HOLLOW STEEL PROPELLER BLADES FOR AIRCRAFT.

(*Continued from page* 163.)

AFTER forming the core tube and the shell of the de Havilland hollow steel propeller blade, as described in ENGINEERING last week, preparations are made for the most critical operation in the process, the brazing of the core tube to the shell. The handling-tube attachment having been removed, the core and shell are thoroughly polished by abrasive methods, which have been shown by experience to be more satisfactory than any form of liquid cleanser; if the slightest trace of the latter remains, the liquid carbonises during brazing and deposits soot on the joint. Sand-blasting is too drastic. A rotary abrasive disc is therefore used for cleaning the core-tube outer surface, and the internal surface of the shell is polished on an internal lapping machine, which is illustrated in Fig. 14, herewith. It consists of a hydraulically-operated reciprocating sander which is carried on a rubber bag, the latter being inflated by compressed air to press the emergy in contact with the shell; several sizes of bag are required for the various parts of the shell. A layer 0·003 in. thick is thus removed from the jointing area of the top and bottom shell skins; to keep a check on the amount of metal removed, the ultrasonic thickness gauge is again used throughout this process. Since successful brazing requires complete freedom from grease, the operators wear gloves when handling the polished components.

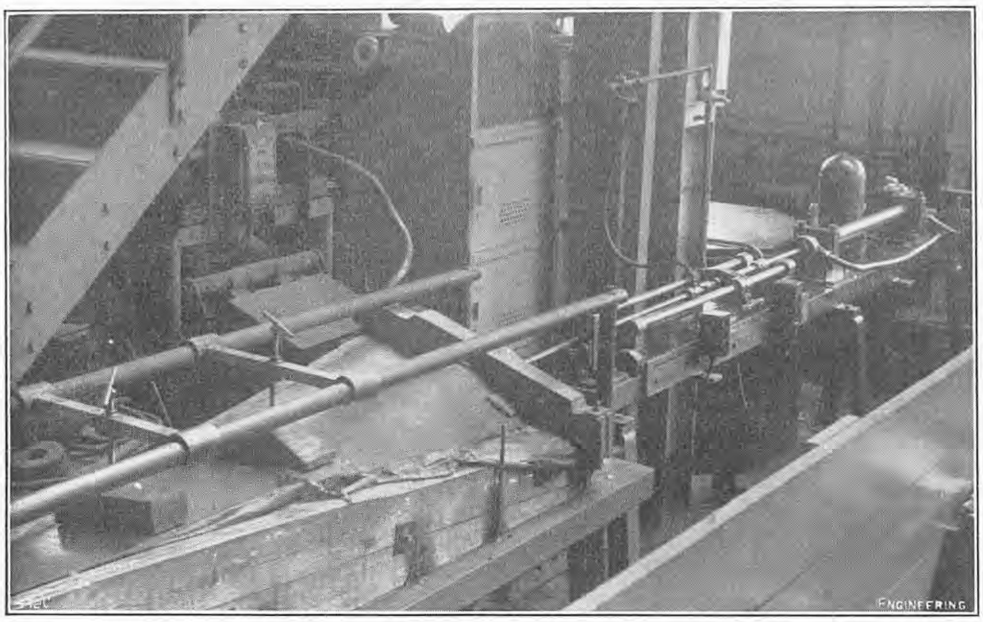


FIG. 14. POLISHING INTERIOR SURFACE OF BLADE SHELL.

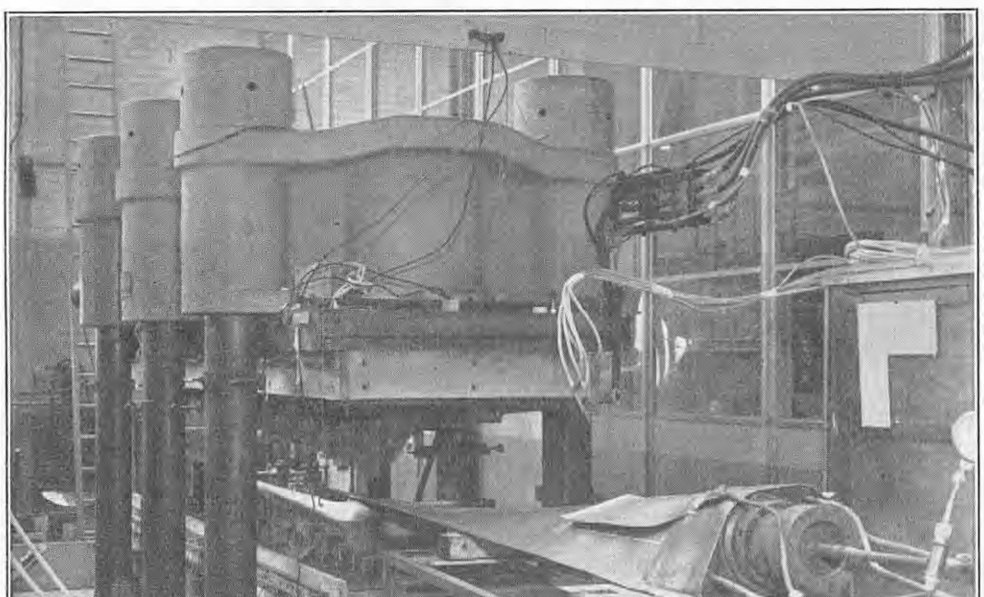


FIG. 15. INSERTING BLADE ASSEMBLY IN BRAZING PRESS.

The final tempering of the blade is carried out simultaneously with the brazing operation. The blade is held between a pair of dies, ensuring freedom from the distortions which would otherwise occur when tempering a component of this size. The optimum physical properties of the blade steel are obtained by tempering at a temperature between 630 deg. and 640 deg. C.; a special quaternary silver-copper brazing alloy has therefore been developed to suit this temperature range. At the brazing temperature, one constituent of the brazing alloy remains as a solid matrix and ensures a joint of uniform thickness. The brazing alloy, in the form of a 9-in. wide foil 0·003 in. thick, is also abrasively cleaned. It is cut to shape on a template and is wrapped over the core tube—up, over the tip, and down the other side, the edges of the foil being tied together at intervals. The shell is slipped over the tube, and is adjusted in a sideways direction to make the final balance of the assembly as perfect as possible. It will be appreciated that at this stage the root end of the blade is still open · two half-pressings, with pipe connections, are therefore welded on to enclose the blade completely, and nitrogen is passed through the pipes for a period of several hours to clear air from the cavities between the shell and the core.

Two stainless-steel dies, machined accurately to the contour of the blade, are bolted on to the top and bottom platens of a 1,000-ton hydraulic press, in which they are completely surrounded by a battery of heating units, comprising 200-kW tubular elements and reflector plates carried by the platens. The press doors also carry heating elements. The whole of the press is lagged by detachable asbestos panels during the operation. The temperature of the dies can thus be raised quickly and can be maintained automatically to within ± 5 deg. C.

Fig. 15 shows a blade about to be placed in the brazing dies, in which it is located by fixtures at the root and the tip; the dies are closed to within $\frac{1}{4}$ in. of the fully-shut position, while the press is being heated. It may be seen in Fig. 15 that the root end of the blade has attached to it a pair of very thin stainless-steel bladders, which are inflated with air during the heating cycle and serve to give a uniform pressure distribution over this part of the blade, which is of complex curvature. During the heating-up period, some 2 to $2\frac{1}{2}$ hours, the fluxing gas, boron trifluoride, is fed alternately through the leading-edge and trailing-edge cavities between the core and the shell so that the surfaces to be joined are thoroughly permeated with flux. When the temperature of the dies has reached 500 deg. C., the flow of fluxing gas is stopped and the dies are fully closed. Nitrogen at a pressure of 200 lb. per square inch is passed into the core tube, and at 100 lb. per square inch into the leading-edg e and trailaing-edge cavities. The differential pressure brings the core and the shell into close contact along the jointing area. The temperature is then raised to 640 deg. C. and held there for 15 minutes. The heating elements are then switched off and the blade is allowed to cool to 350 deg. in the press, after which the dies are opened. Some typical cross-sections through a brazed blade are shown in Fig. 16, on page 194. The stations referred to are shown in Figs. 1 and 2, on page 161, *ante*.

The success of the brazing operation depends largely on maintaining the correct temperature, so that brazing is carried out in the plastic range of the foil. If too low, the bonding is unsatisfactory, whereas too high a temperature, although it gives a strong joint, will cause "blobs" of brazing compound to form on the skin, which act as stress raisers and, breaking loose, may also give rise to unbalance. Rigorous tests are applied to detect unsatisfactory joints. Radiography reveals the outline of the joint, the degree of "blobbing," and the presence of voids, but does not necessarily detect poor adhesion. For this purpose a sequence of testing is carried out using audible and electrical methods. Firstly, the whole of the brazed area is explored thoroughly by tapping lightly with a small hammer, particular attention being paid to areas that radiographic inspection has shown to be suspect. A change of pitch is encountered over an area of poor bonding; such areas are explored further and are mapped by using an electronic resistance probe instrument. Small, clearly-defined areas are acceptable in certain sections of the blade, and it is often possible, by a second brazing operation, to render satisfactory a blade which would otherwise be rejected.

If the blade has passed these inspections satisfactorily, it is subjected to a pressure test to determine the soundness of the complete brazed joint. The electric probe is again used, as illustrated in Fig. 17, on Plate XVI, to determine the outline of the brazed joint at the leading and trailing edges. In using the probe, one lead is connected to the core tube and another to the blade shell; any variation in conductivity through the brazed joint is detected locally by a pair of closely-spaced contact points, and the current change is amplified and indicated on a meter. The joint outline is marked on the blade for reference. Duralumin shims are placed along the span of the blade outside the bond area, and the assembly is placed within a pair of dies held in a press. Air pressure at 300 lb. per square inch is then applied to the cavities between the shell and the core; the leading and trailing portions of the shell are restrained by the shims, and any weakness of the brazed joint will be revealed by the skin lifting away from the core. The blade is therefore re-probed after the pressure test to detect any change in the outline of the joint; if there is such a change, the blade is rejected. It is possible to salvage the core of a rejected blade by stripping off the shell and removing the brazing metal in a cyanide bath.

After the blade has satisfactorily passed all the brazing tests, the steel bulkhead at the root is removed, the tip of the shell is trimmed, and the shell is cut back, as may be seen in Fig. 2, on page 161, *ante*, to a shape that has been determined as the best for avoiding stress concentrations. The blade is then thoroughly cleaned, before applying a corrosion-inhibiting coating, by sand-blasting the leading-edge, trailing-edge and core cavities, then tapping and blowing out any dust with nitrogen. It has also been found necessary to pass the blade through a de-magnetising coil at this stage, followed by further tapping and blowing.

The blade is then placed in a stand, with the open cavities at the root end upwards. The cavities are filled and swabbed with a corrosion-preventative lacquer, after which the blade is swung, as illustrated in Fig. 18, on Plate XVI, so that the lacquer can drain from the root into a collecting tray, to be used again. The blade is allowed to drain for half an hour, and then hot air is blown gently through each cavity, to evaporate the solvent, before baking the lacquer in an oven through which air, heated by passing over a steam heat exchanger, is circulated continuously. The temperature can be held constant to within 4 deg. C. The lacquer is baked for 1 hour at 50 deg. C., followed by 1 hour at 80 deg. C., to get rid of the final traces of solvent, and 2 hours at 115 deg. C. to polymerise the resin. The cavities of the blade are now completely protected from corrosion. A synthetic-rubber adhesive coating, for bonding the filling compound to the surfaces of the leading-edge and trailing-edge cavities, is then applied in the same stand. After draining for half an hour, it is dried in the oven for 1 hour at 50 deg. C.

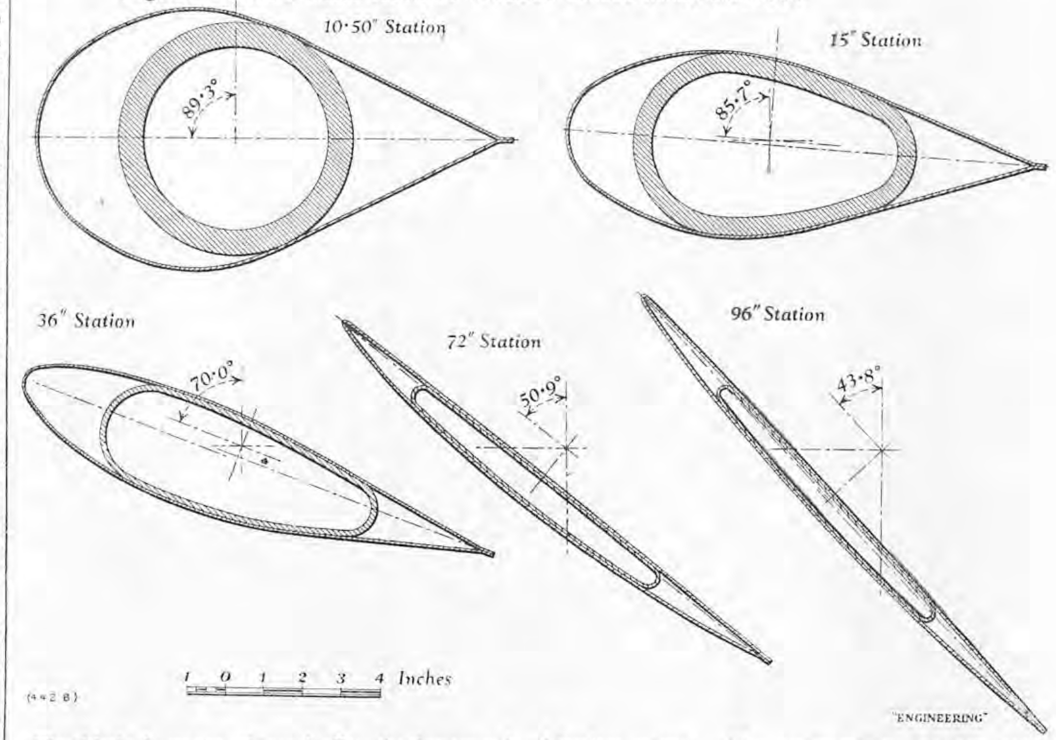
The electro-thermal de-icing elements are placed in position in the leading edge before filling the blade with the filling compound. They consist of a number of parallel paths of fine-resistance Nichrome wire cemented on to a close-woven Fibreglass cloth impregnated with the same synthetic resin adhesive as that which has already been applied to the cavity surfaces. The glass-cloth strip is inserted in the leading edge and is pressed tightly in contact with the metal skin by a roller on the end of a long rod. The ends of the de-icer elements are cemented to wire "bus-bars" at the root of the blade, which are connected to a terminal block which is ultimately embedded in the moulded root closure. It may be mentioned that the de-icing system absorbs 1 kW per blade when working; it operates on a cycle of ½-minute on, 2 minutes off, and serves to break down ice that has built up by destroying its adhesion to the leading edge, centrifugal force then completing its removal. A system which completely prevented the formation of ice would be too heavy.

The blade is now ready for filling with the synthetic filling compound and forming the moulded-rubber root closure, carried out in a single operation and also serving to fix the de-icing elements. The filling compound is composed of one-third rubber, one-third nylon, and one-third phenolic resin, incorporating a "blowing" agent which expands the compound when heat is applied, and containing also barium sulphate which provides sufficient gamma-radiation density for enabling radiographic checks to be taken subsequently. The root closure is formed from a similar material, but without the blowing agent. The filling compound is received in the form of sheets, and is converted into ⅛-in. cubes, in two stages, by a leather-stripping machine followed by an operation in a pelleting machine specially developed for the job by Mr. E. W. Cowell, 7A, Sydney-road, Watford, Hertfordshire; a photograph of this machine is reproduced in Fig. 19, on Plate XVI, the stripping machine being shown in the background. A description of later models of the pelleting machine is given on page 224.

HOLLOW STEEL PROPELLER BLADES FOR AIRCRAFT.

DE HAVILLAND PROPELLERS, LIMITED.

Fig. 16. TYPICAL CROSS SECTIONS THROUGH BRAZED BLADE ASSEMBLY.



The blade is mounted vertically, tip downwards, on a vibrating tray, and the leading and trailing cavities are filled completely with synthetic-rubber pellets. The core cavity is filled to a station 42 in. from the centre-line of rotation; inboard of this, the thickness of the core tube gives adequate stiffness without the need for a vibration-damping filler. The core is sealed by a plastic V-shaped dam, through which passes a central drain tube which extends through the rubber filling to the tip, and serves as a pressure-balance pipe between the inside of the blade and the atmosphere, and as a gas drain when "blowing" the filling compound. It also serves to centrifuge any oil which may penetrate past the balance-cup seals at the blade root. The plastic dam is held by a metal dam, which is inserted by two long hinged bars and is held in place by a compression bar screwed into the core plug. Before the root closure is applied, a radiograph is taken to ensure that the pellets are distributed evenly. The leading and trailing cavities are then sealed by moulded synthetic-resin blocks, around the bottom of which is wrapped lint-free surgical gauze which prevents the rubber pellets from blowing past the closure. A Fibreglass laminate, consisting of an open-weave Fibreglass fabric cemented between two 0·04-in. thick synthetic-rubber sheets, is wrapped about the blocks to form the root closure, and is secured by an adhesive strip; finally, a thick sheet of synthetic rubber is wrapped round the root end of the blade. The end face of the blocks also is covered with gauze, and a ¼-in. sheet of synthetic rubber is held on top of the root closure by two aluminium dams, which are secured in the curing dies by a screw clamp. To prevent the rubber from sticking to the dies, a close-weave Fibreglass cloth is wrapped around the root end. The blade is then placed in steam-heated curing dies, illustrated in Fig. 20, on Plate XVI, at a temperature of 80 deg. C., the dies shaped accurately to the profile of the blade, which is located by a bar on the machined surface at the root end. The top die is lowered into position by lifting tackle, and is bolted to the bottom die. As the rubber slowly moulds, the die-bolts are tightened, and steam, at a temperature of 125 deg. C., is passed through the dies for one hour, causing the filling compound to "blow" and to release nitrogen at high pressure in the cavities to produce the cushioning "sponge"; surplus rubber flows out of the dies and squeezes out to form a flash which can subsequently be trimmed off. A fume-extracting apparatus removes noxious gases given off by the blowing agent. The temperature is then raised to between 170 and 180 deg. C., and the filler and moulded root are cured for four hours to develop the mechanical properties. The final appearance of the moulded root closure can be appreciated from Fig. 21, on Plate XVI, which actually shows a finished blade. At the end of this period it is a hard, tough material with high strength under vibratory loads. The blade is slowly cooled in the dies, to avoid distortion, by trickling water through the die cavities. The cured blade is then subjected to radiographic and tap tests, to determine the quality of the rubber fill and its adhesion to the blade skin.

Before machining the ball races on the root end of the core, the assembled blade has to be balanced vertically—that is, the centre of gravity of each raked blade must be offset from the centre line of the hub by the same amount. For this purpose the blade is mounted vertically in a knife-edge balancing fixture, and a series of unbalance-moment readings are taken as the blade is rotated through 360 deg. about its vertical axis. From the curve plotted from these readings, it is possible to calculate the correct dimensional settings for displacing the blade tip so that, when machined, the centre of gravity is offset by the correct amount. Before removing the blade from the balancing fixture, a setting ring is adjusted and clamped to the aerofoil section so that the blade will take up the same position while the several machining operations are being carried out. After the latter have been completed, balance is finally adjusted by means of a "balance cup," which will be described later.

The bore is then machined to its final dimensions in a planetary milling machine, after which the blade and its setting ring are transferred to a universal milling machine, on which it is mounted vertically, for milling the four ball races simultaneously with a ganged cutter.

(*To be continued.*)

LARGE PIPE-BENDING MACHINE.—A portable pipe-bending machine for solid-drawn steel pipes up to 12¾ in. external diameter, in conjunction with a maximum wall thickness of ⅝ in., has been produced by Chamberlain Industries, Limited, Staffa-road, Leyton, London, E.10. The pipe is held by two chains at 8-ft. centres and is bent by a hydraulic ram; power is provided by a J.A.P. petrol engine and a Beacham two-stage pump. A pipe of the maximum size can be bent cold through 90 deg. in one hour by one operator. The net weight of the machine is 2 tons 9 cwt.

HOLLOW STEEL BLADES FOR AIRCRAFT PROPELLERS.

DE HAVILLAND PROPELLERS, LIMITED.

(*For Description, see Page* 193.)

FIG. 17. PROBE-TESTING THE BRAZED JOINT.

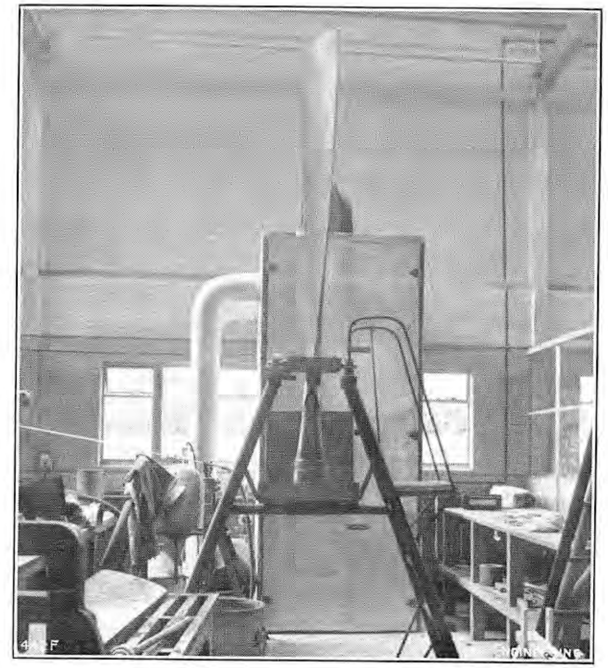


FIG. 18. SWING RIG FOR LACQUERING BLADE INTERIOR.

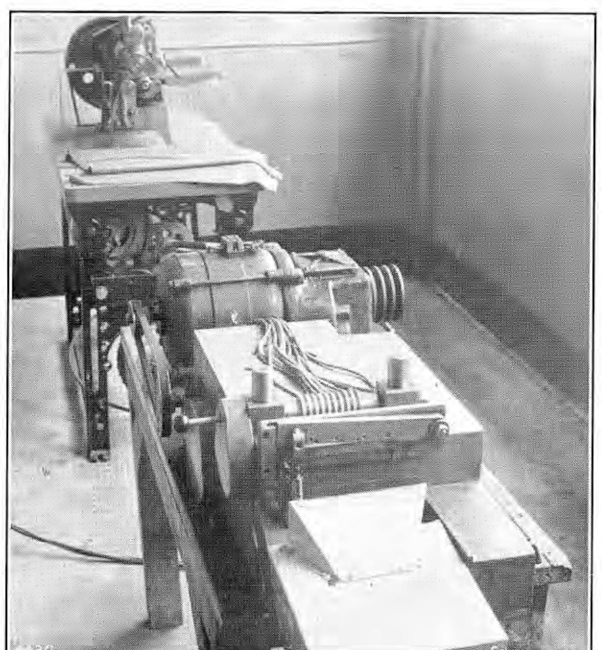


FIG. 19. RUBBER STRIPPING AND PELLETING MACHINES.

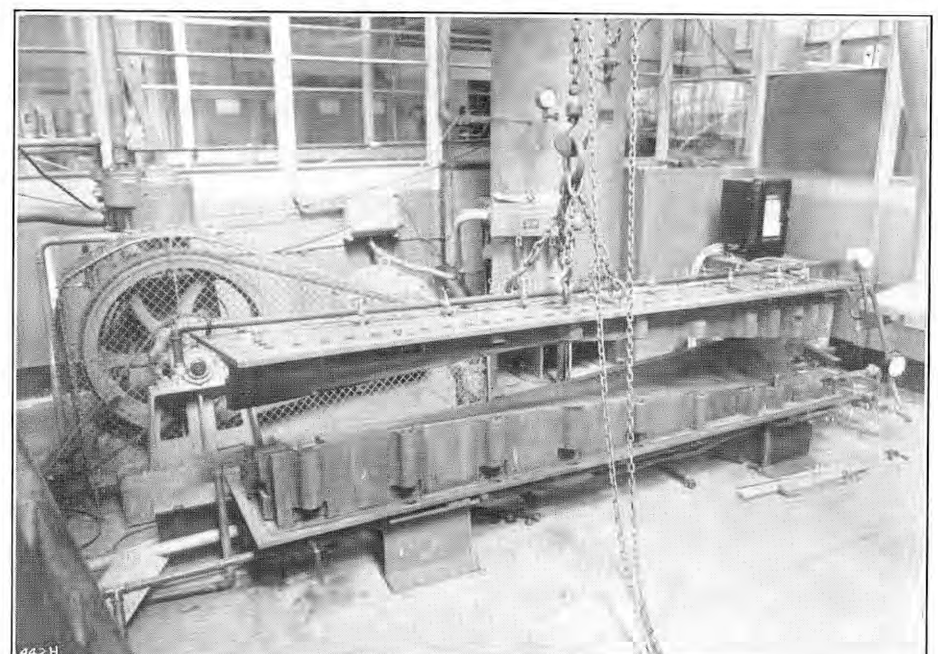


FIG. 20. RUBBER CURING DIES.

