorded by an oscillograph. The load on the springs is determined by mounting the normal suspension springs on stiff springs, the deflection of one end of which is determined by a method similar to that utilised in the accelerometers. The whole equipment is mounted on a special trailer, which is provided with a dark room for development of the records on the road. The effects of different types of tyre and sizes of wheel are being investigated.

In connexion with the investigation of the mechanical properties of materials at high temperatures, creep tests have been made on a variety of materials—cast and forged steels, alloy steels, and non-ferrous alloys—and the effects of an atmosphere of steam and of a hot air blast have been investigated. To obtain greater refinement in such tests, very accurate control of the temperature of the specimens has been found necessary. For this purpose a further batch of creep units has been constructed. These are controlled by a thermionic valve bridge and suitable relays, and the temperature can be maintained constant within $\pm 0{\cdot}5^\circ$ C. The extension of the specimen is measured by means of Marten's mirror extensometers, capable of measuring to one millionth of an inch on a five-inch length. A new 25-ton testing machine to accommodate the new creep units has been installed. With this machine low rates of creep can be obtained.

Attention has been given to a method of testing the hardness of thin coatings of electrolytically desposited metals such as chromium. Some success has been obtained with a diamond scratch method, using suitable loads.

Experiments have also been made to determine the minimum dimensions for correct results of a test piece suitable for use in ball indentation tests. Sample test pieces of various shapes and thicknesses which have been used in the investigation were on view.

Of interest also was apparatus for determining the hardness of white metal bearings at temperatures up to 350° F. The tests are made on the metal in actual half bearings ready for service. A Vickers loading machine is used, the bearing being immersed in an oil bath mounted on the machine and maintained at the required temperature. The apparatus was shown in use for tests on a big-end bearing.

Attention has also been given to the problem of

corrosion fatigue, which is being dealt with under two aspects. In one case experiments have been made on a single crystal of aluminium stressed while immersed in a slow stream of tap water. Corrosion was found to occur preferentially on the site of previously formed slip bands, and to this corrosion the ultimate failure of the crystal was mainly due. Specimen test pieces showing the corrosion product (aluminium hydroxide) were on view. In the second case the relative strengths of aircraft steels and alloys have been determined when tested *in vacuo*, in various gases, in a salt spray, and with and without protective coatings. The specimens are subjected to reversed bending and to reversed direct stresses under these conditions.

Research work has been carried out to determine the causes of failure of wrought iron chains. The investigation has shown that failure may be caused by the occurrence of burnt iron, which is due to an excess of phosphorus and silicon, and dates back to the puddling stage of manufacture. A test has been devised to reveal the presence of such defective material. Work is also in hand to determine the effects of service conditions and of subsequent heat treatment, such as annealing, upon the threaded parts of shackles and upon the pitch of chains. Special machines have been devised in which service conditions are reproduced.

The Department has been responsible for the design of standard forms of crane hooks. Sample hooks have been prepared and tested for strength and have been found extremely satisfactory. The designs have been adopted by the British Engineering Standards Association. Specimen hooks both before and after test were on view.

An investigation was in progress to study the velocity of travel and the wave-length of waves set up on the surface of water by the action of wind. The waves are produced in a 12 in. by 12 in. rectangular tunnel 50 ft. in length. By observation with a stroboscope it is possible to determine the frequency and wave-length at the same time. From photographs of the wave motion, scale models of the actual waves can be constructed and the distribution of wind pressure over them determined in a wind tunnel. The relation between the wave-length and the velocity approximates very closely to that calculated on the basis of the irrotational motion of a frictionless wind.

Of interest also was a liquid gauge used for simultaneous measurements of the wind pressure at a number of points on a building. The tubes contain benzyl alcohol and a solution of calcium chloride; these liquids give a clear surface of separation and the difference of their densities is small. A sensitivity five times that of the ordinary water gauge is attained. A flashlight photograph is taken of the gauge, and the pressures corresponding to different points of the building are read off from the print.

In the Metallurgy Department, research work was in progress in connexion with the effect of various aqueous solutions of salts, such as may be present in boilers, on the behaviour of boiler steels when stressed. Steel specimens which have been subjected to the action of various solutions are bent in alternate directions at intervals of 24 hours. It has been shown that the effect of continuous immersion in tap water is to reduce the survival of the specimens (expressed as the number of bends before fracture) by 30 per cent as compared with the endurance in air. Concentrated solutions of sodium chloride have a similar but less severe effect.