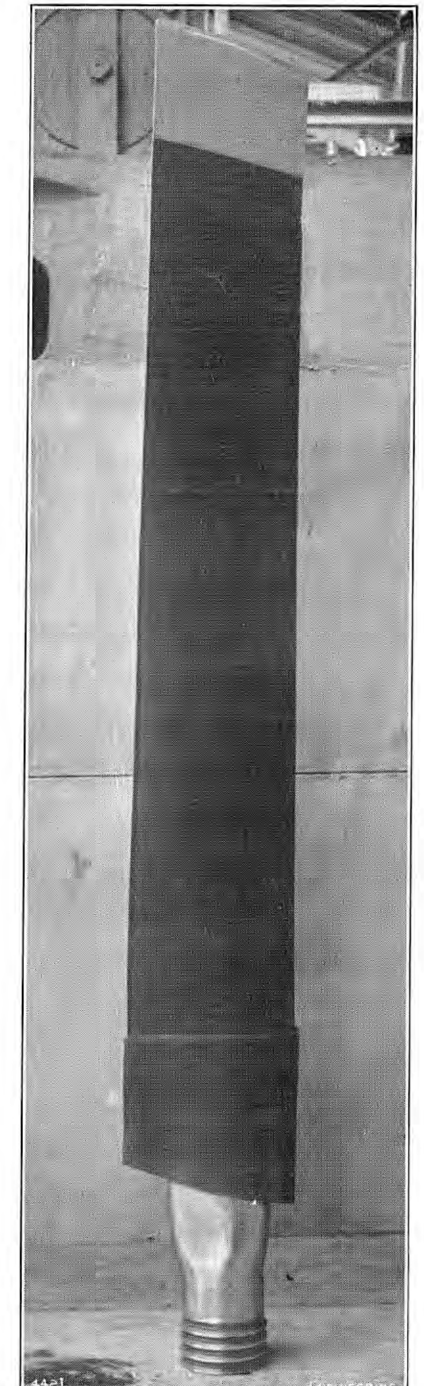


FIG. 21. FINISHED HOLLOW STEEL BLADE.

LITERATURE.

Modern Interferometers.

By C. CANDLER. Hilger and Watts, Limited, Hilger Division, 98, St. Pancras-way, London, N.W.1. [Price 57*s.* 6*d.* net.]

INTERFERENCE phenomena form the basis of a number of refined methods of measurement and control, both in research and industry. With the actual phenomena, as studied in a conventional course in physical optics, Mr. Candler is only incidentally concerned: his primary purpose is the detailed consideration of the various instruments that have been developed and are currently employed to exploit them. Such instruments are termed interferometers, and split a beam of light into two or more parts which, after pursuing separate paths, are reunited to produce interference fringes. They thus permit the determination of differences in optical path in terms of the wavelength of light. Moreover, the optical path being defined as the product of the geometrical path and the refractive index of the medium traversed, changes in either can be separately determined, provided the other remains unchanged.

To use an interferometer to the best advantage, an appropriate source of monochromatic radiation is necessary. Line spectra may be excited, using as sources a flame, an electric arc, a discharge tube, a hollow cathode-tube, or an atomic beam. Useful information concerning each is given, accompanied by a discussion of the reasons for the finite width of spectral lines, hyperfine structure, and the choice of standard wavelengths. A short chapter on the metrological problems involved in the adoption of a wavelength of light as a fundamental standard of length is followed by an account of interference effects in thick plates and thin films, including location of fringes, Edser-Butler plates, transmission filters, Talbot's bands, measurement of expansions and of the amplitude of small mechanical vibrations. (In Fig. 4.16, on page 94, the 45 deg. plate should occupy a position normal to that indicated.) The Michelson interferometer, though now chiefly of historical interest, is important enough to warrant the chapter allotted to its construction and use.

Interferometers can be adapted to the study of the form of a surface with reference to a known surface, and Twyman developed two types for the testing of prisms and lenses. The outstanding importance of both to the optical-instrument maker is well brought out and the major contribution to industry of gauge-measuring interferometers is also exemplified. The applications of the Fabry-Perot Etalon in the measurement of length and of wavelength form the subject of Chapters IX and XIII, and its use as a refractometer is discussed in Chapter XIX. Chapter X deals with Michelson's stellar interferometer, Chapters XI and XII with the reflection and transmission echelon, and Chapter XIV with the Lummer-Gehrcke plate. The author has extended the term "interferometer" to include the diffraction grating, a decision amply justified by the excellence of his treatment. The problems of ruling are fully covered and a striking example of the delicacy of the interferometer technique is afforded in the method of testing the feed screw of the ruling machine, which is capable of detecting a curvature of the axis having a radius of 300 miles. In discussing the plane diffraction grating, attention is paid to groove form, and to wire and laminar gratings; and the advantages and disadvantages of the various methods of mounting concave gratings are fully described, together with the spectrum and its aberrations. The two concluding chapters are devoted to the Rayleigh refractometer and the Jamin interferometer.

Attractively written, and containing a wealth of practical detail based on first-hand experience, Mr Candler's book promises to prove indispensable as a source of reference on modern interferometers and invaluable as a laboratory manual for all who wish to employ these delicate and sometimes temperamental instruments to the best advantage. It may be noted that the Ångström unit is denoted by A instead of Å throughout; on page 105, AnA/1 should read An/A_1; and "change," on page 462, should read "charge."

World Geography of Petroleum.

Edited by WALLACE E. PRATT and DOROTHY GOOD. Princeton University Press, Princeton, New Jersey, U.S.A. [Price 7·50 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 48*s.* net.]

THE expressed determination of the Persian Government to nationalise the oil industry in that country gives an additional topical interest to this comprehensive survey of the world's oilfields and reserves. Published by Princeton University Press for the American Geographical Society, it is a compilation of separate contributions by specialists, headed by Mr. Wallace E. Pratt, who is a geologist; and supplemented by a wealth of statistical, technical, historical and economic data, obtained from authoritative sources all over the world. The text is arranged in four main parts in addition to Mr. Pratt's foreword; of these, Part I, by Mr. Eugene Stebinger, chief geologist of the Standard Oil Company of New Jersey, deals with "Petroleum in the Ground," and Part II, by Mr. William E. Heroy, a past-president of the American Association of Petroleum Geologists, with "The Functional Organisation of the Petroleum Industry." Parts III and IV consist of groups of chapters by separate authors, and are concerned, respectively, with "The World's Petroleum Resources" and "Aspects of Utilisation." The concluding 55 of the book's 460 pages are devoted to an appendix showing the world production and exports of petroleum for 1938 and 1947; a bibliography, arranged under headings corresponding with the parts of the main text; a list of abbreviations, notes, conversion factors, and a really adequate index. The statistics in the text relate to the end of 1948 and the early part of 1949.

In reviewing such a broad, yet thorough, survey as this, the difficulty is to know where to start; a mere catalogue of the contents is seldom a satisfactory guide to the real utility of a book, and random selection is even less so, when the probability is that most users will also be narrowly selective in their searches for information. Comparatively few readers will want to work through the book from cover to cover, though in this case the process can be recommended. It might be expected that, in a compilation of the work of many authors, there would be a certain amount of duplication; there is, in fact, a little, but the editing has been done with evident regard to this possibility, and the actual duplication is slight. The editors have been notably successful also in balancing the distinctive needs of the oil technologist and industrialist, who is familiar with the sources of information on oil, but desires a relatively compact summary without the labour of making one for himself; the economist, who is usually less concerned with the trees than with the wood; and the intelligent "man in the street," who wants to know the facts of the situation.

To such a reader, the presentation of the facts in this book will certainly be of absorbing interest, though they are as likely to increase any disquiet he may already feel as to minimise it. Mr. Wallace Pratt's foreword puts the position in a paragraph: "It happens that the natural distribution of petroleum is admirably adapted to man's needs: great petroleum accumulations are conveniently situated with respect to transport routes serving the main centres of human population and culture," so that, "in a free, peaceful world, the widespread and equitable distribution of petroleum products should offer no formidable problem." It is obvious, of course, that, "in a world in conflict, the control of these same petroleum resources becomes the object of vital military strategy"; but, in Mr. Pratt's opinion—and his foreword is dated March, 1950—"the most formidable immediate barriers to the full development of the earth's petroleum resources lie in the serious restrictions of exploratory activity which have grown out of recent nationalisation policies of many governments." He cites a number of instances in various parts of the world. Persia is not among them, which shows how quickly the dispute there has been worked up; the idea of limiting oil exploration rights to Persian nationals appears to be less than four years old.

In the main, as we have indicated, this book is a chronicle of facts; the only uncertainties of moment, indeed, appear to come at the beginning and the end of petroleum production—the manner of its formation, and the effects of political unrest. At present, the former enigma seems the nearer to a solution, if the unanimity of geologists is as pronounced and the accuracy of their deductions as assured as Part I seems to show. Be that as it may, this is a book which, in our opinion, should be in every public and university reference library in the country; and we hope that it may be studied as carefully (and brought up to date, at intervals, as systematically) as the importance of the subject deserves.

Workshop Technology. Part III.

By DR. W. A. J. CHAPMAN, M.I.Mech.E. Edward Arnold and Company, 41, Maddox-street, London, W.1. [Price 30*s.* net.]

To appreciate this book properly, it is desirable to refer back to Parts I and II, which were published in 1943 and 1946, respectively; for, in the preface to Part I, Dr. Chapman explained its purpose in rather more detail than in the subsequent prefaces. He was then Principal of the Walker Technical College at Oakengates, in Shropshire. The book was planned, and partly written, before the war, when the inter-wars depression, severely felt in Oakengates, may have depressed the author also; for he lamented that the status of the artisan was not what it had been, that he was neglected by educationalists, by writers and by public thought, and that the dearth of suitably qualified prospective artisans was the result. "What this policy has cost us," Dr. Chapman wrote in 1943, "cannot be assessed, but it is now obvious that it almost brought us to disaster." It was for the prospective artisan, therefore, that the book was planned, as a correlation of academic theory and workshop practice that would demonstrate to the intended reader the fundamental principles underlying workshop processes; and as the intended reader was assumed (with some reason before the war, though probably less in 1943) to be a person of small means, special efforts were made to keep the price down. It was 8*s.* 6*d.* and now costs 10*s.* 6*d.* We reviewed the book in our issue of June 25, 1943 (vol 155, page 505), and the good opinion then expressed was reinforced by Part II, published (at 10*s.* 6*d.*, now 12*s.* 6*d.*) in 1946.

When Part II appeared, Dr. Chapman had become Principal of the County Technical College at Stafford, and, it may be supposed, concerned with students from somewhat different technical environments; but he maintained the style of the earlier book, insisting on the importance of fundamentals, devoting much space to practical illustrated examples, and using every endeavour to promote good craftsmanship. Its scope was indicated by the claim that the two Parts together provided a complete introduction to the technique of the workshop, and contained "elements of all the knowledge a student should require while serving an apprenticeship"; but Part II was "primarily written in detail for the inhabitants of the workshop."

Before Part III was finished, Dr. Chapman had "shifted his flag" again, this time to the Hertfordshire County Council's new "major" technical college at Hatfield, of which he has been Principal for the past three years. It is probable that, again, there was a subtle difference in his raw (human) material as well as in his own and their environment; apart from the fact that, as he remarks in this latest preface, since Part I appeared, "there has been a widespread adoption of the subject 'Workshop Technology' in the Ordinary National Certificate courses at our Technical Colleges." At all events, it appears as though Part III, rather more than its predecessors, was intended for what may be termed the "eventually-managerial" class. The author's expectation is likely to be realised, that, with Parts I and II, "it should provide a useful text-book for students working for Ordinary and Higher National Certificates, the I.Mech.E. examination in Workshop Technology, Metrology, and Machine Tools, and the Final City and Guilds examination in Machine Shop Engineering"; and, too, his hope that "it will be read with equal interest, and advantage, by the more mature engineer."

THE LOS ANGELES "FREEWAY" ROAD SYSTEM.

THE population of the State of California in 1940 was 6,907,387; in 1950, it was 10,586,223, an increase of 53·3 per cent.; and all signs point to a population of 20,000,000 for the State in the near future. During this same ten-year period, motor-vehicle registrations rose from less than 3 millions to more than 4½ millions, increasing by 63 per cent.; and, in addition to these 4½ million California vehicles, it is estimated that about a million cars, registered in other States, use the Californian highways each year. This immense increase in the use of motor vehicles has, of course, put considerable strain on the State's highway system; congestion of traffic, particularly in the two largest metropolitan areas, Los Angeles and the San Francisco Bay region, is an ever-present problem, to which much study has been given.

By comparison with most European countries, however, the United States has vast sums of money, derived from gasoline taxes, Federal Aid allocations and other sources, available for highway improvements; though, because of congestion of traffic, the financial resources of California are by no means sufficient to meet all requirements. It is estimated that there will be available, for ten years of post-war highway construction, annual sums of about 80 million dols., plus Federal Aid funds which, in the fiscal years 1949-50 and 1950-51 amounted to about 39,700,000 dols. for the two-year period. What are termed "critical deficiencies" in the State highway system, for which the Highway Department has a long-term improvement plan, will cost an estimated 3,000,000,000 dols. to remedy. This plan began to show results in 1947, with the construction of many miles of improved highways, and with the introduction of "freeways," "expressways," and "parkways."

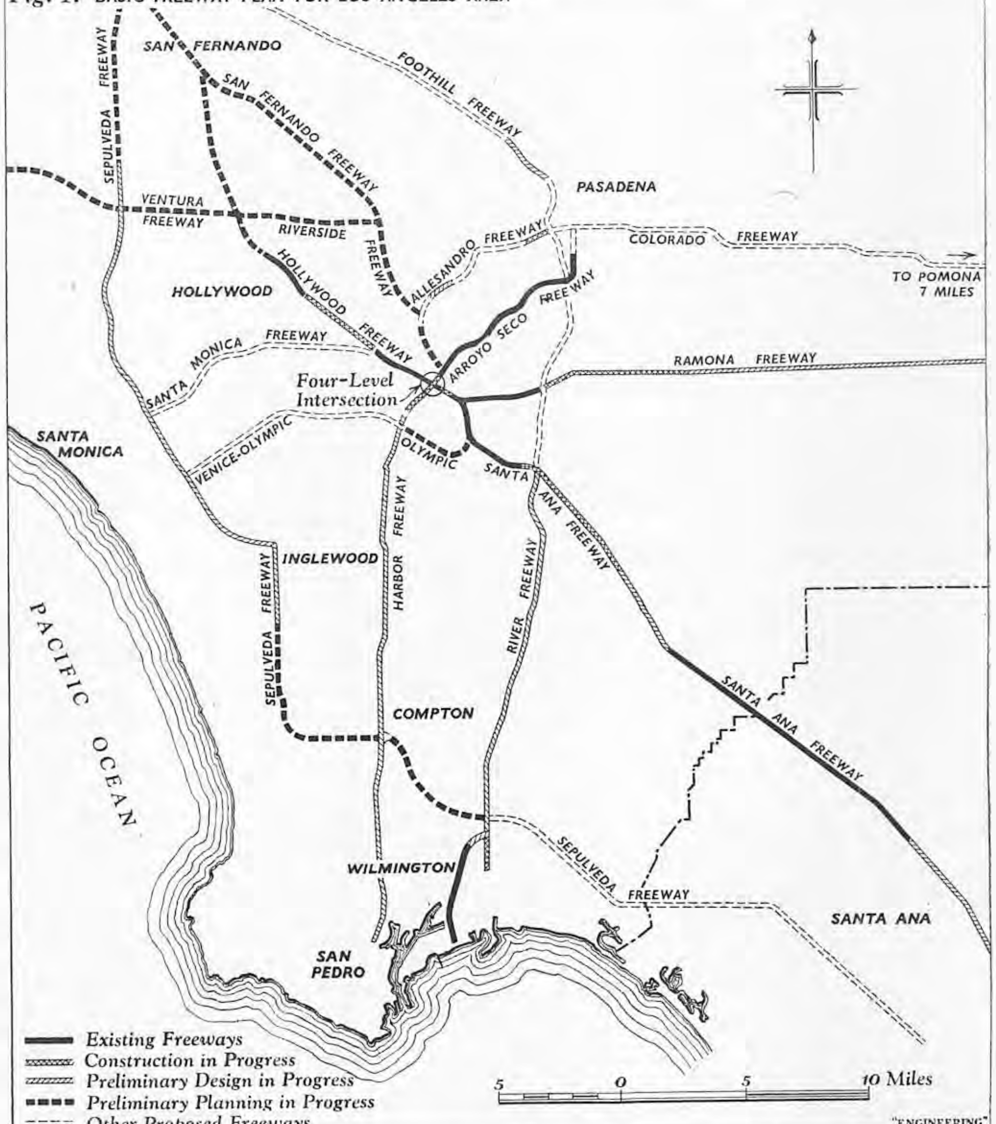
A "freeway" is statutorily defined as "A highway in respect to which the owners of abutting lands have no right or easement of access to or from their abutting lands or in respect to which such owners have only limited or restricted right or easement of access." It will be seen, therefore, that the only distinction between a freeway and an ordinary highway is in the matter of access to the freeway. The mileage of full freeways in the United States is, and necessarily will be, small in comparison with ordinary highways, for freeways are mainly required in urban areas, to carry heavy volumes of traffic. In current practice, such freeways may have a total of four, six or even eight traffic lanes, each 12 ft. wide, with divisions separating traffic flowing in opposite directions, and with all cross traffic passing over or under the freeway.

Los Angeles is said to be the most rapidly expanding large city in the United States. Plans have been made for a system of freeways which, when completed, will give the area a fully integrated road system. These plans have been made by the California State Division of Highways, in co-operation with the Los Angeles City Engineering Department. The more important of the freeways are on the State highway system, and will handle inter-regional and through traffic as well as local traffic. The map reproduced in Fig. 1, herewith, by courtesy of the *Los Angeles Times*, illustrates the basic freeway construction programme within the Los Angeles metropolitan area. Essentially, the plan proposes three main freeways extending north and south, and three other main freeways running east and west. The Hollywood and Santa Ana freeways, and the Harbor and Arroyo Seco freeways, are the main arteries, which intersect in Los Angeles at the four-level structure to be described later. State Highway Route 2, designated Hollywood Freeway in "down-town" Los Angeles, is one of the major highways in California. It is part of a main thoroughfare from San Francisco to San Diego, and crosses the heart of Los Angeles from Cahuenga Pass in Hollywood to Los Angeles Civic Centre at Spring-street, and beyond.

In addition to the freeways illustrated in the map, new routes may, of course, be added in the future. Expenditure so far for construction and rights of way for this system, including funds budgeted for the 1951-52 fiscal year, total 160 million dols., and it is estimated that, when the freeways shown on the map are all completed, the total cost will be some 1,000 million dols.

"FREEWAYS" IN LOS ANGELES, CALIFORNIA.

Fig. 1. BASIC FREEWAY PLAN FOR LOS ANGELES AREA



The appearance of these freeways is shown by a photograph of a typical completed section of the Hollywood freeway at Cahuenga Pass, reproduced in Fig. 2, herewith. Hollywood freeway provides three or four traffic lanes in each direction, each lane 12 ft. in width and consisting of an 8-in. pavement of Portland cement concrete on a cement-treated sub-grade. Acceleration and deceleration lanes are additionally provided, of adequate length, for all "on" and "off" ramps to the freeway. In general, there are rolled combination curbs and gutters throughout, so that emergency parking off the pavement can be obtained by drivers in mechanical difficulties. Parking or stopping anywhere on the pavement is prohibited. Barrier curbs are provided where bridge piers or other obstructions make it impossible to provide for safe off-pavement parking, and at points where it is necessary to guide traffic on to ramps.

The illustrations herewith show, to some extent, the complexity of this freeway programme. New paths have had to be cut for these broad lines of communication right through the heart and residential areas of a city some five times bigger in area than New York City. Many problems of right of way, surveying, design and administration arose, with some nice calculations of economy of design, in calculating the costs of various types of intersections, according to the value of the land through which the freeways passed. The unique four-level intersection, for example, could have been designed in many forms, but the present design was considered the most economical, in view of the high value of the down-town area in which it is situated.

A good start has been made on the construction work, and a considerable mileage of freeway is now in service. Work began some four years ago with the building of the large overpasses and interchange structures, with subsequent letting of contracts for grading and paving the connecting sections of freeway. The full benefits to traffic will not be felt for another two or three years, but already some sections are heavily used. Two levels of the recently completed four-level structure are already in use. Construction on nine miles of the Arroyo Seco Parkway between Pasadena and Los Angeles is completed, and work is in progress on Hollywood, Harbor, Santa Ana and Ramona freeways.

From the engineering point of view, perhaps the two most interesting structures so far under construction are the central four-level grade separation, already mentioned, and the Arroyo Seco bridge, spanning a deep ravine on the Colorado freeway in Pasadena. The Arroyo Seco bridge will be a six-lane reinforced-concrete structure totalling 1,364 ft. in length, with three arched spans.

The unique four-level intersection is clearly shown in Fig. 3, opposite, an aerial view taken early in 1951. Hollywood freeway is seen to the top left-hand of the illustration; the still uncompleted Arroyo Seco connection to the right; the Harbor connection, also uncompleted, to the left, and the Santa Ana in the foreground. This illustration should be referred to in conjunction with Fig. 4, on the same page, showing the streets in the surrounding area. It will be seen that the ramps provide for a full interchange of traffic between the four freeways. The structure is claimed to be the first of its kind to be built anywhere.

The design is much simpler and more economical than conventional types of cloverleaf crossings. The cloverleaf system suffers from inherent defects, such as a left turn accomplished by a 270-deg.

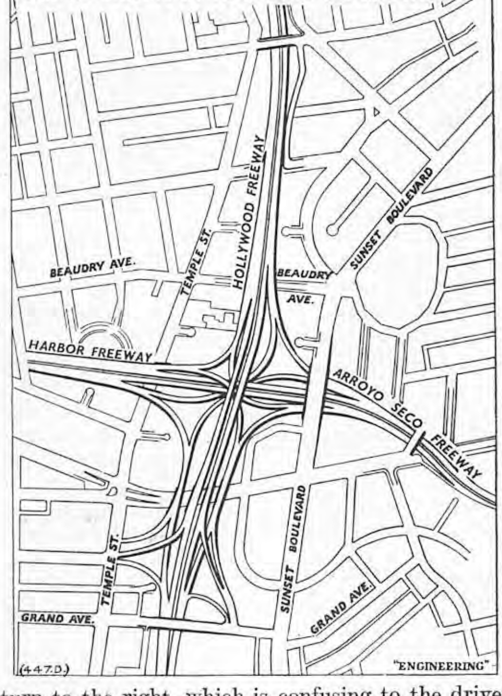
HOLLYWOOD "FREEWAY," LOS ANGELES.

Fig. 2. Hollywood Freeway at Cahuenga Pass.

Fig. 3. Four-Level Separation.

Fig. 4

PLAN OF STREETS AT FOUR-LEVEL INTERSECTION



turn to the right, which is confusing to the driver. In the cloverleaf design there is also an overlap in movements of accelerating and decelerating traffic, with resulting confusion. The design used in the four-level structure gives simple turns in the same direction as the driver wishes to go, for all traffic movements. Another advantage is that movements off the freeway and entries to the freeway are all made on the right-hand side of the roadway. Economy of cost is secured by having a single bridge structure for the four separate roadway levels; but, to make the intersection a true freeway, some twelve "satellite" bridges are required in the near vicinity. All of these properly form parts of the main project, which therefore extends (Figs. 3 and 4) from Grand-avenue to Beaudry-avenue and from Sunset-boulevard to Temple-street. Within this area the total costs of construction were about five million dols. In addition, right-of-way costs to clear 212 dwellings in the area totalled more than two million dols.

Fig. 5, herewith, shows a cross-section through the structure, and Fig. 6, on this page, also serves to show the construction. The main freeway routes cross on the second and fourth levels, and the left-turn interchange ramps also pass through the structure, two on the first level and two on the third level. The lowest level is for the two 26-ft. one-way interchange roadways which connect the Harbor-Arroyo Seco freeways to the Hollywood-Santa Ana freeways. The second level is the Harbor-Arroyo Seco freeway itself, with six lanes and a central dividing strip. The third level is for the two 26-ft. one-way roadways handling exchange traffic from the Hollywood-Santa Ana freeways to the Harbor-Arroyo Seco freeways. The fourth, and highest, level is the Hollywood-Santa Ana freeway, having six lanes with a 34-ft. dividing strip.

The resulting bridge structure is 69 ft. in height from the lowest to the highest roadway, of which about 47 ft. extends above the natural ground level. The lowest level is about 22 ft. below ground level, the limit to which it could be lowered and still obtain gravity drainage to the storm drainage system. The second level consists of a ten-span continuous slab structure, supported on three-column bents. The three central bents are skewed to clear the lowest-level ramps. This deck is at about ground-surface level. The slab is 24 in. thick, of reinforced concrete poured continuously, with column caps measuring 4 ft. by 5 ft.

The third level is elevated in a manner similar to that of an ordinary over-pass. It is of continuous box-girder construction, and is tapered from 6 ft. deep on the high side to 3 ft. 6 in. deep on the low side of the roadway. The decks are supported on single-column bents, or on skewed beams resting on ring bearings where columns pass through more than one level of the structure. The top-level deck consists of two continuous box-girder bridges of 12 spans each. Span lengths are 52·30 ft. and the girder depths are 5 ft. These two bridges are supported on four-column bents, and the decks are tied together by heavy reinforced-concrete beams at the three central bents. Ten U-shape abutments and 73 columns or hexagonal footings form the substructure; 477 steel piles provide additional supports in 25 column footings and three abutments. The column spacing is irregular because of the need to clear various roadways, but in general the structure shows symmetry and elegance. The highest level is on a supported grade, which meets higher ground on each side, so that the effect is natural and pleasing.

The structure has interesting expansion and contraction joints. The heavily-reinforced concrete geometric centre is rigidly fixed to a ribbed footing and the decks radiate from this point. The ends of all decks rest on steel rockers and bearing plates at the abutments. Roadway surfaces are fitted with steel expansion plates, providing for $1\frac{1}{2}$ in. of movement at each deck end. The columns are joined to the decks and footings in two ways, depending on the degree of rigidity required. For fixed connections, reinforcing-steel dowels are placed round the full circumference of the column. For the hinged connections, dowels cross in a straight line at the end of the column, and pre-moulded expansion-joint filler is placed over the column cross-section. There are also special expansion assemblies at the ring bearings which allow the decks to move horizontally around the columns, other than the central anchor column. They consist of two milled steel rings, one cast into the column capital, which is widened for this purpose, and the other cast into the deck. The expansion space is then filled with soft rubber joint-filler, permitting nearly an inch of deck movement.

Material for the approach fills was available from surplus excavation nearby, where the Hollywood freeway is depressed for a considerable distance so that important streets in the Civic Centre region could remain at their existing level. Alignment standards for all the freeways are excellent and are on tangents at the bridge site, with adjacent easy curvature. On the connections, the lowest-level roadways are on tangents through the four-level structure, with adjoining curves varying from 350 ft. to 450 ft. radius, designed to provide safe speeds on the interchange of 35 m.p.h. or more. The third-

HOLLYWOOD "FREEWAY," LOS ANGELES.

Fig. 5. Top Level and Turning Ramp.

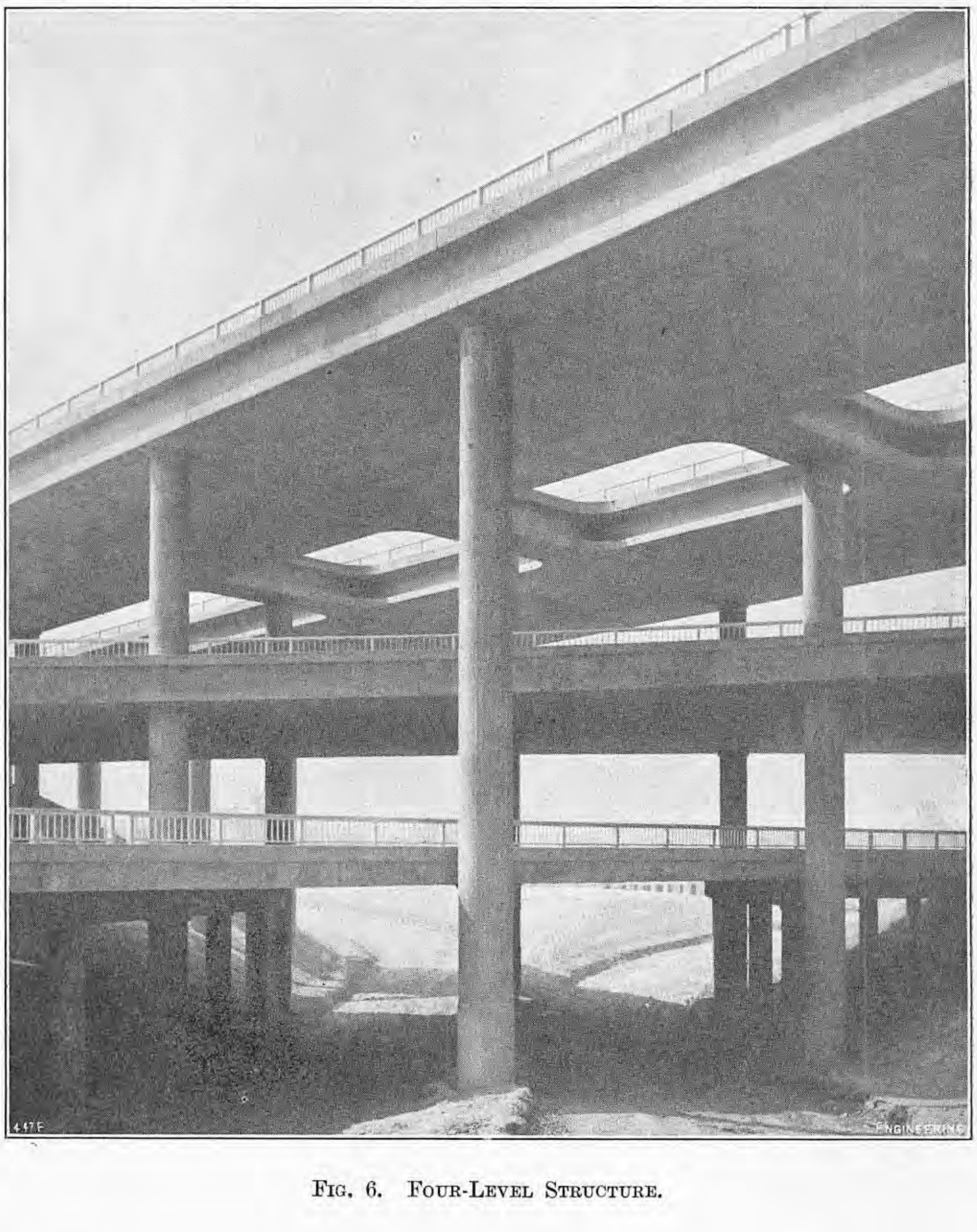


Fig. 6. Four-Level Structure.

level connecting roadways are both on curves of 300-ft. radius, for safe speeds up to 35 m.p.h. These curves could have had a slightly greater radius, had it not been for an important obstruction in the form of a school building, to be seen in the top left corner of Fig. 3.

The grading is also good throughout, meeting requirements for a designed speed of 60 m.p.h. on the freeways and 35 m.p.h. on the interchange roadways. Near the bridge structure the Hollywood freeway has a maximum gradient of about 3 per cent., and on the Harbor-Arroyo Seco freeway the maximum gradient is 4·5 per cent. on a short length. On the exchange roadways, the gradient varies. The area occupied by the four-level bridge is an old district and the buildings formerly on it were obsolete and, in many cases, in need of repair. With the exception of the school, mentioned above, which is modern and is preserved in the plan, there was considerable benefit to the community in clearing away the old buildings and substituting a structure which, with landscaping treatment, should be æsthetically satisfactory. About 105,000 cubic yards of earth were handled at the site, and another 80,000 cubic yards were hauled away to a waste area. About 15,000 cubic yards of concrete were used for the whole job.

The four-level grade separation is a development of an idea first suggested by Mr. W. H. Irish, District Location Engineer of the California State Division of Highways. It is a design applicable to other sites, furnishing a compact, safe and economical traffic-exchange system, and is claimed to be superior in many respects to other systems at present in use.

THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

(*Continued from page* 166.)

AT the afternoon session, on June 28, of the International Conference of Naval Architects and Marine Engineers, two papers were presented and discussed: these were on "A Proposed Design for a Combined Research, Training and Cargo Ship," by Professor Ir. H. E. Jaeger and Ir. J. C. Arkenbout Schokker; and "Some Aspects of Prefabrication in Ship Construction," by Mr. N. G. Eckerbom. During the presentation of the former paper, the chair was occupied by Dr. S. F. Dorey, F.R.S., President of the Institute of Marine Engineers; and, for the latter paper, which concluded the technical sessions in London, by Viscount Runciman, President-elect of the Institution of Naval Architects. The two remaining papers in the programme were read on July 5, in Newcastle-on-Tyne.

PROPOSED RESEARCH, TRAINING AND CARGO SHIP.

This paper began by referring briefly to various projects that had been put forward for research on the strength and behaviour of ships in service, notably those of Dr. P. Maack, in 1935, and Dr. W. Dahlmann, in 1942, and was based on a design worked out by Mr. E. Vossnack, jun., of the shipbuilding department of the Technical University of Delft. The dimensions (converted from the metric units of the original design) were proposed to be: length, 471 ft. 10 in. between perpendiculars; breadth moulded, 68 ft. 3 in.; depth to freeboard deck, 29 ft. 6 in.; depth to shelter deck, 37 ft. 9 in.; summer draught, loaded, 24 ft. 11 in.; corresponding displacement, 15,060 tons, and deadweight capacity, 9,480 tons. The shaft horse-power was calculated to be 8,680 for a speed of 17 knots. Propulsion was to be by a single Diesel-electric set, situated aft, though the authors had contemplated the possibility of using a gas turbine, and so arranged the design that this could be substituted for the Diesel-electric machinery if desired. Accommodation would be provided for about 100 persons in two-berth or three-berth cabins. Special arrangements would be made for access to the ship's sides and the tank top, when the vessel was loaded, for the purpose of applying strain gauges. Denny-Brown stabilisers would be fitted, as well as an anti-rolling tank. The fore part of the ship would be longitudinally framed, and the after part transversely, and all butts would be welded. Details were given of a suggested programme of strength investigations, but no proposals were put forward for research on the machinery or on propulsion generally; in the words of Professor Jaeger, in presenting the paper, little was known of the division of stresses along "the very curious beam that is a ship," and the design was prepared primarily to elucidate these stresses and their effects. The rather high speed of 17 knots would facilitate research into the effect of pitching; moving at that speed in the same direction as the waves, the effect on the hull bending moment would probably be unimportant, but it might be important when going against the waves, with the speed reduced to, say, 15 knots. The instruments would be concentrated in a central "measurement room," and there would be a minimum of mechanical apparatus employed. The working out of test results would be done by a special staff. At the same time, the vessel would be in continual contact by wireless with research stations on shore; this would require a radio installation of rather special quality. The training programme for the cadets, etc., would be arranged by the nautical and marine-engineering schools from which the pupils came, and submitted to the shipping company that would operate the vessel; but her use as a cargo tramp must be subordinated to her function as a research and training vessel.

Mr. James Turnbull, O.B.E., in opening the discussion, suggested that the paper had "a strong sting in its tail." The authors proposed that the maritime nations should build similar ships and collaborate in research, but he felt that that was touching on a major question of policy which was not one for technical institutions, but rather for the industry's research organisations. To some extent, the design defeated its object in that it was a specialised design, and not of the normal commercial kind. It had various transverse and longitudinal bulkheads at the midship area which, he thought, would make it difficult to assess the actual modulus of the section; and the conjunction of transverse stiffening at one end and longitudinal stiffening at the other increased the difficulty, when considering deflections. The Admiralty Ship Welding Committee had found, early in their investigations, that instrumentation was the key to a complete understanding of the stresses in ships in a seaway. The Ocean Vulcan was sent to sea and measurements were taken of the forces acting in the ship; then the ship was placed in still water and the endeavour was made to reproduce those stresses. The experimenters were able to put on many more instruments in still water and to obtain better results in that way. He felt that it was by such means that future developments in structural research on ships would be achieved. Already there was an indication of those developments, because, since the early experiments on the Ocean Vulcan, a statistical strain gauge had been placed on board, which recorded the range of stresses and the number of times that range was reached during one complete year of service. The ship went to various parts of the world, mainly in the North Atlantic. The complete ranges of stress indicated (from hog to sag) occurred the following number of times during the year of service: a stress of 1 ton per square inch occurred 266,884 times; 2 tons per square inch, 7,105 times; 3 tons per square inch, 1,329 times; 4 tons per square inch, 102 times; 5 tons per square inch, five times; and 6 tons per square inch occurred twice.

Those figures were very interesting. By that method, it was possible to apply the instruments to, and to obtain results from, a very wide range of ships; for instance, for all lengths of ships, all coefficients of fineness, various length/depth ratios, various speeds, forms of construction, and other factors. It might even be possible to introduce, as a factor, the quality of workmanship. The ship which the authors had put forward was comparatively deep, and he thought that more valuable information might be obtained from a shallower ship. In short, while the authors had shown considerable ingenuity in their design, he felt that their proposal would not be the line which developments would take. They proposed to put the ship into very severe weather conditions and to load her heavily, but owners had to be very careful with the loading; further, there must be personnel aboard. It might be inferred from the paper that Lloyd's Register had already approved the scantlings of the proposed ship; but he could assure them that if the design had been submitted to Lloyd's Register (and he had not found any record of its submission) the fact that it was abnormal in character would have led to investigation of the distribution of the weights, and the ordinary scantlings, as published in the Rules, probably would have been increased because of the bad distribution of load. The Admiralty Ship Welding Committee had received six reports of tests carried out at sea; three would probably be published before the end of the year, and the remaining three, certainly before the end of 1952. He felt that all the suggestions made in the paper were covered by those reports. Admittedly, they applied only to one ship, but he did not think that anything further should be done until those reports were studied.

Sir Stanley Goodall asked whether the range of six tons per square inch, which Mr. Turnbull had mentioned, meant plus or minus 3 tons; to which Mr. Turnbull replied that he only knew that the range was 6 tons per square inch. The ship went to sea and the gauges were set at zero, but he did not know whether that range was 3 tons one way and 3 tons the other, or 2 tons one way and 4 tons the other. He offered to inquire on the point.

Captain W. H. Coombs said that the authors, in setting forth their case, touched on the relative merits of sail training and modern steam training; but he felt that they had dismissed sailing-ship training too lightly by describing it merely as a system which gave some idea of the hardships of life at sea and, at the same time, made the cadets proficient in the working of sails and ropes. The enthusiasts of sail training believed that it did much more. Sail-trained men learned much more important things than "the splicing of ropes or the reefing of sails"—to quote the authors; there were things of the spirit, as any reader of Joseph Conrad or Alan Villiers would agree. But the days of sail had gone for ever, so far as ocean-going trainers were concerned. That modern navigators' and seamen's training accommodation should be combined in a research ship was quite a practicable suggestion, but he doubted whether it was possible to combine a research ship with a vessel intended to operate commercially as a cargo ship. In practice, the idea of a combined research and cargo ship might not commend itself to those concerned with the carriage of goods by sea, or with the insurers of those goods. A sentence in the paper suggested that the ship's captain would have to follow the directions of the research staff. He felt that such a proposition was very definitely unacceptable*; no ship would keep afloat usefully for long unless there was one man solely in command. It was stated that international collaboration might be necessary to make the author's project possible. If a research ship were desirable and necessary, the only hope would be that it should be financed on an international basis; but Captain Coombs thought the possibility so remote as to be non-existent.

Professor A. M. Robb referred to the difficulty presented by attempting to marry two forms of construction. It was suggested, he continued, that Diesel-electric machinery should be used. He did not object to that; but, though it was the one type of propelling engine in which the power input to the propeller could be measured most accurately, there was no mention whatever of any thrust measurement. Turning to a general question, but approaching it from a slightly different angle from that presented by Mr. Turnbull, it seemed to him that, in all branches of naval architecture, a much wider range of information had become available recently; but understanding had not deepened in proportion.

* We believe that it was the regular practice in the Norddeutscher Lloyd ships, 40 years ago, when testing and research teams used to travel in them, on normal services, up and down the North Sea between Bremerhaven and Cherbourg; but, in effect, the control was only over speed, the course being that of the normal voyage.—ED., E.

In effect, the power of analysis had been completely overwhelmed by the volume of information. In other words, said Professor Robb, "we have already bitten off far more than we can chew, and I suggest that, for some time to come, we should concentrate on chewing, otherwise, instead of obtaining nourishment, we shall merely achieve indigestion."

Viscount Runciman commented that, obviously, a ship of the design indicated would not be cheap to build; he estimated that she would cost more nearly a million than half a million pounds, and, for crew, stores and insurance, well over 60,000*l.* a year to keep in being. He did not feel qualified to speak concerning the value she might possess as a training ship, or, indeed, as a research ship, but her value from the research point of view would have to be extremely high to justify such expenditure in the eyes of commercial operators, whether working individually or through associations, or in the eyes of the Government, if they had to raise the money by taxation. Again, it would probably be impossible in practice to get any noticeable contribution towards the cost of running her from commercial operations. He would be sorry to be in the position of a ship manager who had to face the worries of the bills of lading for a cargo which was specially directed into storms, in a ship whose captain was under the orders of a research staff. It was possible, perhaps, to get over that difficulty to some extent if the Government were willing, for the sake of the knowledge acquired, to use such a vessel for the carriage of strictly Government stores, so that many of the commercial considerations of insurance, finance, etc., not to mention the legal considerations, could be avoided; but that would probably mean abandoning the idea of running such a ship on an international basis. The prospect of a sort of minor United Nations, trying to work out who was going to pay for what, would take some facing. If the ship were to be built and run—he did not feel competent to say how far that would be worth while—he felt very strongly that she would have to be considered simply as a research and training ship, that any cargo she carried would have to be in the form of ballast and nothing more, and that, if she was to float at all, it could not be on the chilly waters of commerce.

The chairman (Dr. Dorey) offered the suggestion, as one of possible interest to shipowners and superintending engineers, that if, occasionally, when ordering new ships, they would have a hole of about 2 in. diameter (not more) bored along the screw shaft, it would help a great deal in the measurement of stresses, not only in the shaft itself, but also in the propeller. The stresses in the propeller would be affected to some extent by the rudder, the shape of the rudder, the stern post, and in particular, the aperture clearance. It was possible to fit strain gauges on the blades of the propeller, and, by means of a hole in the screw shaft, to bring the leads through to the coupling end of the shaft; then it would be quite easy to take the measurements required. Arrangements had been made for that to be done in one ship, but the tailshaft had to be withdrawn for the hole to be bored. If that were done at the start, it would be possible very quickly to find the effect of the aperture clearance, and also the effect of the shape of the aperture itself, on the propeller from the point of view of vibration, "singing" phenomena, etc.

The authors of the paper having intimated their intention to reply to the discussion in writing, the meeting proceeded to a consideration of the paper by Mr. Eckerbom on "Some Aspects of Prefabrication in Ship Construction."

PREFABRICATION IN SHIP CONSTRUCTION.

In this paper, the author, who is shipyard manager of the Swedish firm, Eriksbergs Mekaniske Verkstads A.B., of Gothenburg, described the layout of their shipyard, as modified to construct vessels by prefabrication, in conjunction with an extensive use of welding. The points reviewed included, more especially, the re-allocation of the available area for the assembly of simple units weighing up to 10 tons; the assembly of main units, by combining the simpler units; and the construction of compound units, comprising plates, sections and smaller units. The planning of work in the welding bay, the provision of adequate cranage, the introduction of distinguishing symbols for units, and the advantages of prefabrication in overcoming shortages of skilled shipyard labour were also discussed. For erection purposes, the hull was divided into parts and numbered according to a sequence system which applied to all operations from storing steel in the stockyard to the final erection. The forward engine-room bulkhead was the starting point from which erection proceeded forward and aft. The building of ships in units, the author emphasised, required considerable space and ample handling appliances, and the extent to which it could be adopted depended on the existence of such facilities; but there could be little doubt that it had a great future in shipbuilding, and made for quicker and more economical construction. Moreover, where shortage of labour was a problem, as it was in Sweden, prefabrication offered a solution by providing easier working conditions, and facilitating the employment of labour with a lesser degree of skill. After presenting his paper the author exhibited a cinematograph film illustrating prefabricated construction in the Eriksberg yards.

Sir Amos L. Ayre opened the discusson by complimenting the author on "the very beautiful film." In recent years, he said, the shipbuilders of the various European countries have come much closer together than formerly, visiting each other's yards and studying their various techniques. He was interested, also to see how well a difficult site had been adapted, though the centre berth seemed rather short of storage space. If the desire was to reduce the berth cycle, as in that case, to three months, storage space became very important; from the head of the berth to the assembly sheds and welding sheds, for a monthly cycle, which was achieved in the United States—the Liberty ships, as a rule, were built at the rate of one ship per berth per month—he thought it should be probably equal the length of the ship. In the United Kingdom, 25 years or so ago, there were many instances of hydraulic riveting, extending to 33 or 34 per cent. of the whole hull; 25 per cent. was common. That amount of hydraulic riveting involved a large amount of prefabrication. They were not then handling the very large "lumps" that were handled at the present day, but many yards handled such things as stern overhangs, and that was the beginning of prefabrication. In connection with the two British Government yards in the United States, they had often to consider whether, if there were two cranes on a berth, one would get in the way of the other, and the United States shipbuilders also thought a great deal about it. He asked the author what his experience had been in operating two cranes on the same track. An important point for the consideration of shipbuilders in laying out yards of that type, with the costly modern plant to which the author referred, was the heavy capital outlay, which is closely allied to the average output or turnover. In times of depression, or even average conditions in the cycle of demand, it was possible to spend too much money in the capital sense. That was determined largely by the depreciation allowances. He understood that the Swedish shipbuilders had a paternal Government which gave them generous allowances by way of depreciation; and that it was possible to do a great deal which could be more or less automatically written off out of current profits. British builders were allowed only a few per cent. per annum. He had sent to the Institution of Naval Architects, for their records, an album of photographs which Mr. Henry Kaiser gave him in America, relating particularly to the Kaiser Incorporated yard in the State of Washington, which, he thought, was probably the finest yard the world had seen; and he suggested that Mr. Eckerbom might be interested to examine it.

Mr. J. A. Milne envied Mr. Eckerbom's storage space; the only way in which most British yards could expand was upward, which was not very helpful in building ships. For plates, etc., Mr. Eckerbom had adopted vertical storage, which was more suitable than horizontal storage because of corrosion considerations, and accessibility. He was surprised that the Eriksberg shipyards used alternating current in the welding shops and direct current on the berth. It would appear to be more economical to use alternating-current throughout. In his own yard (Messrs. J. Samuel White and Company) alternating current was used, with only a small amount of direct current at the fitting-out berth, particularly if there were non-ferrous metals to weld. They had done away with most of the welding skids by incorporating channels in the shop floor. No difficulty was found in welding outside with alternating current. He was becoming worried, however, about the use of heavy cranes, and wondered whether to lift a ½-ton plate with a 5-ton crane was not a little ridiculous, and whether prefabricators had not gone to the extreme in trying to provide heavy lifts, losing a lot of time and money in so doing. With regard to cost, his experience had been that shipwrights' costs in the handling of plates and sections for small ships were high, on medium ships they were low, and on heavier ships the curve began to rise again. He hoped that welding technique would not lead to lifts of 100 tons, with all the difficulties of cranage, etc. The author mentioned three-dimensional units, but did not make much reference to drawing-office work in that connection. Did he issue a plan of decks and bulkheads, or three-dimensional drawings of sections of the ships? He would like to hear more about semi-skilled labour, and whether there was an increase or otherwise in the employment of unskilled labour. Undoubtedly, welding had come to stay.

Mr. J. Lenaghan asked the author, in his reference to cold and hot bending, what he meant by cold bending. He was impressed by the fact that, in Scandinavia and other places abroad, the spaces under the berths were used for storage; was that merely to avoid taking in further ground for small stores? He always wondered how modern shipbuilding compared with the older methods in respect of the number of men employed; did the author find that the output per man had been altered considerably, and whether the numbers employed had been reduced? It seemed that a good deal was left to the foremen. Mr. Lenaghan did not altogether disagree with that, but he was sure production planners would say that the shop load should be just as carefully planned as the berth load. Again, in connection with the measuring of the amount of work for one ship in "block days," the author almost suggested that past records were used as a basis. Had there been any time and motion study in connection with the block planning? A matter which merited considerable thought, particularly in connection with prefabrication of large units, was the desirability of positioning the lifting spots, i.e., working out the centres of gravity so that things could be lifted and turned easily. The author suggested building from the engine room, working forward and aft. British practice appeared to be ahead of him in that; in one British yard, ships were being built from the stern, and it was hoped that, when the bow section was put on, the launch would take place on the following day. He was not so pessimistic as the author with regard to the effect of mechanisation on recruitment. It was suggested in the paper that, as mechanisation developed, people were driven to the lighter industries, but his own experience was that mechanisation induced more recruits, though the skill might be in other directions than previously.