The investigation of the effect of flue gases, mentioned last year, has been continued, and has now reached the stage when a batch of a dozen wires can be tested simultaneously for the corrosive action of flue gases. Improved apparatus has been installed, permitting the tests to be carried out at 400° C., 500° C., and 600° C.

An investigation has been undertaken on behalf of the Aeronautical Research Committee in connexion with the constitution and structure of magnesium alloys. The work is directed towards improvements of mechanical properties by the discovery of new alloys in which there is a considerable solubility of the added element, or a change of solubility with temperature sufficient to permit age hardening. Samples of such alloys were on view.

Beryllium is usually prepared by electrolysis of its fused chloride at white heat. A method has, however, been developed in the Department for the electrodeposition of the metal from its fused salts at a much lower temperature. Coherent deposits on copper have been obtained in this way and specimens were exhibited.

Research work has been undertaken for the British Non-Ferrous Metals Association to determine the effects on the strength of copper of such impurities as bismuth, arsenic, antimony, and oxygen. Prepared specimens in the form of strips are subjected to bending in alternate directions in a special machine.

One of the difficulties encountered in the determination of the melting points of some alloys is the presence of vapour, which prevents the use of an optical pyrometer and may contaminate thermocouples. To avoid this difficulty, work is in progress to produce special refractories which are impervious to such vapour. It has been possible to make small tubes of glazed alumina which are satisfactory in this respect, and work is in progress to apply the technique to the production of larger tubes. To avoid glow discharge, and hence error in the thermocouples due to local heating when these are used in the induction furnace, a special furnace of this type has been evolved. This is coreless and is fitted with a water cooled electrostatic screen round the melting chamber.

A demonstration was given in the rolling mill of a special type of failure which can occur in the rolling of ingots of aluminium alloys if the conditions of cooling are not correct. These alloys are rolled while hot. Accurate control of the temperature and the conditions of working previous to rolling—such as casting and forging—are essential.

In the Metrology Department a new clock has been installed depending for its action on the mechanical vibrations of a metal bar held at its centre. The primary vibrating element is a rod of elinvar, an alloy with a low temperature coefficient of elasticity. This is maintained in a state of self-vibration by the application to one end of electrostatic forces obtained after amplification by a valve amplifier from similar feeble forces taken from the other end. A phonic motor operated by the amplifier drives a clock train, one spindle of which rotates once per second. Suitable means are provided for the recording of these seconds on a chronograph. To ensure constancy of frequency, the bar is enclosed in a special housing, the temperature and pressure in which can be controlled by immersion in a vessel of circulating water, the temperature of which is regulated by a toluene thermostat.

Of interest also was a new method of testing surface plates. The plate to be tested is supported on a somewhat larger one provided with levelling screws, and resting on a large flat plate forming the base of the apparatus and carrying a 'Hirth' minimeter as an indicator. The specimen is first set approximately parallel to the base plate by means of the minimeter and then explored by the same instrument. If a standard plate, of which the departures from flatness are known, is substituted for the test plate and the same procedure is adopted, the errors in the latter can be readily determined.

In the Physics Department the investigation on the heat transfer from moving air to cold pipes has been continued, and extended to include banks of pipes such as are used industrially for air cooling in refrigerators.

Experiments were in progress to determine the heat transmission through wall materials. A specimen plate of the material is laid on an electrically heated plate, backed with cork, and is surmounted by a water plate. The electrical input, after correction for the heat conducted through the cork, together with the temperatures of the two faces, gives the necessary data for calculating the conductivity of the material.

The thermal conductivities of heat-insulating materials at high and low temperatures were also under investigation. In the case of the low temperature measurements, the method adopted is similar to that used for the wall materials, a refrigerating plant being utilised for the maintenance of the low temperature. For the measurements at high temperature a water-flow calorimeter is used. The rate of flow, and the rise of temperature of the water when steady conditions have been attained, give the data for the calculation of the thermal conductivity.

An investigation is being carried out, for the Atmospheric Pollution Research Committee, in connexion with the determination of the water in fogs, and a dew point method has been developed for the purpose. A stream of fog-laden air is drawn through a heated tube to vaporise suspended water droplets, and the dew point of the resultant fog-free air is then determined. For the production of artificial fogs a special equipment has been devised consisting of a small chamber provided with air-circulating apparatus which is supplied with steam from an external generator.

A study has also been made of the basic laws of the wet and dry bulb hygrometer over the temperature range 40° C.–100° C. As standards of reference the dew point and gravimetric methods of determining humidity have been used. Apparatus has been designed to give a stream of air at any desired temperature and humidity flowing past the wet bulb thermometer, with velocities exceeding three metres per second. A number of novel features have been incorporated in the apparatus.