Constructor-Captain R. Baker observed that the author had given a diagram showing the complete sequence of erection, and in the text there was a reference to three-dimensional drawings. He thought that the paper would be improved if Mr. Eckerbom could be persuaded to add one three-dimensional drawing, showing the sequence for welding the units together.

The author stated that he would prefer to reply to the discussion in writing. A vote of thanks having been accorded to him by acclamation, the meeting terminated.

(To be continued.)

GOVERNMENT LOANS FOR LOCAL WORKS.—Loans to local authorities sanctioned by the Minister of Health and the Minister of Local Government during the three months ended June 30, included 2,808,438*l.* for water supply schemes, 3,943,468*l.* for sewerage and sewage disposal plant, 321,284*l.* for refuse collection and disposal, and 45,320*l.* for sea defence works.

THE JOINT ENGINEERING CONFERENCE, LONDON.

(*Continued from page* 170.)

THE morning of Wednesday, June 13, having been devoted to the presentation and discussion of two papers on the education of engineers, an abridged report of which was given in last week's issue of ENGINEERING, two papers on practical training were dealt with in the afternoon, the meeting being held at the Institution of Civil Engineers with Lord Dudley Gordon, D.S.O., M.I.Mech.E., in the chair. Mr. H. J. B. Harding, B.Sc. (Eng.), M.I.C.E., gave a paper on "Practical Training of Civil Engineers," and Sir Arthur Fleming, C.B.E., D.Eng., M.I.Mech.E., past-President I.E.E., one on "Practical Training of Mechanical and Electrical Engineers."

PRACTICAL TRAINING OF ENGINEERS.

Mr. Harding, like the other authors of papers, commenced with a historical review of the subject; he prefaced it, however, by remarking that, in general, the training of mechanical and electrical engineers was facilitated by the fact that the products of the industries were self-contained and made in a factory, whereas the embryo civil engineer had to go to a civil-engineering site, where the work was often of a pioneering nature and progressed over long periods. Early civil engineers, Mr. Harding continued, developed their genius under the pressure of work and the tremendous opportunities opening up before them, and trained others to help them. With the founding of the Institution of Civil Engineers in 1818, the problem of balancing academic education and practical experience or training was tackled. The great engineering works which influenced the course of progress included Brunel's Great Eastern (profoundly affecting the design of docks and harbours), steel-framed buildings and bridges, the Greathead tunnelling shield, and civil-engineering works in North-West India.

The pupilage system, which was the accepted method of training in the Nineteenth Century, diminished at the end of the first World War; also, the opportunities abroad lessened. Between the wars, there arose a new race, the contractor's trained and professionally educated civil engineer, who replaced the former "practical men" who were not eligible for institution membership. In the early days of the Institution of Civil Engineers, the majority of practising engineers did not look upon the acquisition of theoretical knowledge as an essential part of a young engineer's training, on the grounds that engineering was to be regarded as an art rather than a science. Nevertheless, no civil engineer to-day was really worthy of the name, Mr. Harding continued, unless he had some experience in construction of works. The principal methods of obtaining practical training were as graduate pupils; pupils or apprentices; graduate assistants; and learners or trainees. Under a scheme which had been initiated by the Institution in 1944, only the engineer holding the chief appointment in a firm, local authority, or large industrial organisation was invited to apply for his name to be placed on the index of approved engineers for training young men. It was important, in these days of large corporate bodies, that young engineers should be pupils to an individual engineer and not to the body as a whole. Mr. Harding then proceeded to outline the duties of a young engineer's sponsor, and to give examples of practical training. Referring to the difficulty a young engineer has in arranging for study when working on remote sites, he suggested the establishment, at selected colleges, of "double-sandwich" courses of, say, $5\frac{1}{2}$ months each, with a holiday period. "The employer could engage students in pairs, and as each half-year's course ends they change places, so that one is always available."

Sir Arthur Fleming, speaking on the "Practical Training of Mechanical and Electrical Engineers," said that such training in this country could be traced back to the Thirteenth Century, when the guilds controlled the trades and the manufactured goods. The guilds were based on the towns, but in 1562 the Statute of Artificers transformed the system into a national institution. From this Statute, which remained in force nominally until 1814, and from succeeding legislation, arose the system of compulsory apprenticeship, the chief features of which were usually: binding by indenture, the due recording of the agreement, a minimum term of seven years on the indoor system, and the close personal relation of master and apprentice, with the master's entire control of the boy.

The premium-apprenticeship system, which was characteristic of the Nineteenth Century and early part of the Twentieth Century, had not generally come into vogue until the Seventeenth Century. After the Civil War of 1642-46, during which the apprenticeship system suffered, the Statute of Articifers was more and more disregarded and, for various reasons, the guilds began to lose their power. With the repeal of the Statute in 1814, the great system of general and technical education for the most part collapsed. The Industrial Revolution led to the decline of the old system and to the beginnings of the modern system; gradually, it came to be considered that the employer and the school shared the responsibility, one giving training in workshop methods and the other in scientific principles. Engineering developments and inventions created a demand for university graduates and young men with advanced secondary education, and, as practical experience was traditional, some industrial concerns established suitable courses.

Practical training in engineering as it now existed, Sir Arthur continued, was a natural evolution based on what had been found by experience to be best suited to the national needs. No single scheme could cover adequately the general needs of the whole profession. Industry required three distinct types of technical personnel—craftsmen, technicians and professional engineers, and an appropriate form of apprenticeship existed for each. In the case of professional engineers, with whom the paper was concerned, there were two forms, one of two years' duration for university graduates, and the other of four years for those who reached the Higher National Certificate by part-time courses; the two types were usually known as "graduate" and "student" apprenticeships, respectively. The former was sometimes modified by the insertion of a one-year pre-university course of workshop practice. From 1939 to 1949 the number of young people attending part-time day classes had increased from 38,000 to 300,000. The "sandwich" course, a third method, was a compromise between graduate and student apprenticeships, and, although comparatively few young men followed this course at present, the Councils of the three engineering institutions were encouraging it.

The intellectual, social and athletic pursuits in which the apprentice joined with his fellows were a great factor in the development of personal qualities, and where the number of apprentices, including craft apprentices, exceeded 50, an apprentice association should be formed to co-ordinate such activities outside working hours. The demand for industrial power in all countries was leading to important developments involving endless engineering problems. Apart from water power, wind power, solar radiation, tidal power, and nuclear energy, there was the development of fuel cells to convert the energy of fuel to electrical form without the interposition of dynamo-electric machinery. The continued expansion of research enlarged the field of employment for the technical engineer, who required, in many respects, highly specialised training (which, however, must not be given too early in the training) so that the fullest advantage could be taken quickly of new scientific discoveries having industrial applications.

DISCUSSION.

Captain A. N. Holbein, who opened the discussion, commenting particularly on the civil engineering point of view, agreed entirely with Mr. Harding about the difficulty of the non-graduate pupil, the boy going straight from school who had to work and do his theoretical study at the same time. It was difficult for the non-graduate pupil to find suitable work near the technical college at which he could study. He therefore endorsed Mr. Harding's scheme for sandwich courses. He believed that at any rate some of the more enlightened companies would be prepared to adopt the suggestion of "double-sandwich" courses, with one man doing practical work while the other was at college. He went further, and said he thought that it could be applied not only to the non-graduate pupil but also to the university-trained man. At the City and Guilds College, due chiefly to the enterprise of Sir Frederick Handley Page, opportunities had been provided for the undergraduates to sandwich in a year's practical work. The students did not go until they had passed Part I of the intermediate-degree examinations. Their further studies took three years before getting a degree, but Part 2, or the final examination, was taken at the end of the second year, after which they had a further year without that awful Sword of Damocles hanging over their heads in the shape of an examination paper, and it was felt that they learned a very great deal in that year. There were, however, objections from the students' point of view. For instance, it had been held by some undergraduates that by leaving the college for a year at the end of their second year they were leaving at just about the time when they were well enough known to be eligible for election to various offices in the students' unions, such as captain of games or president of the union.

Mr. S. E. Goodall said that large and small manufacturing concerns were not designed for the purpose of training; and he felt, at times, that some of their more academic critics of what they did with the students in the factory tended to forget that they were not organised first and foremost as training establishments. In that respect, they were markedly different from their partner the educational establishment. Many of the ideals discussed in the three institutions were, as far as possible, put into practice in the larger concerns, but it was not always possible or practicable in some of the smaller organisations. A factor upon which he thought the success of a students' course depended was the co-operation and good-will of the man on the shop floor. There was a tendency to think in terms of schemes, brochures, educational and training officers and the like, but the man who really mattered to the individual student was the man he worked with, the man on the shop floor, the workman, the artisan and, to a lesser extent, the charge-hand and the foreman, and establishing their good-will was an important feature of the successful running of any scheme of practical training in industry. There was a loophole in the National Certificate scheme which had recently come to light rather forcibly, though some people had been aware of it for a long time. The loophole was that there was nothing to force the employer to provide, or the individual to undertake, practical training while the individual was studying part-time for a National Certificate in engineering.

Mr. F. H. Perkins referred to the training of engineers in the chemical industry. Existing facilities for basic training within the industry differed, he said, very widely from those normally found in companies such as Sir Arthur Fleming's. Machines, tools and manufacturing processes common to these engineering companies, which were recognised as so essential for basic practical training, were not widely available in the chemical industry, which was normally supplied with equipment for the general construction and maintenance of chemical plant. On the other hand, the chemical industry was probably second to none in the provision of opportunities for engineering initiative, imagination and resourcefulness. The chemical industry must therefore look, to some extent, to the engineering industry for the provision of the basic training facilities for its engineering staff recruited at graduate level. In his own firm, great care was taken during the first two years of the graduate's life in the industry in regard to his practical experience. The first year might be spent with another engineering company. The main objective of the second year would be to condition the individual to his future work in the chemical industry, and the individual plan would depend on the man himself and the character of his possible future activity. It was of the utmost importance that this period of practical training should be supplemented by further instruction, either within the factory or in outside educational institutions, on subjects appertaining to the problems of engineering procedure. Little reference was made to that important aspect of the matter in the papers read before the Conference. He referred, he said, to the subjects of industrial relations, production planning and control, factory and plant layout, statistical methods, estimating and costing, work study, including method, motion and time study, incentives and labour control. Further study in those subjects would be necessary after the initial period of training had been completed. Adequate provision for the study of those subjects at post-graduate level was sadly lacking in the country at present, and the professional engineering institutions must examine their past records very critically in this respect if it was to be rectified in future.

Mr. W. K. Wallace, speaking as a civil engineer, agreed with Mr. Harding and Mr. Holbein that training with contractors was very valuable to a young engineer. The economic urge to get the job carried out so as to produce a profit was so definitely before everyone on the job that it was very valuable. Graduates were frequently very weak on the economic side, through no fault of the universities, who could not develop that in the time at their disposal, and it was very important that an engineer should realise in his early days that he must design a job to be as economical as possible. One of the great difficulties that the Institution discovered from the applications for membership was that of obtaining practical training. The London Midland and Scottish Railway had an office in Glasgow, and they took a considerable number of trainees from the University of Glasgow under a "sandwich" system; they were fortunate in having a divisional engineer who took a great interest in training young engineers and did remarkably well.

Mr. L. S. Case, who described the type of training undertaken by the student apprentices in New South Wales, said that, in Australia, the opportunities for social and athletic activities were very few and far between; any spare time they had was taken up with personal study. They suffered, he said, from a lack of social contact; but that could be gained after the five years' study were completed.

Major-General H. Williams, Chief Military Engineer, India, commenced by pointing out that when a large number of British engineers went out of India there was rapid promotion for many Indians, but that happy state of affairs was coming to an end and they were confronted with the problem of ensuring that the young engineer in India received proper training. The Government, which was the largest employer of engineers in India, industry being still very much in its infancy, found it very difficult to understand that a young man must be trained for some years, and the tendency was to appoint a man and let him learn his engineering afterwards. India, he said, was likely to be a paradise for engineers in the next ten or twelve years; there was a large number of important projects. He concluded by asking that every encouragement should be given to young Indians who came to England for their practical training.

Mr. G. K. Wood said that the encouragement that had been given to Sudanese students in England was remarkable. Students who had come to England without a great deal of experience in engineering, and possibly with no great knowledge of the English language, had, almost without exception, returned to their own country full of gratitude to, and with an entirely different outlook on, England.

Mr. F. R. Livock pointed out that several universities required electrical-engineering students to decide during their final year whether they would follow light-current or heavy-current work, and he contended that vacation training would help them to make the right decision. He wanted to see more universities exercising greater pressure on their students to seek vacation training. Furthermore, there were many students at universities reading electrical engineering who, if they had known something about the industry before going to the university, would probably be reading physics, or mechanical engineering—or even civil engineering. He therefore commended the spending of one year in industry before going to a university.

Lieut.-Colonel R. H. Edwards said his experience of two years on the membership committee of the Institution had been that a large number of civil engineers who signed as sponsors and certified that men had received "training under agreement," did so when in fact there had been no undertaking whatsoever, and probably in many cases the man proposed had only been employed as a member of the staff, obtaining his experience as and when he could. Under an agreement the engineer undertook to see that the trainee obtained as varied an experience as possible during the specified period, which was very different from just being a member of the staff, because as such he might be kept on one type of work for some years.

Mr. R. G. Bellamy said that he would appreciate Sir Arthur Fleming's comments on why, in practically all trades, there seemed to be a "closed shop" for craftsmanship at the age of 21. Fortunately, he was with the British Electricity Authority, where that closed shop was not quite so tight; a mechanical fitter had to be a mechanical fitter by the age of 21, but a joiner or linesman could be bred at a later age. He did not see why a man of 25 should not train to be a craftsman. He stressed that the electricity supply industry must rely considerably on mechanical engineers. The term "electricity" might suggest that they wanted only electrical engineers, but he would say it was 90 per cent. mechanical and only a little electrical tagged on. He agreed wholeheartedly with the view that the training for those in the supply industries should be a combination of manufacture and supply, and he acknowledged that there were present a number of people who had been of tremendous assistance to the electricity supply industry in providing reciprocal training facilities in manufacturing.

Colonel C. E. Calveley, who commenced by describing engineering training in the Post Office, said that the Post Office did not pretend that by an organised course a man could be trained to be a supervisor, but they did think that he could be helped very considerably. Their course was in three sections: human relations, job organisation and departmental organisation, costing and accounting. They used the case method to an appreciable extent, and they felt that discussion of practical cases was a far better method of training than talking principles to people who had not had much experience.

Mr. J. D. Lane, speaking as a full-time engineering student, said that, when making direct application for vacational employment, one was faced with references by the employer to the difficulties in providing facilities owing to objections from the workers. Could that objection be overcome?

Mr. J. Wooding said that he always advised young men, on going to a new department, to put to themselves the question: "What questions am I going to get answered in this department?" He had had sheets of information which were given to the young men before going into the various departments but had found that they tended to make them lazy. These students must know the technical particulars of the plant they came in contact with; there must be some source to which they could easily refer to find out, say, pressures and temperatures, so that they could get a full picture of the plant. His method was to get the students to make a bulletin for themselves. He was against getting students together and then just having a member of the staff lecture them; that was difficult for the staff member and did the students little good. If students came to him and said they would like to hear something about, say, centrifugal pumps, his method was to make the students get together and prepare a questionnaire and to supply every student with a copy. A member of the staff was then presented with the questionnaire, which halved his work in preparing his lecture because he knew in advance what the students wanted to know and could get straight down to it. He would like, he said, to hear this debated, perhaps elsewhere, perhaps at a symposium on different techniques applied internally to practical engineering training, because by applying the more recently developed psychological ideas he was sure they could achieve a great easement in training and improve the results obtained.

Sir Arthur Fleming, replying to the discussion, said that a question raised by several speakers which he wished to stress very strongly was the tendency for young men who had completed the university course to take the best—perhaps the most attractive financially—job that he was offered. To-day a great many such jobs were available; really first-class graduates in applied science were scarce, and there was a grave risk of men starting off in their jobs in a half-trained condition. That was unfortunate, because the man did not get a really broad foundation on which to build a career. Mr. Livock's idea of the introduction of one year of practical training for electrical and mechanical engineering students before going to the university was practised to a limited extent, but he believed that it was fundamentally sound. It was one of which he had experience. There was a course in his own organisation, started by Mr. K. R. Evans many years ago, and the results had been outstandingly good. Under it, men could go to the university with some knowledge of application to technical studies, understanding what their studies were all about. He was sure that was very helpful. If they got in some practical work during the vacations and then had a further year's practical work at the conclusion of the university course it made the course a very good one indeed. Mr. Bellamy had asked why craft apprenticeship ended at 21 years of age, but that had not always been so. Under the guild system there was a period of seven years training to be put in, irrespective of age. More recently, however, the tendency had been to make the period end at 21, but the introduction of military service upset that quite a bit. In the United States, for instance, there were many firms who provided training, usually not of more than three years' duration, for men of almost any age. He had, he said, known men up to the age of 30 starting as apprentices, earning just about enough to keep them alive during their apprenticeship, spending three years learning a trade. He fully agreed with Mr. Perkins's suggestion of continuing education of a technical character after post-graduate training. In the North of England, about 1938, there was a plan for starting advanced courses of training, the idea being that there were many new developments in industry which had outstripped the production of text-books and there were techniques about which students could learn nothing in the university, and about which they could not always get what they needed from the technical Press—although the technical Press was always extremely able in these respects. Therefore, courses were set up, often of perhaps half-a-dozen men who were keen on some specialist knowledge; they would be given perhaps half-a-dozen lectures by an expert on the subject who could, if he wished, sub-let some of his work to other lecturers. That was an important development, because it meant that keen young men got knowledge which they could use quickly; the time-lag between getting the knowledge and using it was reduced. He concluded by hoping that Mr. Wooding's suggestion that there should be a general discussion at one of the institutions could be carried out.

Mr. Harding also replied, and on the motion of the chairman, a vote of thanks was accorded to the authors for their papers.

(To be continued.)

Iron and Steel Production in Europe.—The committee of the Economic Commission for Europe, representing the United States and 13 European countries, which has been meeting in Geneva, recommends special measures to increase the European output of iron ore, and the exploitation of new deposits, in the endeavour to obtain a 10 per cent. greater output by 1953. On the basis of 40 per cent. average iron content, this represents an increase of not less than 7,000,000 tons of ore, and perhaps as much as 12,000,000 tons.

Educational Charts on Oil Industry.—The Shell Petroleum Co., Ltd., have produced a series of ten pictorial charts on the main activities of the oil industry, namely, exploration, drilling, field development, production, land transport, transport by water, primary distillation, vacuum distillation, thermal cracking, and fluid catalytic cracking. The charts are in colour, with the text written in a straightforward, though technical, style, suitable for educational purposes, and each measures 31 in. by 23 in. Sets are obtainable from Shell-Mex and B.P., Ltd., Shell-Mex House, Strand, London, W.C.2, price 11*s*. 6*d*. each, including postage.

TELEVISION AT THE BRITISH ASSOCIATION MEETING.

THE 1951 annual meeting of the British Association for the Advancement of Science, held in Edinburgh from August 8 to August 15, will go down in the annals of British television. As noted previously in our columns, the inaugural proceedings on Wednesday, August 8, which included the conferring of the degree of Doctor of Laws by the University of Edinburgh on H.R.H. The Duke of Edinburgh, this year's President of the Association, were transmitted by a radio-television link from the University's M'Ewan Hall to the city's Usher Hall, nearly a mile away, and were viewed there, on a screen measuring 12 ft. by 16 ft., by a large audience which filled the hall almost to capacity. Although the occasion was not, by any means, the first on which televised pictures had been displayed on a large screen before a British audience, such a demonstration had never before been given north of London nor had a radio link been employed as the means of transmission. The audience, numbering well over 2,000 persons, was also the largest single audience ever to view television on a screen of cinema size. The most remarkable feature of the demonstration was the steadiness and brilliance of the picture. The clarity of the close-up views provided by the telephoto lenses of the viewing cameras was astonishingly good, though it appeared to be associated with a restricted depth of focus which occasionally resulted in the background being somewhat blurred. However, although a standard 405-line system was employed, the lines on the screen were at all times quite invisible owing to the use of a technique known as "spot wobbling." The excellence of the whole transmission drew spontaneous and prolonged applause from the whole audience at the close of the proceedings and the achievement was described by Sir John Russell, a past-President of the Association, who presided, as the end of the first phase in television and the beginning of the second, the end of which no one could foresee.

Only one feature of the original was missed in the transmission, namely, the colour, which was particularly brilliant. The extent of the loss was appreciated by the audience at the close of the proceedings when the leading members of the platform party, in their glowing academic gowns and robes of office, paid a short visit to the Usher Hall. On the other hand, the audience had unquestionably a much better and more intimate view of many details of the proceedings than did those in the M'Ewan Hall. Little was missed by the roving eye of the television camera, which at times picked out and displayed the idiosyncracies of members of the platform party with almost alarming candour. Gestures and mannerisms revealed by this innocent, and frequently accidental, prying, at times gave the audience in the Usher Hall considerable amusement, especially as the victims frequently appeared unaware of the camera's scrutiny. The arrangements for televising the proceedings were carried out by Messrs. Cinema-Television, Limited, Worsley Bridge-road, Lower Sydenham, London, S.E.26, who have given the following details of the installation.

Two standard Marconi cameras of the Image Orthicon type were employed. Each was fitted with a turret containing four lenses any one of which could be employed at will to show close-up (head and shoulders), semi-extended (three-quarter length), or full-length views, or again a wide-angle view including the whole platform party. The angle or the closeness of the view was changed every 30 seconds, approximately, during the transmission. Each camera had its own chain of ancillary equipment, including an electronic viewfinder, and a camera control and monitor unit having a stabilised power supply. A synchronising signal generator fed both camera units and supplied the master pulses to the transmitter. A mixing and a switching unit was provided for selecting from either camera the picture to be televised, and the output from this unit was fed directly to the transmitter.

The transmitter was of the Marconi micro-wave type, employing wide-band frequency-modulation in the 6,500 to 7,100 megacycles per second waveband. The system is highly directive and it was necessary to provide a line of direct vision between the two buildings. This was accomplished by mounting an aerial on the roof of each. The transmitting system consisted essentially of the transmitter, its rod-type aerial behind which was a parabolic reflector, a control unit and the necessary interconnecting cables and accessories. The control unit was placed at a convenient point and connected to the transmitter through a single multicore cable, the only restriction on which was that its length had to be less than 400 ft. The transmitter was run from the supply mains and consumed 170 watts, compared with 250 watts in the case of the receiver.

The receiving and projection equipment was that designed, developed and manufactured by Messrs. Cinema-Television, Limited, for the projection of television pictures on to cinema screens of normal size, and had been used previously in Britain only for private demonstrations. The receiving equipment was mounted back-stage in a series of racks. It consisted of the receiver proper, a high-voltage power supply unit for the cathode-ray tube, a control monitor panel fitted with three knobs for controlling the brightness, focus and contrast of the picture, and various ancillaries. The actual projector was situated in the stalls of the auditorium and was operated by remote control. It consisted of a high-powered cathode-ray tube which gave a very bright image of the televised picture measuring 5 in. by 6 in., approximately. The cathode-ray tube faced the rear of the hall and the image was reflected by a large mirror 27 in. in diameter, through a plastic correcting plate 18 in. in diameter surrounding the neck of the tube, and thence on to the screen which, as already mentioned, measured 12 ft. high by 16 ft. wide.

The signal was picked up at the Usher Hall on an aerial similar to that at the transmitting end. From the receiver, the video signal was fed to the vision receiving racks, where it first passed through a video amplifier in which the synchronising signals were filtered out and fed to the synchronising-signal separator. This unit separated out the line and frame synchronising signals, which were then passed to their respective scanning generators for transmission by cable to the scanning coils of the projector tube. The video signal was passed subsequently through various correcting units and was fed finally into the output amplifier. The latter applied approximately 450 volts of vision signal to the cathode of the projection tube.

The focus supply was modulated with line and frame frequency signals to keep the spot size uniform over the whole of the screen, and the heater of the cathode was fed by a low-capacity transformer which was voltage-stabilised. The anode voltage supplied to the tube was 50 kV. It, also, was stabilised and the face of the tube was cooled by an air blast. The average beam current during operation was between one and two milliamperes but under peak conditions it rose to 15 milliamperes. The projector was designed to give a brightness comparable with that of a normal film projector, 7 foot-lamberts brightness of illumination being obtained. The contrast range was 50 to 1. The equipment was designed specially to minimise the effects of impulse interference such as is caused by the ignition systems of motor cars and, in fact, there was no trace of interference during the transmission. One concluded indeed, from the sustained excellence of the latter, that the equipment had now reached a stage of development where it could meet fully the requirements of the contemporary cinema.

MINIATURE BALL BEARINGS.—The British distributors of the Swiss-made R.M.B. ball and roller bearings, Miniature Bearings, Limited, 192, Sloane-street, London, S.W.1, have sent us a sample of a ball bearing only 1·5 mm. in diameter and 0·93 mm. in depth. It is designed for a 60-deg. pivot and consists of a pressed-steel cup, a dust cover, a ball cage and three chromium-steel balls. They state that the smallest standard ball bearing in the world, also an R.M.B. product, is the model C1, which is 1·10 mm. by 0·70 mm. A booklet issued by the agents illustrates and describes some applications of small ball bearings of this type.

AIRCRAFT TORPEDO RANGE OFF THE LIZARD.—The Admiralty announce that it has been decided to establish an aircraft torpedo range off the Lizard peninsula, Cornwall. It will cover an area of about five square miles off the south-west coast of Cornwall, near the Manacles. Two observation posts will be erected on the coast, and red flags will be flown from these posts when the range is in use, and no aircraft will be permitted to drop a torpedo if there appears to be danger to any ships in the vicinity. The torpedoes used will not carry explosive charges. A public local inquiry will be held by the Ministry of Local Government and Planning before sanction is given to proceed with the scheme.

EDUCATIONAL FILMS AT CAMBRIDGE UNIVERSITY.—The need for an institution to provide cinematograph services and to produce films, in the same way that a university press provides printing services and produces books, is stressed in the fourth report of the Cambridge University Educational Film Council. Films continue to be made, however, under restricted conditions, by individuals in the University; a working-print of a film recording the building and opening of the Engineering Laboratory workshops has been made, and cinematography is being used for research on the flow of gases in internal-combustion engines. An investigation has shown that, in an educational film session, an appropriate musical accompaniment to a silent film aids visual attention. The Council's general secretary is Mr. C. Denis Pegge, M.A., Engineering Laboratory, Trumpington-street, Cambridge.

SENSITIVE TEMPERATURE CONTROLLER.

THERE are many occasions in engineering practice and research where high temperatures have to be maintained approximately constant over extended periods. Instances where this is necessary are to be found in metallurgical and chemical processes and in studies of the properties of materials. In creep tests, for example, furnace temperatures have to be kept steady within narrow limits, not so much because the properties of the materials under examination change rapidly with temperature as because the measuring equipment is never wholly insensitive to temperature variations. The elongations which occur during creep are so small that thermal effects on the measuring equipment must be guarded against carefully. To modern science, the accurate measurement of temperature presents no serious difficulty and it can generally be controlled satisfactorily provided sensitive apparatus is employed. Sensitivity, however, usually implies complication.

The temperature regulators in most frequent use employ either thermocouples or resistance thermometers, those in the first category being the more common. The thermocouple has the advantage over the other that it measures the temperature locally. The indicating instrument may be either a direct-reading millivoltmeter and the control a manually-operated rotary switch, or it may be a compensating device or a recording instrument. For the accuracy which work on creep demands, compensating instruments are essential, but they may involve a considerable expenditure of power since the switching must be done by means of a servo mechanism which is sensitive enough to operate quickly and accurately on very small inputs. The obvious course of amplifying the small thermo-electric voltages electronically in order to increase the sensitivity and eliminate the servo-mechanism presents considerable difficulty since the magnitude of the input voltage is of the same order as the disturbance levels of the amplifying valves.

In the case of temperature regulators in the second category, platinum resistance thermometers are generally employed. The magnitude of the voltage change which accompanies a change in resistance is normally sufficient for electronic amplification to be used without much difficulty. An electrical bridge circuit is always employed and the amplified currents are used to operate an ordinary relay. The highest temperature which can be controlled in this way is limited, however, to about 900 deg. C., owing to the resistance wires being platinum and the temperature probes being subject to expansion.

In an effort to find a simple solution to the temperature-control problem in electric furnaces, Messrs. Alfred J. Amsler and Company, Schaffhouse, Switzerland, have produced the equipment illustrated in Fig. 1, on page 204, which is capable of maintaining any working temperature between 0 and 1,000 deg. C. constant within $\pm$ 0·5 deg. C. Most of the control devices already mentioned work on the "on-off" principle and come into operation only when the temperature which is being controlled has risen or fallen by a certain minimum amount. Consequently, in furnaces which have a high thermal inertia, the temperature can deviate considerably from the desired value. Although the Amsler temperature controller employs a well-known principle, namely, that different materials have different coefficients of thermal expansion, its design has certain novel features which will be understood by reference to Fig. 2, on page 204.

The temperature probe is a tube *a* closed at one end and made of a highly heat-resisting steel. It contains a quartz rod *b* and a distance rod *c* made of the same steel as the tube. The active length of the probe is fixed by the length of the quartz rod, which is approximately 2 in., but the overall length may have any one of four standard values which range from 3½ in. to 11 in., approximately. Owing to the shortness of the active length, the temperature is measured relatively locally, and this allows the regulator to be inserted into small furnaces radially. In other cases it may, of course, be fitted axially. When the probe is heated, the steel tube expands more than the quartz and the difference is transmitted through the rod *c* to the lever *d* and the leaf-spring *e*, which are supported on a strip of metal from the baseplate *f*. The latter can be adjusted by means of the toothed nut *g* geared to the pinion *h*. The pinion is rotated by means of a knob having a pointer and scale which are visible in Fig. 1.

The leaf-spring at its free end has a contact stylus *i* tipped with precious metal, and the differential expansion of the probe is magnified approximately a hundred-fold there. Beneath the stylus is a rotating disc *k*, also of precious metal, which is inclined to its driving spindle, and thus forms a swash plate. The relative positions of the stylus and disc are such that the former rests on the latter over a circular arc, the length of which depends on the height of the stylus point above the centre of the disc. As the latter rotates, the stylus

SENSITIVE TEMPERATURE CONTROLLER.

ALFRED J. AMSLER AND COMPANY, SCHAFFHOUSE, SWITZERLAND.

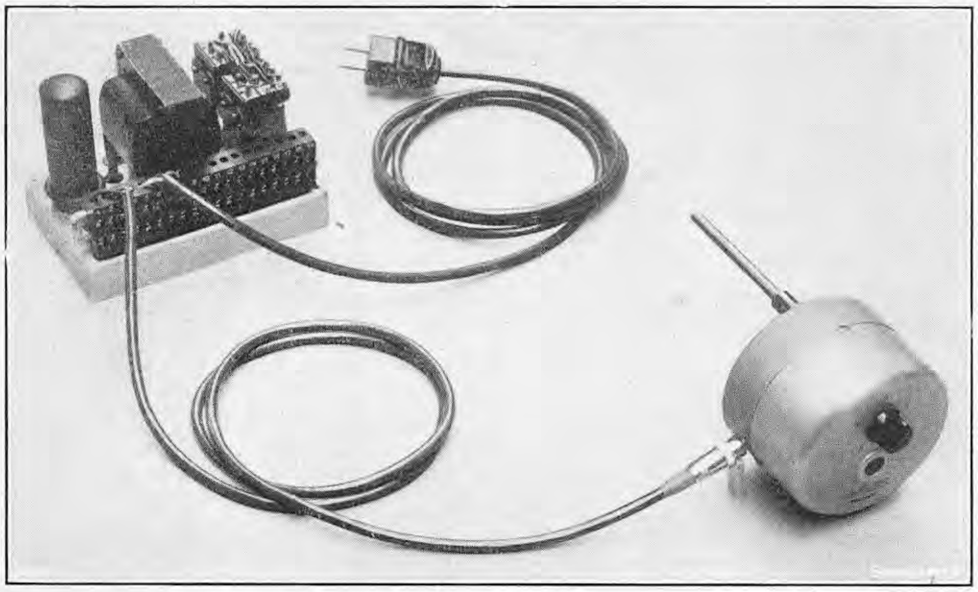


FIG 1.

Fig. 2.

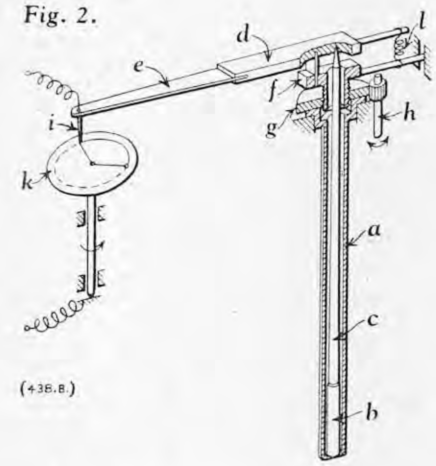
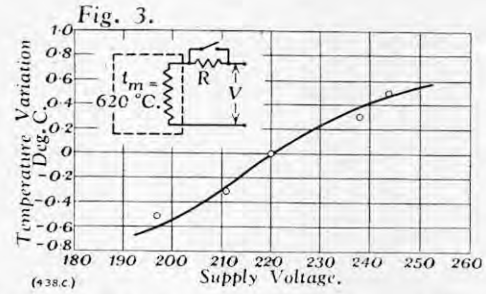


Fig. 3.



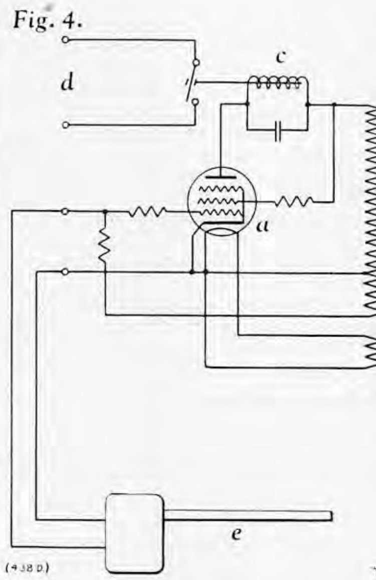
rides up and down along the arc of contact under the light restraint of the leaf spring. Electrical leads connected to the disc and stylus are in the grid circuit of a single-valve electronic amplifier which actuates a relay in accordance with the making or breaking of the contact. The relay, in its turn, controls the supply of current to the furnace. Since the disc is rotated at constant speed—6 r.p.m., approximately—the sum of the " on " and " off " periods is constant. Their ratio, on the other hand, depends on the distance of the stylus from the disc.

Control of the furnace is therefore accomplished by repeatedly switching the furnace current—or part of it—on and off. Since this is done comparatively rapidly, the temperature can never change much in the interval. Should it tend to rise steadily, the probe will expand and cause the rod *c* to withdraw into the tube *a*; the lever *d* will tilt under the action of the spring *l* and lift the stylus away from the disc, thus reducing the arc of contact. The process will continue till the temperature begins to fall again. The range of temperature between the extreme positions in which the stylus either touches the disc continuously or is wholly out of contact with it, depends on the mechanical ratio of the lever and—more important still—on the inclination of the swash plate to its spindle. Since the current which passes through the contact is no more than suffices as the input to the electronic control unit, it can be kept comparatively small and, in consequence, the inclination of the disc may be extremely small. It is easily possible to limit the range between " permanently on " and " permanently off " to 1 deg. C. and still secure dependable working of the switch. Under such conditions, the furnace temperature may be maintained constant with a few tenths of a degree. The sensitivity of the control is constant over the whole of its useful range of regulation between 0 and 1,000 deg. C.

An example of the degree of control obtained during a test of the equipment is given in Fig. 3, on this page. The furnace was set to operate at 620·0 deg. C., at the nominal supply pressure of 220 volts, and the voltage was varied. The full curve in the diagram shows the theoretical temperature variation and the small circles the measured values. The resistance R was chosen so that, when it was short-circuited, the output of the furnace was doubled. The temperature fluctuation corresponding to a supply-voltage fluctuation of $\pm$ 10 per cent. was only $\pm$ 0·5 deg. C.

The electronic relay, which is actuated by the rotating contact, is shown diagrammatically in Fig. 4, on this page. The electronic valve *a* is one of the standard 6L6 output type and is fed entirely with alternating current from the transformer *b*. It acts, therefore, as an amplifier and a rectifier combined. The anode circuit contains a relay *c* to which a switch of a size suited to the furnace is connected at the terminals *d*. When the contact in the controller *e* is open, no current flows through the valve, and it is only when the contact is closed that the relay is energised. The voltage at the contacts of the controller is approximately 20 volts and the current which flows when the circuit is completed is about 20 milliamperes. Should the supply voltage fail or the valve break down, the relay automatically reduces the furnace temperature. If, owing to failure of the rotary switch, or damage to the controller, the furnace temperature is exceeded by a certain preselected amount, the whole of the heating current is cut off by the operation of an auxiliary contact, within the controller, which is adjustable. The relay itself has three sockets; two of these are for temperature regulation and the third is for the limit switch.

Fig. 4.



In the case of thermally sluggish furnaces, it is found that, with all direct regulators, i.e., those which operate only when the probe has attained some definite temperature, the furnace temperature oscillates more or less widely about a mean value. The period and amplitude of the variations are dependent on the thermal characteristics of the furnace and the amount of thermally sluggish material interposed between the source of heat and the temperature probe. If, however, the interval between the times of successive switchings is controlled by external means and kept short, the temperature fluctuations will also be reduced. As already mentioned, this is accomplished in the Amsler controller by fixing the period of rotation of the swash plate at 10 seconds, approximately, during which time the furnace temperature cannot vary by much. Thus, the controller is equally effective with thermally-sensitive and thermally-sluggish furnaces.

The operation of a sliding contact is not without its problems, and these have been investigated very fully by the Amsler company. Although it does not follow that the difficulties are any greater with a sliding contact than with a fixed make-and-break, the reliability of the temperature controller described above depends mainly on the reliability of the contact on the rotating disc. Even at low voltages, a certain amount of burning takes place at a contact, and the relative motion of metal surfaces is always accompanied by some adhesion and shearing of the metals. The situation is also complicated by the presence of oxide and other films on the metal surfaces. Without going into details, suffice it to say that all these matters have been considered by the Amsler company and that their conclusions have been published in a technical paper* to which we are much indebted for the information contained in this article.

In conclusion, it should be mentioned that the Amsler temperature controller also records the temperature, in the sense that the selected temperature at which the controller maintains the furnace is displayed on the instrument. The setting and fine reading of the desired temperature are effected with the aid of the control knob and scale, visible on the back of the housing, in Fig. 1. The coarse reading of the temperature is displayed in the circular window below the knob. All the mechanical components, including the driving motor for the disc, are in the housing, which is of light alloy. The electronic relay works on either 220 volts or 110 volts, alternating current, 40 to 60 cycles per second, and consumes 30 watts. Controller and relay, together, weigh 6½ lb. Models of greater sensitivity and accuracy, covering narrower temperature ranges, and other variants on the standard patterns, can be supplied on special order. The sole agents in Britain for the Amsler temperature controller are Messrs. T. C. Howden and Company, Limited, 12, High-street, Leamington Spa.

FIRST DIESEL LOCOMOTIVE BUILT IN SOUTH AFRICA.—The first Diesel locomotive for handling main-line wagons to be built in South Africa has been completed at Johannesburgh by Hunslet Africa (Pty.), Limited, an associate of the Hunslet Engine Company, Limited, and is at work in a timber yard at Germiston, where it handles timber trolleys and wagons in connection with the South African Railways, and performs all the internal shunting of the yard. It is of 3 ft. 6 in. gauge and embodies all the usual Hunslet features. Power is provided by a Gardner 6LW engine giving 100 h.p. at 1,700 r.p.m. on site, which is nearly 2,000 ft. above sea level. The drive is through a two-step transmission, giving track speeds of 4 and 8 m.p.h., with corresponding tractive efforts of 7,000 lb. and 3,500 lb., respectively. The weight of the locomotive is 13½ tons. Loads up to a maximum of 400 tons are hauled on straight level track, and up a 1 in 50 grade a trailing weight of 100 tons is pulled in bottom gear. Wheels are 33 in. in diameter, and the wheelbase is 5 ft. 6 in.

* *Ueber einige Probleme bei der Regulierung hoher Temperaturen.* By M. Russenberger and H. Lustenberger. Verlag Vogt-Schild AG, Solothurn, Switzerland (1950).

DRILLING MACHINE WITH CAM-FEED HEAD.

ALFRED HERBERT, LIMITED, COVENTRY.

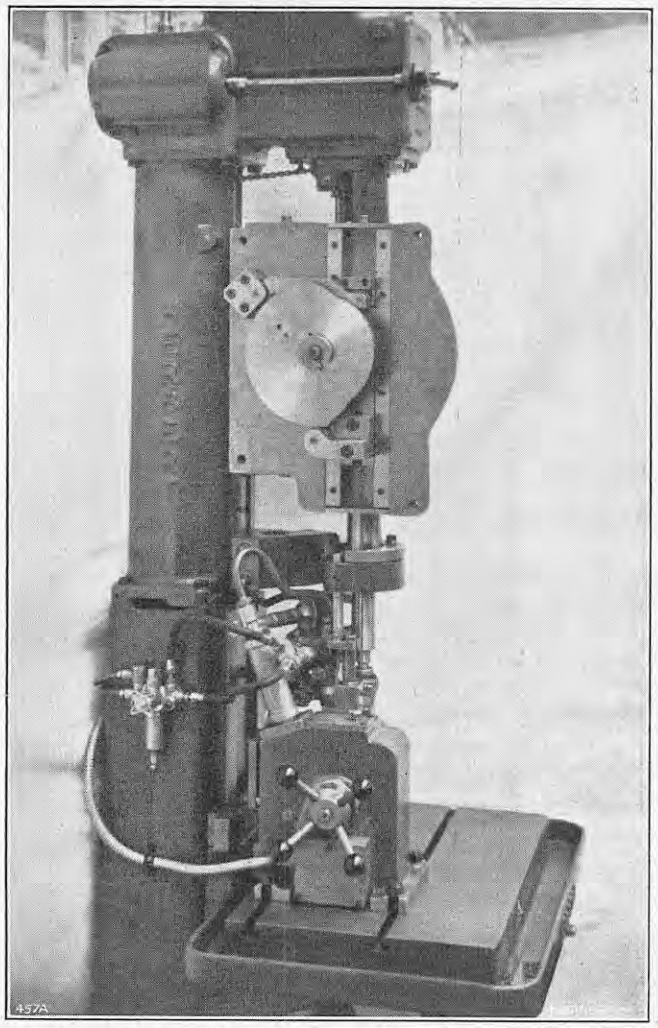


FIG. 1.

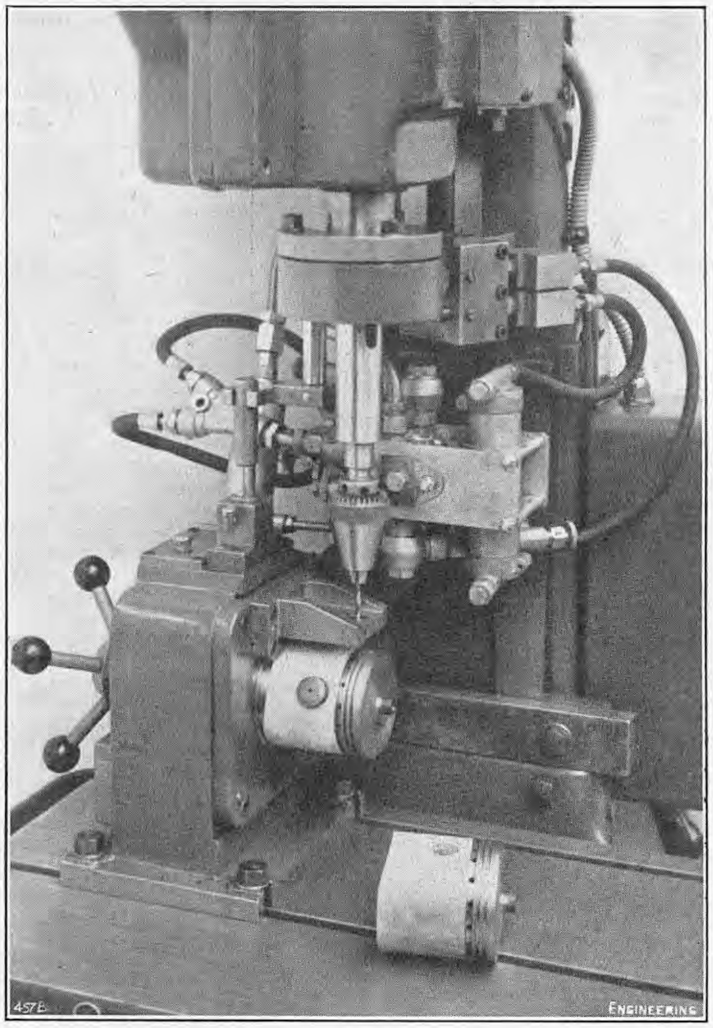


FIG. 2.

DRILLING MACHINE WITH CAM-FEED HEAD.

FOR use with their drilling machines, Messrs. Alfred Herbert, Limited, Coventry, have recently introduced cam-feed heads which control the machines automatically. Used in conjunction with suitable fixtures, it is therefore possible to carry out a sequence of drilling operations automatically and thereby, it is claimed, idle time can be greatly reduced. An example of such an application is illustrated in Figs. 1 and 2, which show a Herbert Type C single-speed drilling machine with a cam-feed head arranged for drilling 14 equally-spaced holes in the scraper-ring groove of a piston. This type of machine is available with any one of eleven speeds within the range 72 to 2,415 r.p.m.

The feed shaft is driven through reduction gearing by the main spindle; in the machine illustrated, the reduction ratio is 2·745 to 1. From the feed shaft, a horizontal camshaft is driven through gears, which provide a means for varying the camshaft speed, and a worm and wormwheel. The camshaft carries two cams: a large cam, which can be seen in Fig. 1, controls the downward motion of the main spindle, and provides for the required variation in the speed of the motion for rapid approach to the work, normal feeding, and dwelling. Where deep holes are to be drilled, the cam can also be arranged to clear the drill of swarf automatically. The withdrawing motion of the spindle is controlled by a second, smaller cam which is bolted and dowelled to the inner side of the large cam. At the other end of the camshaft, a timing mechanism, consisting of an electrical limit-switch tripped at each cam revolution by a dog on the camshaft, is provided to stop the machine automatically at the end of each cycle. In the machine illustrated, however, this switch is electrically connected to the fixture in such a way that 14 drilling operations are carried out consecutively before the timing switch cuts out the machine.

The piston which is being drilled is carried on an air-operated indexing fixture which is located in 14 positions successively by a Geneva motion actuated by the main spindle. At the top of its stroke, the spindle operates a trip valve, mounted on the column of the machine, which admits air into the outer end of an air cylinder, driving a piston inwards. An extension of this piston carries a rack which engages with a small pinion, and drives a ratchet and pawl mechanism which moves the driving plate of the Geneva motion through 180 deg. and thereby rotates the Geneva index plate through $\frac{1}{14}$ revolution. At this point, as the drill spindle commences its down stroke, the driving plate is retained by a plunger under light spring pressure. A bar attached to the drill spindle positively locates the Geneva index plate just before the drill commences cutting. At the bottom of the stroke of the spindle, another trip valve is opened, admitting air to the other end of the cylinder and driving the air-cylinder piston and rack outwards. In this case, however, the ratchet does not engage the pawl and the motion is not transmitted to the Geneva driving plate. As the spindle again reaches the top of its stroke, the cycle is repeated. To stop the machine automatically after 14 cycles, a timing switch fitted to the fixture is tripped at the end of each revolution of the Geneva index plate, that is, once every 14 revolutions of the camshaft. This switch is wired in the same circuit as the limit switch on the camshaft in such a way that the latter does not operate until the timing switch on the fixture has been tripped.

MESSRS. JOHN LAING AND SON, LTD.—The history of the building and civil engineering contractors, Messrs. John Laing and Son, Ltd., London, N.W.7, is the subject of a lavishly-produced book, "Team Work," a copy of which we have recently received. The firm was founded over a hundred years ago—1848 is regarded as the foundation year—and gradually extended the size of contracts undertaken. In recent years, the many large works completed have included military establishments, factories, the underground headquarters of the Royal Air Force during the war, power stations, schools, open-cast coal workings and the 1⅔-mile runway for the Brabazon at Filton airport. Marshal of the Royal Air Force Lord Tedder has contributed a foreword to the book and Mr. J. W. Laing, governing director has written an introduction.

CEYLON GOVERNMENT RAILWAY.

THE annual report for 1950 of the Ceylon Government Railway* reveals a loss of Rs.13,622,382; the gross revenue was Rs.57,650,139, and working expenses were Rs.71,272,521. "Being State-owned," the general manager remarks, "the railway has to be a model employer, but at the same time it has to face road competition and also justify itself as a commercial enterprise."