In the Sound Division attention is being devoted to the increasingly important subject of noise measurement. The laboratory has co-operated with the Royal Aircraft Establishment in connexion with measurements of the noise of airscrews and exhausts. In the case of the former, the effects of tip speed of rotation, blade diameter and blade shape have been studied and have yielded interesting results. An investigation has also been undertaken for the Ministry of Transport on the noisiness and stridency of motor horns. The loudness was measured by means of an audiometer of the Barkhausen type. By means of a portable microphone amplifier arrangement and cathode ray oscillograph, measurements were also made of the spectral distribution of the sound intensities emitted by the horns. The results indicated that some of the factors affecting the stridency might be the occurrence of strong high frequency components and the presence of inharmonic series of frequencies.

In the Radiology Division the depth below the surface of the cathode at which X-rays originate is being explored. A special hot-cathode X-ray tube is used, the target consisting of thin foil of the material to be investigated. The nature of the X-ray output is analysed by comparative measurements of the absorption in an ionisation chamber.

A number of investigations are being undertaken in connexion with the application of X-rays to industrial problems. These include a study of tungsten steels and tungsten steel residues, the effect of rolling on the crystal orientation in aluminium, and of drawing on that in constantan wire, problems of electrodeposition, paints, and artificial teeth. In the case of constantan wire, the temperature coefficient was found to change as the wire was drawn, and the effect on this phenomenon of changes in crystal orientation is being studied.

In the Electrical Standards Division considerable attention has been devoted to the development of a standard of radio-frequency of high accuracy. The requisite precision has been attained by the use of a valve-maintained tuning fork operating in an airtight enclosure in which the pressure and temperature can be maintained constant. The six walls of the enclosure are provided with heating mats, temperature control being effected by means of a toluene thermoregulator. The tuning fork controls a phonic motor and chronograph, on which are recorded hourly the differences of the fork and the standard Shortt clock. The electrical and mechanical arrangements are such as to permit the determination of the frequency of the fork at any time to an accuracy of two parts in ten millions.

A method has been evolved for the measurement of the small anode-grid capacity of screen grid valves. Use has been made of the amplification of the valve itself. A tuned circuit, the coil of which is loosely coupled to a radio frequency generator, is inserted between the grid and the filament, resonance being indicated by a valve voltmeter. Readings of the condenser in the tuned circuit with no impedance, and with high impedance in the plate circuit, enable the anode-grid capacity to be determined.

An investigation has been commenced in connexion with the magnetic susceptibility of various rocks on behalf of the Geological Survey of Great Britain. An instrument of the type used by Prof. E. B. Wilson has been designed for the purpose. The specimen, in the form of a cylinder, is suspended at the end of a torsion arm in the gap of a large ring electromagnet. The instrument is capable of measuring susceptibilities one hundred million times less than that of iron.

For the precision measurement of the resistance and inductance of four-terminal resistances at power frequencies, a substitution method which avoids the necessity of taking current from the voltage terminals has been evolved in the Electrotechnics Division. The resistance under test is connected in series with a known standard resistance of nearly the same value and with the primary of a nickel-iron transformer. In series with the secondary is a resistance the value of which is so adjusted with reference to the transformer ratio that the voltage drop across it is approximately equal to, and may be opposed in turn to, that across each of the standard and test resistances. A vibration galvanometer is included in the apparatus and its deflection can be reduced to zero by suitable shunts incorporated in the secondary circuit. The resistance and inductance of the unknown resistance can then be determined.

Another exhibit showed arrangements for the measurement of the current rating of power cables. The modern trend in building construction has led to a more extensive use of electric power, and it is becoming standard practice to employ single core lead or rubber covered conductors to carry the current. Owing to sheath losses and skin effect, the current carrying capacity of a cable for a given temperature rise is less with alternating current than with direct current, and is determined by the maximum temperature rise that can be allowed in any given set of circumstances, having regard to the deleterious effect of

high temperature on the properties of the insulating material. The object of the investigation is to determine the current carrying capacity of standard cables of various types and sizes under different conditions of laying, both for alternating and direct current.

For work in connexion with the testing of fuses, the laboratory facilities have been extended to cover the latest specification of the British Engineering Standards Association for domestic fuses up to 250 volts and 100 amperes. The specification requires that the tests be made at 260 volts and at suitable short circuit currents up to a maximum of 6500 amperes. With the new equipment, the short circuit is made from a distance by means of a solenoid controlled switch, the cut-out being observed through a wired glass panel in the door of the test enclosure. An auxiliary circuit incorporating a neon lamp indicates whether iron-clad cut-outs show any tendency to arc to their cases.