The total route mileage remained unchanged during the year at 896, of which all but 87 miles of 2 ft. 6 in. gauge are broad gauge, 5 ft. 6 in. Difficulty was experienced with the supply of sleepers owing to a ban on the export of hardwood sleepers from certain countries. The best had therefore to be made of local timber, supplemented by 77,000 Douglas fir sleepers from Canada and 25,000 steel sleepers from the U.K. Seven out of 12 bridges ordered from the U.K. were received. In the mechanical engineering branch, delays in obtaining new locomotives, carriages and wagons resulted in many "over-age" engines and vehicles being kept in service at the expense of normal scheduled repairs and replacements. The number of heavy repairs fell and the repair cost per unit increased (from Rs.663 to 1,497 in the case of wagons), due to more extensive repairs being necessary on over-age vehicles.

The number of locomotives in commission at the end of the year, including narrow-gauge engines and Diesel-electric shunting engines, was 235. Four narrow-gauge Hunslet Diesel-mechanical shunting engines were received during the year and are being used for passenger service as well as shunting. A "Diesel de Luxe" observation car, designed for tourist traffic and special parties, was placed in service during the year. It has accommodation for 30 to 35 passengers and can be hired for journeys over 25 miles at a minimum of 20 first-class fares at 1¼ times the single fare for the double journey.

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* *Administration Report of the General Manager, Ceylon Government Railway, for* 1950. Government Publications Bureau, Colombo. [Price Rs. 2; postage, 25 cents.]

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SCOTTISH STEEL OUTPUT.—The production of steel ingots and castings in Scotland during July declined to the annual equivalent of 1,184,500 tons, compared with 1,573,600 tons in the corresponding month last year, representing a shrinkage of almost 25 per cent. Blast furnaces turned out the equivalent of 674,900 tons of pig iron per annum against 542,600 tons in July, 1950, when, however, one large furnace was just coming back into production after a major overhaul. The output in June was at a rate of 756,400 tons per annum.

COAL POSITION.—Stockpiling of coal in Scotland has been slowed down recently as a result of the suspension of Saturday working at the pits since June. The total distributed stocks, compared with last year, however, retain a favourable margin, built up in earlier months. All categories, with the exception of the domestic section, share in the improvement. Industrial reserves are about 17½ per cent. higher, and stocks at iron and steel works, reflecting reduced activity on account of raw material shortages, are up by 30 per cent.

SHIP-BREAKING ACTIVITIES.—Metal Industries, Ltd., have acquired the Norwegian Government's fish-freezing steamer Thorland (5,176 tons gross) for breaking up at Faslane, on the Gareloch. The firm are still engaged on the hull of the Aquitania, of which about 20 ft. remains above the waterline.

EFFECT OF METAL SHORTAGE.—A shortage of raw materials, particularly nickel, is reported to be threatening the level of employment at the Newhouse factory of Vatric Ltd., manufacturers of vacuum cleaners. Dismissals within the next few weeks may be necessary, platers and polishers being probably the most affected. The firm, who do a considerable export business, have the largest factory in the Newhouse industrial estate.

OIL IMPORTS AT KIRKCUDBRIGHT.—Dredging has begun at Kirkudbright harbour to allow Shell-Mex oil tankers to discharge fuel oil. The firm are building a storage depot nearby, to which the oil will be conveyed by pipelines.

FACTORY AT EAST KILBRIDE.—Mr. J. D. Wormley, managing director of the British subsidiary concern of John Deere and Co., agricultural-machine manufacturers in the United States and Canada, visited East Kilbride on August 8 to discuss preliminary arrangements for the firm's factory in the new town.

EXTENSION OF GRID SYSTEM.—The Rt. Hon. Hector McNeil, M.P., Secretary of State for Scotland, has confirmed a scheme prepared by the North of Scotland Hydro-Electric Board for the erection of overhead transmission lines from Boat of Garten, in Inverness-shire, to the Board's transforming station at Craigiebuckler, in Aberdeen. The scheme is estimated to cost 698,600*l*. The Amenity Committee asked that the lines should avoid woodlands and plantable land as far as possible; the Board have given an assurance that this will be done, and that, where practicable, towers will be kept below the skyline. The Secretary of State did not consider it necessary to hold an inquiry, which was not asked for by any objectors. A White Paper (Cmd. 8304) on the scheme is available from H.M. Stationery Office, 13A, Castle-street, Edinburgh, price 2*d*.

CLEVELAND AND THE NORTHERN COUNTIES.

BUSINESS IN IRON AND STEEL.—Last week, transactions in Cleveland iron and steel products dwindled to a very low ebb. Makers of most descriptions of material have congested order books and expect the tonnage available for distribution to be under official direction for some time to come. Unfortunate features in the unsatisfactory general situation are the continued decrease in steel-scrap supplies and stocks of pig iron. Ironfounders are desperately short of blast-furnace materials and users of East-Coast hematite are calling persistently for larger deliveries than they are receiving, while refined-iron makers have difficulty in dealing satisfactorily with the demands of the usual buyers. Scarcity of semi-finished steel commodities is hampering operations at re-rolling mills. The heavy steel mills are running at as high a pressure as the present conditions permit.

PASSING OF NEWCASTLE-GATESHEAD TRAMWAY SERVICE.—Just before midnight on August 4, the last tramway car to run from the Central Railway Station, Newcastle-upon-Tyne, to Gateshead, left the Newcastle terminus, passed across the High Level Bridge over the River Tyne and travelled on to the depot in the Dunston district of Gateshead. It is described as the last privately-owned and operated tramway car in this country, and the service, which was instituted in 1883, with coke-consuming steam tramways and electrified in May, 1901, will now be maintained by omnibuses operated by the newly-named Gateshead and District Omnibus Co.

LANCASHIRE AND SOUTH YORKSHIRE.

RE-STARTING OF A STEEL FURNACE.—It has been found practicable to bring into production again one of the five open-hearth steel-smelting furnaces at the plant of Steel, Peech & Tozer, Ltd., Sheffield. These, it will be recalled, were closed some time ago owing to scarcity of melting material, chiefly scrap. The furnace has been re-started for the time being on materials accumulated during the holiday. There are now 13 furnaces in production at the company's plant, compared with a normal total of 16. There is a prospect of fuller supplies of scrap from Germany.

SHEFFIELD AREA OUTPUT OF STEEL.—The steel production of the Sheffield area in July was nearly 5,000 tons a week lower than in July last year. Lack of sufficient scrap and imported iron ore caused a drop in steel production which reached an average of 36,300 tons a week, the lowest figure since December, 1949. Compared with June, the drop was 4,000 tons a week, a contributory factor being the annual holidays. A view is held in Sheffield that the worst of the shortages of some materials has now been witnessed.

SUPPLY OF SCRAP.—Sheffield industry is settling down after the annual works holidays and is making the best of the situation created by the shortage of coal, pig iron, ferro-alloys, lime and acid, and especially of iron and steel scrap. The home drive for scrap is yielding some satisfactory quantities and there is an impression that imports will be increased. Some of the largest furnaces are still out of production because of the lack of scrap. When steel production achieved a record high level last year, the imports of scrap totalled about 2,000,000 tons; this year, so far, they have reached only about 500,000 tons.

POWER-CUT WARNINGS.—There has been a disappointing response to the inquiry sent to 4,000 Yorkshire industrialists, asking them whether they would agree to install the special short-wave radio sets required to receive warnings of power cuts. The Yorkshire Electricity Board have had only 40 replies in the affirmative, whereas about 200 is the minimum required to make the scheme worth while. The Board's technicians spent some months in working out the scheme, in response to hundreds of complaints of the danger of sudden cuts.

DOLLAR-EARNING ORDER.—A valuable order, placed with Edgar Allen & Co., Ltd., Sheffield, for manganese-steel castings for export to Chile, has recently been completed. The help of the company's French subsidiary was sought to enable the Sheffield firm to comply with the stipulation for early delivery. Some 63 per cent. of the order was dealt with in France and the balance of manufacture was carried out in the Sheffield works. The value of the order was 250,000 United States dollars.

SHORTAGE OF HOUSE COAL.—South-Yorkshire coal merchants are aggrieved because they are being kept very short of house coal. Rotherham merchants state that since Whitsuntide they have received only 85 per cent. of their allocations, and, whereas the shortage for the whole of the country is about four per cent., it is approximately 9·2 per cent. in the North-Eastern Division. The large number of employees on shift work employed in the area necessitates fires in many homes almost throughout the 24 hours of the day, for the purpose of washing and drying working clothes. The merchants urge the necessity for 100 per cent. allocation for the remainder of the programme and the delivery of arrears. They ask for the removal of the anomaly of a rich coal-producing area being one of the worst treated of all districts for household coal.

THE MIDLANDS.

DEVELOPMENTS AT BILSTON STEELWORKS.—Plans have been passed for the erection of a new blast furnace at the Bilston Steelworks of Stewarts and Lloyds, Ltd. There are three blast furnaces, all hand-charged, at the works at present, and the new furnace will be the first of two which will supersede them. It will have a capacity of 3,000 to 3,500 tons of iron a week and will be mechanically charged. It will be worked with high top pressure, and will, it is believed, be the first blast furnace in this country to be designed and built to work in this way. There is a furnace in Scotland working with high top pressure, but it was adapted and not built for the purpose. The new furnace will be equipped with electrostatic dust-precipitation plant, and new turbo-blowers will be installed to provide the blast. Gas from the furnace will be stored, after cleaning, in a 5,000,000-cub. ft. dry-type gasholder. No contracts have been placed yet for the supply and erection of plant, but it is expected that work will begin almost immediately. Some alterations to the steelworks are also to be made, and the whole scheme will require about three years for completion.

SHIPMENT OF MOTOR CARS FOR EXPORT.—The Midlands, where the greatest proportion of the country's motor-car production is centred, is interested in the action taken by the Nuffield Organisation to overcome the problem of shipping vehicles to Australia. Vehicles for Australia have accumulated in this country, in spite of the fact that the market is good, because of shipping delays. To clear the accumulation, the Nuffield Organisation has chartered a number of ships specially for the transport of motor vehicles. The first of these ships, the 5,324-ton motor vessel Exmoor, will sail from London shortly with 1,000 behicles, including cars, tractors and commercial motors. The consignment will be landed at Melbourne.

EXTENSIONS BY THE STANDARD MOTOR COMPANY.—The arrangement made between the Standard Motor Co., Ltd., and Rolls-Royce Ltd., for the former company to make Avon jet aircraft engines will necessitate the employment of considerable extra labour. Authority to extend the works at Coventry has already been sought and it is possible that a new works at Liverpool will also be brought into operation for the aero-engine work. The new project will be additional to the company's normal production of motor vehicles and tractors.

LARGE GLASS PIPE.—Messrs. Quickfit and Quartz, Ltd., of King's Norton, Birmingham, and Stone, Staffordshire, have produced what is claimed to be the world's largest glass pipe, 18 in. in diameter. Considerable difficulties were met in its manufacture, particularly in making the pressed flanges and joining them to the main body of the pipe, but these have now been overcome, and the pipe is in production.

WATER SUPPLY OF NUNEATON.—A public inquiry was held at Birmingham on August 8 to consider the Birmingham Corporation's plans to supply water to Nuneaton, Warwickshire. The scheme includes the construction by Birmingham of a weir across the River Blythe and the reconstruction of existing intake works. The scheme proposes a supply of 1,250,000 gallons a day at first, increasing to 2,250,000 gallons later.

SOUTH-WEST ENGLAND AND SOUTH WALES.

THE LATE MR. IVOR WILLIAMS.—We note with regret the death of Mr. Ivor Williams, which took place on August 8 in a London hospital after an operation. Mr. Williams, who was 74, was chief engineer of Powell Duffryn, Ltd., and had been associated with the firm for 60 years. Previously, he had been with Crompton Parkinson, Ltd., and Fraser & Chalmers, Ltd., and, in 1903, installed the winding engines at the Wankie Colliery, South Africa.

SOUTH WALES COAL TRADE.—Absenteeism in the South Wales coalfield on the two days following the August Bank Holiday was heavy. Demands from the inland electricity stations, gasworks, railways, iron and steel works and other general industries were swollen by additional requests for supplies to go into stock.

BARRY DRY DOCK.—The first repair job to be carried out in the reconstructed Barry dry dock of C. H. Bailey, Ltd., entered the dock on August 8. The vessel is the 12,000-ton tanker Ennerdale, one of the last to leave Persia before the present oil dispute. There is still two months work on the dock before it is completed, but it is sufficiently advanced to enable ships to be docked. The contract to modernise the dock involved a sum of 250,000*l*. The entrance locks have been widened from 55 ft. to 78½ ft. and the length extended by 77 ft. to 939 ft. Some 80 per cent. of the work is finished.

CARDIFF SHIPOWNERS AND SOUTH AFRICAN TRADE.—The South American Saint Line, Ltd., shipowners, Cardiff, have purchased a controlling interest in Parry, Leon & Hayhoe, Ltd., freight, shipping and insurance brokers in South Africa. This company have offices, and, in a number of cases possess warehouses in several important ports in the South African Union, in addition to the head office at Johannesburg.

WATER RESERVOIR AT PORT TALBOT.—A special meeting of the Port Talbot Council on August 9 approved the first steps of a scheme to build a new water reservoir at Port Talbot, at a cost of 320,000*l*. Councillor C. Mort, chairman of the waterworks committee, said that the present water supplies were adequate, but the committee were thinking of the position in 20 years' time.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, September 4, 7 p.m., Electric Light Manufacturers' Association, 2, Savoy-hill, Strand, W.C.2. "Storekeeping," by Mr. J. Barrett.

CONTRACTS.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, are to supply television equipment to the Municipality of Bogota, Colombia, comprising the transmitter and the complete studio centre. These will be similar to those being supplied to the United Nations Organisation in New York, and to Montreal, Toronto, Madrid and Barcelona. The equipment will be manufactured to the American standard of 525 lines. E. K. COLE, LTD., Ekco Works, Southend-on-Sea, Essex, are to supply the television receivers.

WESTINGHOUSE BRAKE AND SIGNAL CO., LTD., 82, York Way, King's Cross, London, N.1, have received orders for their compressed-air brake equipment for vehicle chassis for Australia, Spain and Portugal. These three countries have ordered 50 four-wheeled and 50 six- or eight-wheeled Atkinson lorries, fitted with type-E10PA air compressors, single-chamber reservoir units and MLS foot control valves. Meanwhile, the Kromhout Motoren Fabriek, of Holland, are to take delivery of 35 brake sets, comprising E11P air compressors, two-chamber reservoir units and S.2 control valves; these being for TB.50 "D" omnibus chassis. At home, orders have been received for brake sets for 320 goods vehicles for the Road Haulage Executive in Bristol. These will carry E5V air compressors (fitted to the Leyland engines), simple reservoir units, S.2 control valves and "push-pull" cylinders for the Girling brakes.

LAUNCHES AND TRIAL TRIPS.

S.S. "BRETAGNE."—Twin-screw refrigerated-cargo vessel, carrying 135 first-class, 81 tourist, and 1,048 third-class passengers, built and engined by the Chantier et Ateliers de St. Nazaire-Penhoët, St. Nazaire-sur-Loire, France, for the Marseilles/South America service of the Société Générale des Transports Maritimes à Vapeur, Marseilles. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 42 ft. 6 in. to "D" deck; deadweight capacity, 7,884 metric tons on a mean draught of 26 ft.; gross tonnage, about 15,500; cargo capacity, about 410,000 cub. ft. (133,000 cub. ft. refrigerated). Two sets of Parsons steam turbines with single-reduction gearing, and three forced-draught boilers, developing a total of 15,000 s.h.p. at 150 r.p.m. Service speed, 18 knots. Launch, July 20.

M.S. "BRITISH WARRIOR."—Single-screw oil tanker, built by Joseph L. Thompson & Sons, Ltd., Sunderland, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 423 ft. overall by 56 ft. by 30 ft. 1 in.; deadweight capacity, 8,400 tons on a draught of 25 ft. Three-cylinder opposed-piston reversible oil engine, developing 2,500 b.h.p. at 108 r.p.m., constructed by William Doxford & Sons, Ltd., Sunderland. Service speed, 11 knots. Trial trip, July 27.

S.S. "EXEDENE."—Single-screw cargo vessel, with accommodation for three passengers, built and engined by William Gray & Co., Ltd., West Hartlepool, for the River Plate trade of the Dene Shipping Co., Ltd., London, E.C.3. First vessel of an order for two. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 36 ft. 4½ in. to shelter deck; deadweight capacity, 8,890 tons on a draught of 24 ft. 11½ in. Triple-expansion engines in conjunction with a Bauer-Wach exhaust steam turbine and two oil-fired forced-draught boilers, developing 2,005 h.p. at 78 r.p.m. Speed on service, 10½ knots. Trial trip, July 31.

S.S. "EASTERN STAR."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland & Wolff, Ltd., Belfast, to the joint order of Common Brothers, Ltd., Newcastle-upon-Tyne, and Matheson & Co., Ltd., London, E.C.3. Main dimensions: 462 ft. overall by 59 ft. 9 in. by 38 ft. 6 in. to shelter deck; gross tonnage, 6,200. Parsons triple-expansion condensing steam turbines with double-reduction gearing, to develop 7,250 s.h.p. at 110 r.p.m. in service. Launch, August 2.

M.S. "JEPPESEN MÆRSK."—Single-screw cargo vessel, to carry twelve passengers, built and engined by Burmeister and Wain, Copenhagen, for A. P. Möller, Copenhagen, Denmark. Second vessel of an order for two. Main dimensions: 445 ft. between perpendiculars by 63 ft. 6 in. by 41 ft. 6 in. to upper deck; deadweight capacity, 9,500 tons on a draught of 27 ft. 8 in.; cargo capacity, about 635,000 cub. ft. Ten-cylinder single-acting two-stroke Diesel engine, developing 9,200 b.h.p. at 115 r.p.m. Speed 17¼ knots. Launch, August 9.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Micrometer Items.—A further specification in the series of publications for engineers' precision tools, B.S. No. 1734, covering micrometer heads, has been issued. It may be regarded as complementary to B.S. No. 870 dealing with external micrometers. The new specification relates to micrometer heads supplied independently for assembly with measuring tools or machine tools, and applies to three types, having measuring ranges of ½ in., 1 in., 13 mm. and 25 mm. and thimble diameters of three types. These are below 1 in. in diameter, 1 in. and below 2 in. in diameter, and 2 in. thimble diameter and over. General requirements for the component parts of the head are given, and dimensions, graduations and standards of accuracy are prescribed. [Price 2s., postage included.]

Bevel Mechanical and Optical Protractors.—Another addition to the series of specifications for engineers' precision tools, B.S. No. 1685, relates to three mechanical types and one optical type of bevel protractors. Standards of accuracy are prescribed for the body, stock and blade of the protractor and for the acute-angle attachment, when provided. The method of graduating both types of protractor is specified and general requirements in respect of material, workmanship and marking are included. [Price 2s., postage included.]

Alternating-Current Relays for Railway Signalling.—It has been found desirable to revise the series of specifications for relays for railway signalling, and the opportunity has been taken to combine in a new specification, B.S. No. 1745, the provisions of B.S. No. 520, covering alternating-current track relays, and B.S. No. 557, relating to alternating-current line relays, since many of the provisions of these two specifications were similar. The new specification applies to alternating-current line and track relays of the induction type intended for use in railway-signalling circuits not exceeding 250 volts, and is applicable to relays with or without a local element. [Price 2s., postage included.]

Gas-Fired Boilers for Central Heating by Hot Water.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, working under the ægis of the Ministry of Works, have issued, in final form, Code No. 332.303, covering the installation of gas-fired boilers for central heating by hot water. The Code includes the consideration of points appropriate to boilers required to provide hot water for domestic purposes in addition to space heating. The design of space heating and domestic hot-water systems, however, is dealt with in other codes. In the present Code are listed essential points on which information should be obtained before an installation is commenced, to enable the work to be fitted into a time schedule. It also affords guidance on the selection of the type and number of boilers most suitable for the heating installation to be served, having regard to adequacy of boiler rating, flexibility in meeting variations in the load and preserving the continuity of the supply. Details of clearances to allow of accessibility are given and recommendations made on fire precautions and gas supply and connections, including the master control cock and safety devices. Various automatic controls, their functions and major components, are described, and advice given on points of design. Typical installations are illustrated in a series of diagrams showing various combinations of control and equipment and their points of connection. [Price 3s., postage included.]

Methods for the Analysis of Soaps.—A new specification, B.S. No. 1715, covers methods for the analysis of soaps. It is divided into two parts, in the first of which are given British Standard methods. In Part 2 are given the methods of the International Commission for the study of fats. The publication deals with the sampling and the preparation of material for analysis and gives methods for the determination of loss on drying, water content, total fatty matter, total alkali, free alkali, matter insoluble in alcohol and in water, unsaponifiable matter, rosin, glycerol, and other quantities. [Price 5s., postage included.]

FAST MINELAYERS.—The Admiralty announce that the fast minelayers Apollo and Manxman have been withdrawn from reserve and recommissioned. H.M.S. Apollo joined the Home Fleet on August 1, and H.M.S. Manxman will leave Sheerness on August 27 for trials before sailing on September 9 to join the Mediterranean Fleet.

PERSONAL.

SIR ARCHIBALD J. GILL, B.Sc. (Eng.), M.I.E.E., Engineer-in-Chief, General Post Office, is retiring on October 1. He will be succeeded by DR. W. G. RADLEY, M.I.E.E., at present deputy Engineer-in-Chief.

An advisory committee on metals economy has been formed to help the Minister of Supply to ensure that the most economical use of metals is made in the engineering industry and the defence programme. MR. D. A. OLIVER, M.Sc., F.Inst.P., F.I.M., metals-economy adviser to the Minister, is chairman of the committee. Members of the committee are drawn from industry and Government departments and the other industrial members are MR. G. L. BAILEY, M.Sc., F.I.M., MR. H. A. R. BINNEY, MR. H. H. BURTON, F.I.M., MR. W. C. F. HESSENBERG, M.A., F.I.M., MR. E. G. GRINHAM, M.I.Mech.E., DR. IVOR JENKINS, M.Sc., DR. L. B. PFEIL, O.B.E., A.R.S.M., F.I.M., F.R.S., and DR. C. J. SMITHELLS, M.C., F.I.M. The secretary is MR. K. M. MCLEOD of the engineering industries division, Ministry of Supply.

VISCOUNT FALMOUTH, M.I.Mech.E., Comp.I.E.E., has been re-elected President of the British Internal Combustion Engine Research Association, 111-112, Buckingham-avenue, Slough, for 1951-52. AIR COMMODORE F. R. BANKS, C.B., O.B.E., DR. S. F. DOREY, C.B.E., F.R.S., SIR LYNDEN MACASSEY, K.B.E., VICE-ADMIRAL (E) THE HON. D. C. MAXWELL, C.B., C.B.E., and LIEUT.-GENERAL SIR FREDERICK G. WRISBERG, K.B.E., have been re-elected vice-presidents. MAJOR-GENERAL H. E. PYMAN, C.B., C.B.E., D.S.O., has been elected a vice-president, while MR. H. B. V. TEAGUE, of Crossley Brothers, Ltd., has succeded MR. J. JONES, M.I.Mech.E., as chairman of Council.

COMMANDER (E) F. W. HORNSBY, R.N. (Ret.), M.I.Mech.E., A.M.I.C.E., has been appointed to the newly-created post of director of standardisation (defence) for the Ministry of supply.

MR. TOM JOHNSTON, the present chairman of the North of Scotland Hydro-Electric Board, and MR. NEIL BEATON, whose current terms of office expire in September, have been re-appointed for a further period and SIR HUGH MACKENZIE, of Inverness, at present a member, has been appointed deputy chairman, in place of the late SIR EDWARD MACCOLL. Three new members have also been appointed as from September 1; they are MR. E. S. HARRISON, MR. WILLIAM LEONARD, and MR. A. I. MACKENZIE. All the members of the Board, including the chairman and deputy chairman, will serve on a part-time basis, in future.

MR. J. JONES, M.I.Mech.E., the chief engineer of the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne, since 1939, was appointed technical director in 1948 and general manager in 1949. Upon relinquishing the position of chief engineer in July, 1951, the board of the company have appointed, as chief engineer, MR. J. SMITH, Assoc.M.C.T., A.M.I.Mech.E., A.M.I.Mar.E., who has been assistant chief engineer since January, 1949. Mr. Jones is to continue as director and general manager.

DR. R. W. K. HONEYCOMBE, M.Sc., has been appointed senior lecturer in the physical-metallurgy department in the University of Sheffield. DR. D. W. WAKEMAN, B.Sc. (Birm.), has been appointed a lecturer in the same department.

The British Broadcasting Corporation, London, W.1, announce that MR. G. STANNARD, A.M.I.E.E., has been appointed assistant superintendent engineer (lines) in succession to MR. W. G. EDWARDS, who has retired. MR. R. C. PATRICK, Assoc.I.E.E., has been appointed assistant superintendent engineer (recording).

DR. R. W. CAHN has left the staff of the Atomic Energy Research Establishment to take up a lectureship in the Department of Metallurgy of the University of Birmingham. He entered upon his new duties on August 1.

MR. J. A. J. BLANCKENSEE and MISS E. P. WOOD, joint general managers of the raw materials division of George Cohen, Sons & Co., Ltd., have been elected to the boards of Pollock Brown & Co., Ltd., Westbourne Park Coal & Iron Co., Ltd., and Southall and Hayes coal & Iron Co., Ltd.

MR. J. F. ELPHICK, A.M.I.E.E., until recently power adviser, Land Nordrhein-Westfalen, under the Foreign Office (German Section), has been appointed overseas liaison engineer on the staff of the British Electricity Authority. MR. W. G. S. BOND, hitherto an assistant chief accountant, has been appointed a deputy chief accountant to the Authority in succession to MR. F. H. GRIGSBY, O.B.E.

The name of JURY HOLLOWARE (STEVENS), LTD., Thorns-road, Quarry Bank, Brierley Hill, Staffordshire, has been changed to JURY HOLLOWARE, LTD. The office of the company remains at Quarry Bank.

B. O. MORRIS LTD., Clay-lane, Coventry, have been appointed sole agents in the United Kingdom and in Australia for automatic polishing machines manufactured by ERMA, of Paris.

VILA NOVA HYDRO-ELECTRIC POWER STATION, PORTUGAL.

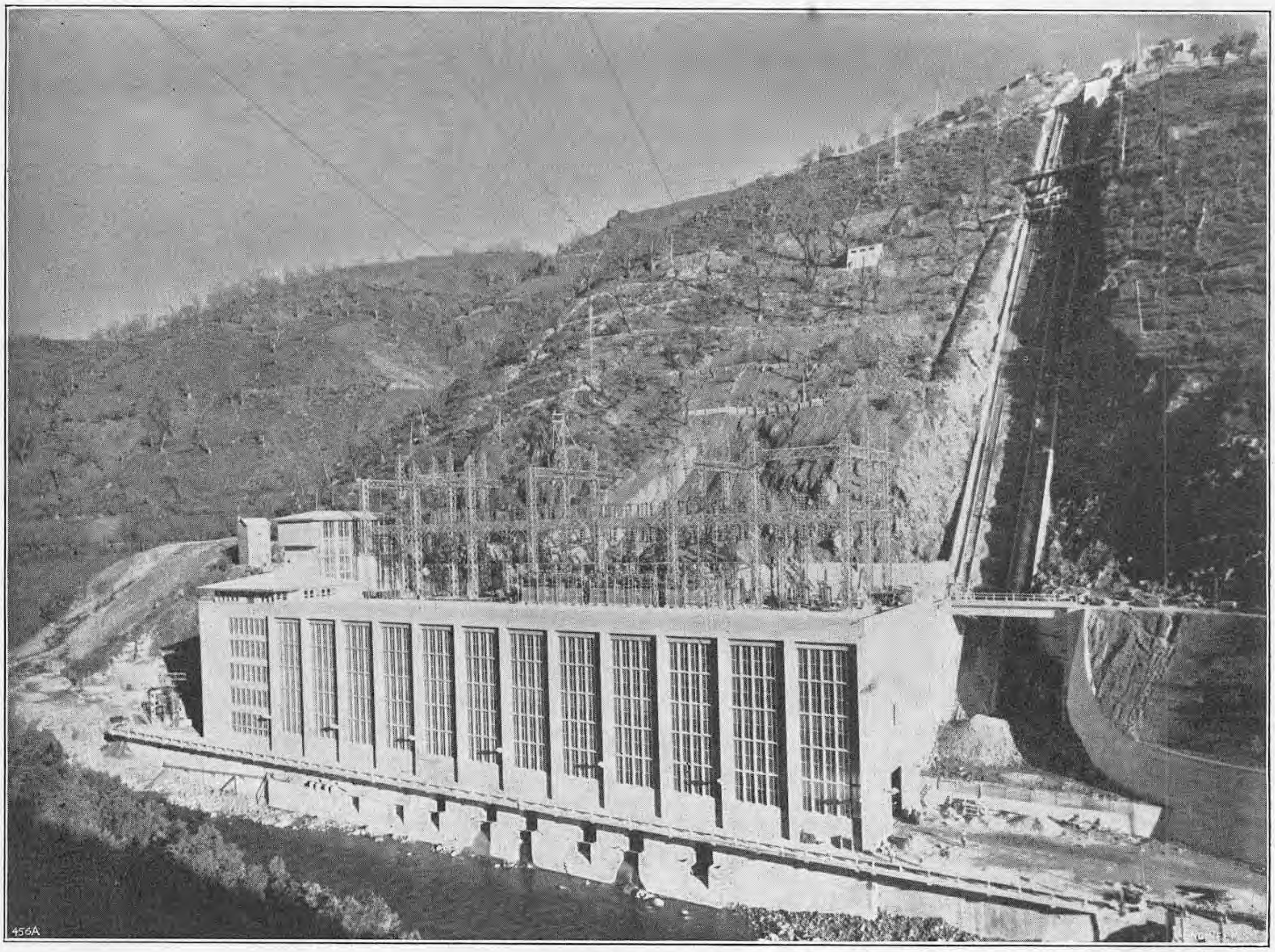

FIG. 1. GENERAL VIEW OF POWER STATION AND SWITCHGEAR.

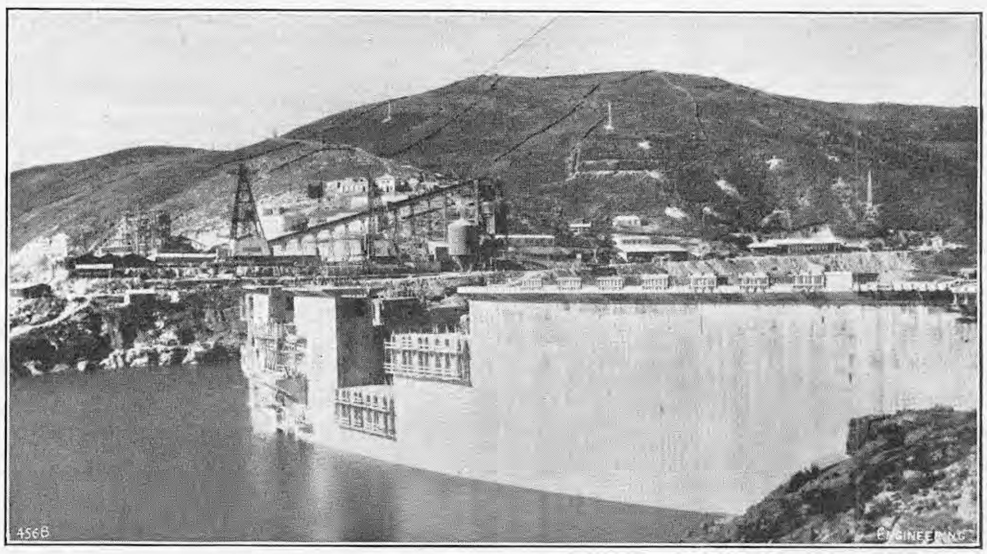

FIG. 2. UPSTREAM SIDE OF DAM.

THE VILA NOVA HYDRO-ELECTRIC POWER STATION.

FOR a number of years, Portugal has been experiencing a shortage of electric power, for, though a considerable amount of hydro-electric generating capacity has been installed, there has been a decrease in the installed capacity of steam power-stations, so that the net increase has not kept pace with the increase in demand. An important scheme for the further development of water power was initiated by the Portuguese Government, therefore, in 1945, and is now rapidly approaching completion. The first stage in this scheme was accomplished when the late president Carmona started the turbines of the Castelo do Bode station on the Zezere river, about 90 miles north-east of Lisbon. The second stage was reached when, on June 9, His Excellency Dr. Coste Leite Lumbrales, Senior Minister of the Portuguese Government, accompanied by other Ministers and a large gathering of guests and officials, started the first of three water-turbines installed in the Vila Nova power station, which we illustrate in Fig. 1, herewith.

Vila Nova, situated about 60 miles north-east of Oporto, is on the Cavado river, near its confluence with the River Rabagão. The development of the Cavado-Rabagão basin is in the hands of a company, the Hidro-Eléctrica do Cavado, which was formed for the purpose. The Rabagão is a tributary of the Cavado and, at the site of the power station, flows about two miles to the south-east, at an altitude about 1,500 ft. higher. A dam about 300 ft. high, known as the Venda Nova dam, illustrated in Fig. 2, has been constructed across the Rabagão, forming a reservoir from which the water flows for 1½ miles through a tunnel driven through the intervening mountain. At the tunnel outlet, there is a valve house from which the water flows through a steel pipe, 8 ft. in diameter and about 950 ft. long, into the turbine house. This pipe, which was supplied and erected by the South Durham Steel and Iron Company, can be seen in Fig. 1.

The station is equipped with three 39,000-h.p. Pelton wheels of the double-runner type, each coupled to a 32,000-kVA alternator running at 428 revolutions per minute. There are three 30,000-kVA 11/165-kV three-phase banks of single-phase transformers. The 165-kV and 30-kV switchgear includes air-blast circuit-breakers. Space has been provided in the power-station for a fourth set, to be installed at a future date when the demand requires it. The hydraulic and electric equipment has been supplied and installed jointly by the English Electric Export and Trading Company and the Metropolitan-Vickers Electrical Export Company, who also equipped the Castelo do Bode station, mentioned above.

THE SCIENCE MUSEUM.—A model of H.M.S. Vanguard, possibly the last battleship that will be built for any navy, has been lent to the Science Museum by the builders of the ship, Messrs. John Brown and Company, Limited, Clydebank. It is to the scale of 1 : 64, and has been placed on exhibition in Gallery 41, with the Steamships Collection.

ENGINEERING,

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ENGINEERING

FRIDAY, AUGUST 17, 1951.

VOL. 172. No. 4464.

THE ELECTRICITY SUPPLY SITUATION.

THE British Electricity Authority estimate that if the electrical demand is unrestricted during the coming winter and average weather conditions rule, the maximum load on the national system will amount to 13,800 MW. If, however, the number and intensity of the cold spells are also average, this figure will be increased to 14,400 MW and to 15,100 MW, if the weather is severe. It is expected that the capacity of the plant available to meet these demands will be 12,000 MW in December, 1951, but will rise to some 12,200 MW by February, 1952. There will therefore be deficits of 1,800 MW, 2,400 MW or 3,100 MW, depending on the weather conditions; and the position next winter will be generally similar to that during the last. These figures, of course, refer to the overall national situation; and the actual position in individual areas may depart considerably from them. Experience shows, moreover, that load spreading cannot be expected to reduce the demand by more than 300 MW. There thus remains the problem: what steps can, and should, be taken to liquidate the remaining deficit.

It is this problem which, during the last few weeks, has confronted the Electricity Sub-Committee of the Joint Consultative Committee of the Ministry of Labour, a body which, it may be recalled, was set up after the coal crisis of 1947 to examine the measures necessary to reduce peak industrial loads on the electricity supply system. Its latest conclusions are set out in a report* published last week, and include the recommendation that effective arrangements should be made to secure the fullest co-operation of domestic and the smaller commercial consumers in reducing their demands at peak hours. It is also recommended that industry should strive, through the medium of load spreading, to reduce the national simultaneous demand by 600 MW and that load spreading should apply to all consumers between 8 a.m. and 12 noon and between 4 p.m. and 5.30 p.m. from November 1, 1951, to March 31, 1952. Further, the possibility of securing a reduction in the maximum demand by adjusting the customary hours of work is hinted at, and, finally, it is proposed that no obstacle should be placed in the way of installing or increasing the use of auxiliary generating plant.

Dealing with these recommendations, it may first be noted that it is suggested that the afternoon "danger period" should be extended throughout the five winter months, instead of being applied, as last year, from December to the middle of January only. The morning danger period is also to be continued through March, instead of terminating in February. The reason for this is, undoubtedly, the fact that, during the year ended March 31, 1951, load shedding, either by voltage reduction or disconnection of supply, was necessary on no less than 267 occasions, compared with 124 in the previous year. Moreover, the maximum amount of load shed at any one time was about 2,000 MW, equivalent to about 15·8 per cent. of the total potential demand on the system, compared with 10·6 per cent. in 1949-50. It may also be noted that the improvement of the situation by the "adjustment of customary hours of work" is dealt with more realistically than in former years. While expressing themselves conscious of the disturbance such an alteration would cause, both domestically and industrially, the Committee say that load shedding can only be avoided by modifying working hours, introducing double shifts, increasing night work, or a combination of all three remedies. Any of these courses is likely to be unpopular, but it is stated that the British Employers Confederation and the General Council of the Trades Union Congress have indicated their readiness to do all within their power to assist arrangements of this kind. Nevertheless, it will be interesting to see the reactions of the rank and file on whom, of course, the main burden of such changes and all that they imply will fall.

There are, however, two significant omissions from the report. The first, and less important, is that nothing is said about the extent to which the situation could be alleviated by arbitrarily controlling the domestic load. This may no doubt be partly explained by the unfortunate results of what has come to be known as the Clow Differential. The Committee must, however, know that industrialists expect the problems arising from the domestic and commercial loads to be tackled more vigorously than in the past and that a working party is examining the operation of the various kinds of load limiters and other means of curtailing less essential demands. The most charitable explanation of this diffidence is perhaps that the employment of such devices cannot be introduced at once and that winter, if the conditions of the last few days are any criterion, is already sending out its harbingers. At the same time, this diffidence is to be deplored.

Far more important, however, is the fact that nothing is said about the reason why the electricity supply prospects during next winter are worse than at any time since the fuel crisis of 1947. In mitigation, the Committee may plead that their terms of reference only required them to examine measures for reducing peak load and that methods which would ensure that such reduction was unnecessary are outside the scope of those terms. As, however, we are not restricted by any such inhibition, we may point out that the real, and indeed the only, solution

* *Report of Electricity Sub-Committee of the Joint Consultative Committee, Ministry of Labour and National Service*, August, 1951. London: H.M. Stationery Office. [Price 9*d.* net.]

of the problem the Committee are endeavouring to solve is the installation of more generating plant, and that no opportunity should be lost, before it is too late, of bringing home that fact to all who are responsible.

The position was clearly stated by Lord Citrine in an address which he delivered to the British Electricity Conference in June. Although there had been, he said, a substantial increase in the amount of generating plant installed since the British Electricity Authority came into being, the gap between supply and demand was widening. Nevertheless, it is an open secret that certain people, euphemistically described as planners, are endeavouring to limit the annual programme of new plant commissioned to 1,500 MW when an amount some 25 per cent. greater is required. The provision of sufficient generating plant, not to speak of the related transmission and distribution equipment, is vital, not the least because, without it, rearmament will be checked and industry will be handicapped. As shown by the articles recently published in ENGINEERING, the central authority is pressing on with the construction of new power stations. Considerable extensions to existing stations are also being made. Nevertheless, progress is slower than it should be and the position is not being improved by the ban on overtime which has been introduced at several power stations in London and Manchester, in protest at the British Electricity Authority's refusal to grant a wage increase of 10 per cent. In this dispute more than 5,000 men are taking part in protest actions.

There remains a further aspect of the situation which must be dealt with. It will be recalled that the disastrous breakdown of power supply in the early part of 1947 was caused, not by a shortage of plant, but by a shortage of fuel. It may also be recalled that this situation arose after the then Minister of Fuel and Power had proclaimed that "there was not going to be a crisis" and that "the solid fuel position is better to-day by far than it was 12 months ago." May we be forgiven for feeling it a little ominous that the present Minister of Fuel and Power in a statement published on Sunday should have found it necessary to say "that power station stocks of coal were being built up extremely well; allowing for a higher rate of winter consumption they were better than they ever have been at this time of year." If this statement should engender in any one a feeling of complacency, may we point out that prophesy is not only dangerous, but often erroneous and that history does sometimes repeat itself? At the moment it can only be said that coal output is again unpromising and that no definite steps have been taken to alleviate, by imports or in other ways, any shortage that may occur. If, moreover, difficulties on the railways result in a lag in deliveries on domestic account present estimates of the demands for both electricity and gas may be falsified, as it will be quite impossible at short notice, and in a non-totalitarian state, to expect householders to forgo the comfort which is provided by other sources of heat than raw coal.

Since it is clear that during the coming winter there will be a shortage of generating plant and that there may also be a shortage of fuel with which to operate it, it is distinctly disturbing to see that the Government's approach to the situation is both leisurely and unrealistic. Apart from exhortations to keep off the peak and to reduce consumption their principal action has been to appoint a Committee "to consider whether any further steps can be taken to promote the best use of Britain's resources in fuel and power." This body is being asked to survey the whole question of the use that is being made of the basic fuels available to us, apparently in the light of the facts that coal consumption in 1950 was over 202 million tons, compared with an average of 178 million tons before the war, that electricity consumption has gone up by 50 per cent. since 1946, gas by 25 per cent. and oil by 90 per cent. It is, however, difficult to see what this curiously constituted body can tell the Minister that he should not know already, or what he is going to do with the information when he has obtained it that he cannot do at once. The appointment of this body, indeed, seems to be yet another example of a reluctance to appreciate the stark facts, which are unfortunately only too clear, of a situation containing elements of real danger to the community.

THE BROADER OUTLOOK.

To most readers of ENGINEERING, it is probable that the annual meetings of the British Association centre around Section G; but the full programme extends to 13 Sections, and those who ignore the other twelve not only frustrate one of the main purposes of the Association, but miss a great opportunity to receive the kind of stimulus that almost inevitably leads to constructive thinking, if not to constructive action. Many years ago, it was our practice to devote considerable space to reports of some of the other Sections—principally Section A (Mathematics and Physics) and Section B (Chemistry), but gradually, as a result of various restrictive influences, that policy had to be abandoned; for, curious as it may seem (and is), as mechanisation has developed in the printing industry, it has become steadily more difficult to set large amounts of "copy" in a limited time. There are various reasons for this, but to examine them in detail would be beside the present point, which is the fact that the limitation exists and that, most unfortunately, it has become more stringent just when there is more need than ever before that mankind in general, but engineers in particular, should cultivate a wider outlook.

It is not infrequent in these days, to hear speakers urge upon audiences in engineering institutions the desirability that engineers should interest themselves more in public affairs and in commercial administration, and there is a certain amount of evidence that this reiterated advice is being taken to heart. What is less commonly realised in connection with the British Association, however, is that engineering, in its widest sense, impinges to-day upon practically every one of the 13 divisions in which the interests of the Association are somewhat arbitrarily classified. Zoology and psychology are possible exceptions; though, remembering how intimately the engineer has been concerned with the latest developments in means for studying submarine life, it is doubtful whether zoology should be excluded from the general hypothesis. For the rest, engineers and the apparatus that they construct certainly come to-day into fairly close association with the work of the mathematician, the physicist, the chemist and the geologist; they have placed new techniques at the disposal of the geographer, the agriculturalist and the botanist; by the study of tools and their uses, they have aided the archæologist and, to a less extent, the anthropologist—both of whom are concerned with the evolution of man as a tool-using animal; and, if their influence in the sphere of the physiologist is a little difficult to define, it can hardly be held to be non-existent so far as the individual physiologist is personally concerned.

To ask that ordinary working engineers (which means most of them) should strive to be really knowledgeable in all these fields would be unreasonable; but it is not unreasonable to urge that they should cease to shut themselves up with their engineering, content to remain ignorant of what is going on around them. Sir Hector Hetherington, in his presidential address to Section L (Education), drew pointed attention to the partial vacua in which so many ostensibly educated men to-day appear to keep their minds, and to the lack of any impulse to rise above the level of mass mediocrity. "I have known men of my own land," he said, "mostly alas! elderly, and most of them country-bred, of no great schooling and no wide accomplishment, who were yet, and enviably, educated men. . . . They had no rubbish in their minds; they thought and spoke with wisdom and dignity."

The type is not extinct; possibly the number of its exemplars is even greater now than in the days of Sir Hector's youth. Relatively, however, they certainly appear to be less numerous in proportion to the growing population of those whose interests become ever more circumscribed, and who, as the progress of civilisation provides them with steadily increasing leisure, increasingly demonstrate their inability to make profitable use of it. The only real solution, as Sir Hector put it in a phrase, is "the discipline of practical learning," which he admitted to be "the very heart of the challenge with which, as educators, we are faced." In a materialistic world, that challenge imposes a hard task indeed; for, as he continued, "We have to engender not only the skill and the will to do, but the conviction that the doing is itself rewarding. Whatever the instrument—solving equations, judging the quality of timbers, using a lathe, playing a fiddle—we miss the summit of it all if there be no moment when the mind of the learner takes fire, when he has sight of a kind of perfection attainable in this activity, so that here at least he has hold of an ideal standard and wants with all his heart to do this as well as it can be done."

There could be no better inducement to such a frame of mind than to attend, if it were possible, the meetings of all Sections of a British Association meeting. That is not possible, even for those on the spot; and, unfortunately, most of those who, whether they know it or not, are in most need of such a salutary "exposure to the best" (to quote Sir Hector Hetherington again) are prevented by circumstances or sheer disinclination from hearing any of the papers and addresses. Many more could be exposed to the contagion of enlivening knowledge, however, if only more of the papers could be printed and widely circulated. At present, it is difficult enough to obtain them, even for those who urgently desire to; but a general "exposure to the best" implies a wholesale and even extravagant sowing of the seed, and it is one of the most deplorable features of the current time that economic conditions frustrate so seriously the dissemination of knowledge which could be permanently valuable, while seeming to present so few obstacles to the exploitation of the inferior and even demoralising. No newspaper could hope to report a British Association meeting thoroughly, and few have attempted to do so with any wisdom of selection. Most of those that have done so at all have looked for no more than half a dozen eye-catching sentences, with a phrase or two that could be set sensationally in heavy type.

To any protest, no doubt, the answer would be that they know their public. Unquestionably, they do, and should do, for they have been largely instrumental in making that public what it is; but, if there is some excuse for a certain mental stagnation in a multitude predominantly composed of people who pass routine days in doing routine jobs that require little alertness and from which the demand for skill is becoming progressively less, there is none for the engineer, at whatever level in the profession or industry he may follow his calling. He, at least, making his living by applying the physical laws which are at the basis of all pursuits, should feel a perpetual inducement to lift his head and look about him; for he, more than most men, has the opportunity to experience "the discipline of practical learning" amid circumstances that are an education in themselves, providing a constant reminder of the pioneers who were able to build up his craft and science because "they had no rubbish in their minds."

NOTES.

THE ENGINEERING, MARINE AND WELDING EXHIBITION.

THE exports of the British engineering industry in 1950, including electrical goods and vehicles, have been valued at 808*l.* million—a record figure. In marine engineering, the United Kingdom maintains its leading position, having been responsible for over one-third of the world's total of merchant ships launched during the year, namely, 1,325,000 tons. The organisers are therefore probably justified—especially in view of the fact that the Festival of Britain is still in progress—in expecting a large number of overseas visitors to the Engineering, Marine and Welding Exhibition (incorporating the Foundry Trades Exhibition) which will be held at Olympia, London from Thursday, August 30, to Thursday, September 13. It is described as the largest event of its kind in the world; it is normally held in alternate years and was founded in 1906. The chief sponsoring organisations are the British Engineers' Association, the Society of Motor Manufacturers and Traders (Marine Section), the British Electrical and Allied Manufacturers Association, the Institute of Welding, and the British Acetylene Association. The honorary President of the Exhibition is Engineer Vice-Admiral Sir Harold Brown, G.B.E., K.C.B. Internal-combustion engines for industrial and marine uses are among the main exhibits; very large engines of this type will be represented by models, but at least one of 3,000 brake horse-power will be on view. Many firms producing ancillary equipment for engines, and others who build boilers and gas, steam and hydraulic turbines have taken stands. Manufacturers of pumps and valves are also represented. Special interest attaches to the welding section of the exhibition as the report of the Productivity Team on welding is expected to be published during the exhibition. A wide range of electrical equipment will be on show, including alternators, motors, generating sets, switchgear, industrial X-ray apparatus, accumulators, cables, ships auxiliaries, radio and radar apparatus, and an electron microscope. The Department of Scientific and Industrial Research and six research associations are combining to show the results of some recently completed work. One of them, the British Cast Iron Research Association, has formed an operational research team to visit foundries by invitation and report confidentially on steps required to increase efficiency and production. In the foundry section, 27 firms have taken stands. The exhibition, which will be open each week-day from 10 a.m. to 8 p.m., is organised by Messrs. F. W. Bridges and Sons, Limited, Grand Buildings, Trafalgar-square, London, W.C.2.

INCREASED PRICES FOR IRON AND STEEL.