In the Wireless Division a new type of dynatron oscillator has been developed by the use of the negative resistance characteristic of the screen grid valve. By coupling the anode to the control grid through a small capacity and including a resistance of the order of a megohm in the filament-control grid circuit, higher frequencies than are possible with normal dynatron circuits have been obtained. The exhibit shown can be used for the generation of oscillations of wave-length as small as 6 metres.

The same principle can be applied to the problem of selective amplification. With the usual triode valve the presence of the positive shunt resistance of the valve decreases the selectivity of the tuning circuit through damping. If the negative resistance characteristic of the screen grid valve be utilised, the selectivity of the amplifying stage can be made greater than that of the tuned circuit alone. A demonstration of this was given by means of a circuit incorporating a valve of this type.

The investigation on behalf of the Radio Research Board in connexion with the development of transmitting and receiving apparatus for very short wave-lengths has been continued, and equipment capable of transmitting and receiving oscillations of wave-length as small as 1·5 metres was shown. The apparatus has been used for the study of the propagation characteristics of very short waves.

The apparatus for testing the performance characteristics of wireless receivers has now been extended to cover the shortest wave-lengths in commercial use. Improved apparatus has been installed capable of carrying out comprehensive tests at wave-lengths from 7 metres to 2000 metres. The tests comprise over-all sensitivity, radio-frequency, selectivity, and fidelity in the reproduction of radio-frequencies. The last-named test is carried out by the use of an input modulation free from harmonics. Any harmonics present in the output constitute a measure of the distortion produced.

In the High Voltage Building, equipment for the measurement of the dielectric loss of high voltage porcelain insulators was exhibited. Demonstrations were given of flashover tests to determine the maximum voltage withstood by a 132-kilovolt porcelain insulator string.

In the Photometry Division an investigation was in progress in connexion with the light-diffusing properties of diffusing glassware. These properties are governed by the size and concentration of the particles, and apparatus has been developed in the division for the measurement of these two quantities by the use of a powerful microscope. Half-silvered interferometer plates are fitted to the fixed and movable stages of this instrument, enabling the movement of the latter to be obtained directly in terms of light wave-lengths. The diameter of a particle can be determined by observation of the interference fringe system, as the particle is made to traverse a fixed cross wire, or alternatively by attaching the cross wire to a travelling microscope, the scale of which can be calibrated by means of the interferometer. To determine the concentration, the field is limited by an aperture of known diameter. The microscope is focused through the particles by a slow-motion device, the distance traversed being measured by a second interferometer.

The fundamental work on glare has been extended to cover the glare effect of coloured light sources with white and coloured backgrounds. Practical application has also been made of the results already obtained with normal light sources by the design of an instrument for the determination of the glare effect due to an actual lighting system. Two measurements of the brightness difference threshold, one with the glare sources exposed to the observer's eyes, and the other with the glare sources screened, give a ratio which is a measure of the glare effect.

In the William Froude Laboratory a model of a single-screw vessel was being tested to compare its behaviour in shoal and deep water. There are reasons for supposing that there is a scale effect leading to differences between the model and the full-sized ship. The model under test was equipped with its own inboard motor and propeller and apparatus for determining its resistance through the water. A model twin-screw vessel fitted with its own propelling and recording gear and utilised for research work on the backing qualities of propellers was exhibited. The tests are designed to show the thrust capacities of propellers of various shapes and diameters to destroy and reverse the motion of the model.

The International Congress of the History of Science and Technology.

THE Second International Congress of the History of Science and Technology, which assembled in London on June 29–July 4, has achieved a notable success, thanks to the untiring efforts of its distinguished president, Dr. Charles Singer, and the executive committee, and thanks also to the active interest it has aroused among scientific workers and historians throughout the world. The Congress, which was really the first of its kind, originated with the Comité International d'Histoire des Sciences, which was founded at Oslo on Aug. 17, 1928. It has, however, been fortunate in enlisting the co-operation of the Comité International des Sciences Historiques, of the American History of Science Society, and the Newcomen Society for the Study of the History of Engineering and Technology, of London. It has thus been possible to show, in its widest extent, the important part played by the sciences in historical and technical research. The papers and discussions of the Congress, and the large attendance of official representatives, who came not only from most of the universities of Great Britain and the Empire, but also from the Continent, North and South America, Asia, and Africa, bear witness to this fact.

At the inaugural session of the Congress, which was opened by the President of the Board of Education, the Right Hon. H. B. Lees-Smith, M.P., in the Great Hall of the Royal Geographical Society, Dr. C. Singer