The Ministry of Supply announced on August 12 that the Minister (Mr. G. R. Strauss, M.P.) had made two Orders, to take effect from the following day, one increasing the controlled maximum prices of iron and steel products and the other the prices of bolts and nuts. They are entitled, respectively, the Iron and Steel Prices (No. 2) Order, 1951, S.I. No. 1423, and the Bolts, Nuts, etc., Prices (No. 2) Order, 1951, S.I. No. 1422, and are obtainable from H.M. Stationery Office; the price of the former is 4*d.* and that of the latter, 3*d.* It is stated that the increases are necessary because of "a sharp rise" in the prices of imported iron ore, scrap, pig iron and semi-manufactured steel, and because of recent increases, in this country, in wages and in transport, scrap and fuel costs; and that "the British Iron and Steel Federation informed the Minister in March that, in view of the serious cost increases due to these causes, early consideration needed to be given to the position." The statement continues: "The prices now authorised are based on recommendations submitted by the Iron and Steel Corporation of Great Britain, after consultation with the British Iron and Steel Federation, and take account of the savings in capital charges secured by nationalisation. The loss arising from buying finished steel abroad and selling it in this country at home prices has hitherto been borne by the Exchequer. This loss has risen steeply with the sharp rise in world prices and the Government have decided that, to avoid an increase in the subsidy, the trading loss, but not the import duty, should now be recovered by an adjustment spread over home controlled prices. This accounts for over 20 per cent., and other imported steel and steel-making materials for approximately 40 per cent., of the overall price increases." Examples given of the increases show that foundry pig-iron will rise from 10*l.* 13*s.* to 11*l.* 4*s.* 6*d.* a ton; basic pig-iron from 10*l.* 19*s.* to 11*l.* 15*s.* 6*d.*; soft basic billets from 17*l.* 9*s.* to 21*l.* 16*s.* 6*d.*; joists from 20*l.* 11*s.* 6*d.* to 24*l.* 2*s.*; re-rolled bars from 22*l.* 15*s.* to 27*l.* 11*s.*; uncoated sheets from 29*l.* 13*s.* to 35*l.* 15*s.* 6*d.*; and tinplate from 2*l.* 2*s.* 7½*d.* to 2*l.* 9*s.* 6½*d.* per basis box. It is claimed, however, that United Kingdom prices, in the main, will still be lower than corresponding domestic prices in other countries. No specific examples are given of the increases in the prices of bolts and nuts, for which reference must be made to the relevant Order, the statement made being merely that "the increased prices reflect the increase in the price of steel, under the Iron and Steel Prices (No. 2) Order, 1951 . . . together with increases in the costs of the bolt and nut industry, including increases in wages, transport and fuel costs."

AERONAUTICAL INFORMATION STUDY GROUP.

During the last 15 years the volume of technical information on aeronautical and allied subjects has expanded to a degree which is perhaps greater than that in any other field. To ensure that the fullest use is made by the aircraft industry of all published information, Aslib are forming an aeronautical-information study group. The first meeting of the group will be held on Thursday, September 27, at the Royal Aircraft Establishment, South Farnborough, Hampshire. Organisations concerned with the aircraft industry who wish to send representatives are asked to advise Mr. R. G. Thorne, at the Royal Aircraft Establishment, of their names and nationality by September 10. Representatives travelling by train to Farnborough on the 9.54 a.m. train from Waterloo will be met at the station by coaches. From 11 a.m. to 12 a.m., the group will be conducted on a tour of the library of the Royal Aircraft Establishment. The inaugural meeting, to be held in the main conference room, will commence at 1.15 p.m. and will close at 5.30 p.m., with a half-hour break for tea at 3.30 p.m. Further particulars, and copies of memoranda prepared by the librarians of the Royal Aircraft Establishment, which may serve as a basis for discussion at the meeting, may be obtained from the Director, Aslib, 4, Palace-gate, London, W.8.

RECONSTRUCTION OF PIER 57 AT NEW YORK.

Pier 57, formerly used by the Grace Line as their New York terminal, which was destroyed by fire in September, 1947, is to be reconstructed by the New York Department of Marine and Aviation. The old pier was supported by 2,300 timber piles, but the new pier will be carried on three reinforced-concrete caissons, apparently not unlike those used in the "Mulberry" harbour for the invasion of Normandy; these will rest on a level bed of gravel, laid on the river bottom. The buoyancy of the caissons will support about 90 per cent. of their weight. Their dimensions are 350 ft. long, 82 ft. wide and 34 ft. deep. They will be arranged in T formation, one along the line of the shore and the other two, making the pier, end to end at right angles to it. The contractors, the Merritt-Chapman and Scott Corporation and the Corbetta Construction Company, are constructing them in an abandoned claypit, about 30 miles north of New York, which is about 42 ft. deep and separated from the Hudson river by an embankment about 125 ft. wide. The pit has been pumped out, and the bottom is now being levelled and covered with gravel. The concrete will be poured directly on to the gravel, into plywood forms. When completed, the caissons will be floated out through a cut to be made in the embankment, and towed downstream to New York. On the pier site, the silt is being removed by dredging to a depth of 36 ft. 6 in. below low water. The old piles will be cut off near to the bed level by a chain saw, driven by compressed air, and the stumps covered with 2 ft. of sand and a top layer of gravel, which will be levelled to receive the caissons. To ensure a firm bed, sand cores will be sunk to a depth of 50 ft. by driving steel pipes into the bed of the river, washing the silt out of them with water jets, filling them with sand, and then removing the pipes. When the caissons are sunk on to the gravel bed, it is expected that their weight will express the water from the underlying mud into the cores, whence it can rise to the sand layer at the top; thus the mud will be consolidated where it lies instead of being squeezed out at the sides of the bed. The caissons will be located by 30-in. reinforced-concrete piles, 40 ft. apart along their sides, and driven 50 ft. into the river bed. When they are in position, they will be spanned by concrete beams to carry the decking. The two-storey pier shed will be 700 ft. long and 120 ft. wide. The interior of the caissons will be used for cargo storage, and the deck will be strong enough also to carry light cargo. Cooled and warmed rooms will be provided inside the caissons for special cargo.

WIRELESS INTERFERENCE FROM IGNITION SYSTEMS.

JUST over a year ago, the Postmaster-General appointed a Committee under the chairmanship of Sir Stanley Angwin to advise him on wireless interference from ignition systems. This Committee, which has now presented its report, devoted its attention in the main to the question of interference with the television services of the British Broadcasting Corporation from the ignition systems of motor vehicles, motor boats, tractors and fixed and portable engines. Their recommendations are based on the assumption that all reasonable measures will be taken to reduce the susceptibility to interference of receiving installations. They recommend that ignition equipment, when tested as installed in the vehicle or stationary engine with which it is used, should not radiate an interference-producing field exceeding 50 microvolts per metre for frequencies up to 40 to 70 megacycles per second frequency band, this field being measured at a point not less than 10 metres distant from the vehicle or engine. The Committee advise that suppression to this limit can be achieved with negligible effect on the mechanical performance of the engine and think that, in the case of 60 per cent. of the existing motor cars, the required degree of suppression can be achieved by fitting a single resistor at the cost of about 2*s.* 6*d.* They also recommend that at least six months should elapse between the making of any regulation prescribing the requirements which must be complied with to prevent undue interference and the time of its coming into force. As regards the application of the regulation to users las distinct from manufacturers), they say that the efficacy of such a measure will depend mainly on the co-operation of the public and adequate publicity regarding the simple remedial measures which users can take.

THE PATENT SHAFT AND AXLETREE COMPANY.

The Iron and Steel Corporation of Great Britain announce that the board of directors of the Patent Shaft and Axletree Company, Limited, of Birmingham, which is one of the iron and steel companies now publicly owned, has been reconstituted. Before nationalisation, the company was a wholly-owned subsidiary of the Metropolitan-Cammell Carriage and Wagon Company, Limited, and the board consisted of one full-time director and eight part-time directors. The Corporation state that they "consider the constitution of each Board on its own merits and seek to obtain a balanced Board containing both full-time directors, including executives of the company, and part-time directors of wide experience." Five of the present directors are retiring, these being Lieut.-Col. J. B. Neilson, C.M.G. (chairman), Mr. Howard Williams, Sir Robert S. Johnson, Mr. R. W. Johnson, and Sir J. Reid Young. The new board will consist of four full-time directors and three part-time directors. Sir Archibald Boyd, Mr. A. T. Cheesley and Mr. H. N. Edwards continue as part-time directors, Sir Archibald Boyd to act as chairman; Mr. B. S. Pritchard, the managing director, will continue as a full-time director; and three new full-time directors have been appointed, these being Mr. R. L. Haskew (works manager), Mr. D. Cockburn (chief engineer) and Mr. P. J. Davies (secretary and accountant).

OBITUARY.

PROFESSOR C. A. MIDDLETON SMITH.

We regret to record the death on July 31, at his home in Guernsey, of Professor C. A. Middleton Smith, who for 27 years, until his retirement in 1939, held the Taikoo chair of Engineering in the University of Hong Kong. He was 72 years of age.

Cades Alfred Middleton Smith was born on February 4, 1879, and spent his boyhood in Portsmouth, where he received his general education at the grammar school. At the age of 16, he secured admission to the Royal Naval Engineering College at Keyham, where he spent five years, leaving in June, 1900, to take up an appointment as assistant engineer in the Plymouth electric power-station. He remained there only a few months, however, before going to Birmingham as chief assistant in the testing department of Belliss and Morcom, Limited. A year later, he joined the staff of Birmingham University as a lecturer and demonstrator and there developed the gifts as a teacher which he was to display so effectively in later years at Hong Kong. Having graduated as B.Sc. (Eng.) at Birmingham, he moved to London in 1904, on appointment as assistant lecturer in engineering at King's College, and, three years later, was transferred to what was then the East London College (now Queen Mary College) in Mile End-road, where he was assistant professor of engineering, under the late Professor D. A. Low. During this period, he became an occasional contributor, to our columns, of articles based on research work, including one on "Guest's Law of Combined Stress," in our issue of July 10, 1908 (vol. 86, page 27); another on "The Strength of Pipes and Cylinders," in that of March 5, 1909 (vol. 87, page 327); and a third, on "Some Experiments on Solid Steel Bars Under Combined Stress," on August 20 in the same year (vol. 88, page 238). He also contributed papers to the Institution of Mechanical Engineers, which he had joined as an associate member in 1904, becoming Member in 1912, and to other institutions. He was an honorary member of the Junior Institution of Engineers, to which he had belonged for just under 50 years.

In July, 1912, Smith was successful in securing the appointment of Taikoo Professor of Engineering at Hong Kong, being the first occupant of the chair, and it was in that capacity that the major work of his life was accomplished; the development of the Engineering Faculty there was, indeed, his personal achievement, in the fulfilment of which he displayed considerable administrative as well as teaching ability. This was recognised by the conferment upon him of the honorary degree of LL.D. Some years previously, Birmingham University had awarded him the degree of M.Sc. (Eng.). He retired in 1939, with the expectation of spending his remaining years quietly among his family and many friends; but the outbreak of war sadly interrupted these plans, for he lost most of his belongings from his home in Hong Kong and, having established another in Guernsey, had the mortification of losing that also, to the German invaders of the Channel Islands. He did settle there eventually, however, and, as stated above, it was there that he died.

Motor Industry Committee.—The car manufacturers of the Society of Motor Manufacturers and Traders have appointed a committee to advise on matters relating to the sporting side of the industry, and the regulations of it. The committee consists of: Mr. W. H. Aldington (chairman), A.F.N., Ltd.; Mr. T. Sangster, Riley Motors, Ltd.; Mr. M. E. S. Warren, Jaguar Cars, Ltd.; Mr. S. H. Allard, Allard Motor Co., Ltd.; Mr. J. Watt, Lagonda and Aston Martin, Ltd.; and Mr. N. Garrad, Sunbeam-Talbot, Ltd.

Connah's Quay Generating Station.—The British Electricity Authority give notice that they have applied to the Minister of Transport for consent, under section 34 of the Coast Protection Act, 1949, to the construction of intake and outfall works below high-water mark on the River Dee at Connah's Quay, Flintshire, where a 60-MW generating station is to be erected. Plans illustrating the proposed work may be inspected at the office of the Clerk of the Connah's Quay Urban District Council and objections should be sent to the Ministry and the Authority before Wednesday, August 29.

THE BRITISH ASSOCIATION MEETING AT EDINBURGH.

As recorded in last week's issue of Engineering, the annual meeting of the British Association for the Advancement of Science opened on Wednesday, August 8, in Edinburgh. This, the 113th meeting of the Association, was the sixth to be held in the Scottish capital and was notable for the fact that H.R.H. The Duke of Edinburgh, K.G., F.R.S., accepted the invitation to act as President. The meeting may be regarded as the Association's contribution to the Festival of Britain.

The inaugural meeting was held in the M'Ewan Hall, but the proceedings were both seen and heard by an even larger audience assembled in the Usher Hall about a mile away, by means of a television installation described elsewhere in this issue.

Laureation Ceremonial.

The inaugural general meeting was preceded by the Laureation Ceremonial, in which the Dean of the Faculty of Law, Professor M. G. Fisher, first presented H.R.H. The Duke of Edinburgh for the Degree of Doctor of Laws. In the presentation, the Dean said that in the long history of Edinburgh University they had had the honour of enrolling many members of the Royal House as honorary graduates and they were proud that once more they were to have that privilege. It was with special gratification that they received one who bore their name of Edinburgh, and they recalled how his predecessor in that title, His Royal Highness Prince Alfred, was at one time one of their undergraduates. The gift they offered was no mere conventional symbol. His Royal Highness was a representative of that generation of ex-Service students which had just passed through their midst and had been acclaimed as among the best that had studied within those walls. His Royal Highness had shared in their dangers and their difficulties; he had been nurtured in their Scottish culture; he had served in Scottish waters; and he had been styled by a Scottish name. It was with pleasure, therefore, that they gave him that Scottish honour and by their act of Laureation placed, as it were, the coping-stone on an education which was begun in Scotland and perfected amid the fiery trials of war.

They were glad too to welcome the Duke of Edinburgh as President of the British Association. Nearly a hundred years ago that body had met in Scotland, and His Royal Highness the Prince Consort had been installed as President. In memorable phrases, he had summed up its purpose: "These meetings draw forth the philosopher from the hidden recesses of his study, call in the wanderer over the field of science to meet his brethren, to lay before them the results of his labours, to set forth the deductions at which he has arrived, to ask for their examination, to maintain in the combat of debate the truth of his positions and the accuracy of his observations."

The Chancellor of the University of Edinburgh, the Marquess of Linlithgow, in conferring the degree upon His Royal Highness, said it was his privilege to express the University's profound sense of the honour he was doing it by his acceptance of the Honorary Degree. He had shown the most active and effective interest in all that concerned the welfare of the people; the proofs he had given of his readiness to encourage and support in many ways the youth of the nation had everywhere been received with the utmost satisfaction. His Royal Highness, as President of the British Association, showed his special interest in scientific advancement, with which was bound up the prosperity of the nation in peace and the safety of the realm in time of war. They welcomed him, also, as a sea officer of proven gallantry and high promise in his profession. The lively pleasure which had been experienced by all His Majesty's Scottish subjects when His Royal Highness assumed the title of Duke of Edinburgh had increased the more as his qualities of heart and mind had become manifest. As for the future, they were very mindful of the extending responsibilities that must fall upon his shoulders; whatever the years might bring, His Royal Highness could, with all confidence, rely upon the affection and the support of the University of Edinburgh. After Lord Linlithgow had performed the capping ceremony, the Duke signed the *Sponsio Academica* amidst loud applause.

In reply, the Duke said he was honoured and proud to receive the degree of the University o. Edinburgh, particularly as he already enjoyed the freedom of that city and had many other close ties. He understood that the Degree of Doctor of Laws conferred on him the licence to teach Canon and Civil Law in all the universities in Christendom! Unlikely as it seemed that he would ever presume to exercise this licence, it was certainly comforting and indeed flattering to possess it. However, he felt sure they had conferred that distinction upon him not only to give him much personal pleasure but also as a mark of welcome to the British Association, of which he had the privilege to be President during the current year. In both capacities, he was deeply grateful for that expression of their favour, and in the words of every freshman as he signed the *Sponsio Academica*, he promised "fidelity and all good service to the University."

Inaugural General Meeting.

At the conclusion of the Laureation Ceremonial, the Rt. Hon. James Miller, Lord Provost of the city of Edinburgh, welcomed the members of the Association to the city. In the course of his remarks, the Lord Provost said that in Edinburgh, the capital of Scotland, the Association had chosen a very appropriate setting for their gathering. The city had enjoyed pre-eminence in connection with the Arts, but equally Edinburgh might claim a foremost place in the Sciences.

Sir Edward V. Appleton, G.B.E., K.C.B., F.R.S., Principal and Vice-Chancellor of the University of Edinburgh, then welcomed the members of the Association on behalf of the University, pointing out that the British Association, in its own way, was also a university—a peripatetic university with but a single faculty and a rather short term, to which admission was not controlled by matriculation or by a Dean. The Association had developed like a university under the urge of great and devoted personalities whose influence had continued long after their own time. The common theme for the Edinburgh meeting had been set by the President.

Presidential Address.

After thanking the Lord Provost and Principal Sir Edward Appleton on behalf of the Association, the Duke of Edinburgh delivered his presidential address, an abridged report of which was published in last week's issue. In thanking His Royal Highness at the conclusion of the address, Sir Harold Hartley, K.C.V.O., F.R.S., described it as a most discerning survey and a generous tribute to British science. He was happy to have the honour of voicing the gratitude not only of the members of the British Association but also of the millions who would have been listening to the broadcast. For the first time in its long history the British Association had as its President a serving officer of His Majesty's Navy. For the Duke of Edinburgh's Presidency in that Festival year, which celebrated the creative vision of his great ancestor, they were proud and grateful. They met in a historic city whose name he bore, and all that, together with his address, would make the meeting a landmark, or rather, a leading mark, in their annals. At the start of his address, the President had told them he had come to the conclusion that it was as an outsider, as a layman, that he could be of use to the Association and to science. The great interest and the understanding of science that he had shown in his address encouraged the hope that they might look to him in future, as their forebears had looked to the Prince Consort, for leadership and help. They hoped in future to look upon His Royal Highness as the Patron of Science, just as H.R.H. Princess Elizabeth, by her gracious patronage of the arts and medicine, had done so much to advance their cause.

This concluded the proceedings in the M'Ewan Hall and the President then paid a brief visit to the Usher Hall, where the meeting terminated. The attendance at the Edinburgh meeting, 4,012, is a record for the Association; previously, the highest figure was reached at Manchester in 1887, when the attendance was 3,838.

SECTION G (ENGINEERING).

When the proceedings of Section G opened on August 9, in the Heriot-Watt College, the President of the Section, Sir Claude Gibb, C.B.E., F.R.S., announced that the two sessions, A and B, would be combined temporarily, as H.R.H. The Duke of Edinburgh was to honour the Section that morning by attending part of the proceedings. When His Royal Highness arrived, Sir Claude invited him to open the meeting, which he did in a few words. Sir Claude then called on Mr. T. A. L. Paton to deliver his paper entitled "Hydro-Electric Schemes—Modern Trends in Civil Engineering."

CIVIL ENGINEERING IN HYDRO-ELECTRIC SCHEMES.

Mr. Paton then presented his paper (which will be published in a subsequent issue of ENGINEERING), in a slightly abbreviated form, and at its conclusion, Sir Claude Gibb opened the meeting for discussion. The first speaker was Sir Edward Appleton, who said that, speaking as a mere physicist, it seemed to him that there were two sources of energy through water: that which came from rainfall, and that which came from tidal action. In the first case the source of the energy was the sun itself. Its energy lifted water to a higher level and rainfall followed; in that case we were using energy which the sun was giving out. In the second case, when using the tides, we must be tapping the energy of rotation of the earth; so that, if we continued to use the tides, we should slow up the rotation of the earth. In reply, Mr. Paton said that practically no tidal schemes had been put into operation, so that we had still a long time during which to exist on that energy.

At this point His Royal Highess left the meeting to visit other sections, and the discussion on Mr. Paton's paper was continued in session B, in another room, in which Mr. J. S. Wilson occupied the chair. The first speaker in the renewed discussion was Mr. R. W. Weekes, who referred to the rate of run-off. He noted that in the case of the Thames, in successive 30-year cycles there was a variation of as much as from − 10 to + 15 per cent. from the long-term mean. He asked if that could be traced to the action of man in changing catchment areas by the building of towns, and thus increasing the rate of run-off by the impermeability of the soil, or whether it was a factual change of rainfall in the particular catchment area. In reply, Mr. Paton agreed that changes due to the building up or the development of land had to be borne in mind; but, so far as he knew, in the case of the Thames that had not been the cause.

Mr. A. Feiner, referring to the question of fish passes, said the author had mentioned both the pool type and the lift or elevator type. The latter type was used successfully at the Leixlip dam, in Ireland; he thought it might possibly replace the more lengthy fish-ladder type and asked whether, in the author's opinion, the fish-ladder type should be replaced. After emphasising the importance of the part of the paper dealing with pressure pipelines, Mr. Feiner referred to underground power stations, one of the advantages of which was said to be that they reduced friction losses. He asked if these reduced losses were not affected by the need for a long discharge tailrace. It might be necessary even to provide a surge chamber on the downstream side. The author replied that, from the engineering point of view, there was no doubt that the fish lift installed at Leixlip dam was adequate. The lift was a very simple device. A tunnel down the slope of the dam was provided, and it appeared that salmon liked to work against a stream. Nothing could be simpler from the engineering point of view, but it was for fishery experts to decide whether it would be satisfactory for the fish. With regard to pressure pipelines, Mr. Paton said that the static head on the turbines had exceeded 5,500 ft. in a scheme in Switzerland. The strengthening of pipes to resist such a head by means of reinforcing hoops at intervals, shrunk on by heat treatment, was giving place to the method of winding high-tensile wire on to the pipes. The greatest head that could be developed in this country, however, was of the order of only 1,000 ft. Referring to underground power stations, he said it was true that with a very long tailrace it might be necessary to provide a surge chamber for the tailrace; but even so, there was a saving in the cost of the penstock. The pressure pipeline leading to the turbine was very simple; it was only necessary to tunnel through the rock and line the tunnel with concrete, relying on the strength and thickness of the rock to resist the forces and pressure encountered, with a simple arrangement of pipes running through to each machine. There were, however, some difficulties. The power station had to be kept dry, and it would probably be necessary to treat the inner walls to render them waterproof and to counteract condensation. The worst trouble, however, was to design and plan the access arrangements in order to be able to replace or repair machines. These problems, however, could all be solved, and it had been proved in a number of schemes that the saving in cost was of the order of 30 per cent.

Professor W. Fisher Cassie, the next speaker, raised the question of the need for impervious cores in earth dams, and the author explained that he had not meant to imply that earth dams were always completely impervious without a core. The problem was to select a kind of sand-clay mix which, when thoroughly compacted and of the necessary volume and width, acted in the same way as an impervious clay. He, however, did not claim any expert knowledge of that particular question.

Professor R. O. Kapp said it seemed to him that the designer of an earth dam had to be prepared to accept a certain amount of loss by seepage. As in other engineering work, it might be a case of striking a balance between the losses due to seepage and the extra cost of making the dam more impermeable, provided, of course, that the dam were perfectly stable and that seepage was not likely to cause any trouble from erosion. The dams and power stations which Mr. Paton had illustrated were certainly not blots on the landscape; in fact, they were pleasing in appearance. Mr. D. H. McPherson also thought that the hydro-electric power stations were of good appearance, as also were the reservoirs when full; but when half empty, showing an expanse of ground with no vegetation, this was a blot on the landscape. There was a chance for the civil engineer, and possibly the botanist, to overcome that particular feature of hydro-electric schemes.

Dr. J. Cameron Smail, who was interested in the author's reference to an apron whereby the erosion below a dam was reduced or prevented, asked if there were experience of the deterioration of a dam by scour. In that connection he recalled having visited a power station, about 90 miles from Winnipeg, where the whole of the back of a large dam had had to be re-surfaced as the result of deterioration. With regard to flooding, he said that, when in Winnipeg, he had realised that the Red River flowed north, and the water might be freezing at the outlet while the upper waters were coming down in great volume due to the melting snow. If the river could be made to run in the opposite direction, much of the trouble there would disappear. Subsidiary dams to regulate the water in the tributaries would be valuable.

The chairman, at the conclusion of the discussion, recalled that erosion trouble was experienced at the Aswan dam in the early days, due to the discharge from the large sluices. The structure was founded on what was considered to be sound granite, but it had proved to be less sound than was expected, the result being that enormous pieces of granite were dislodged from the bed. Colossal work was necessary on the downstream side of the dam to cope with that erosion; more than a million pounds had been spent on the construction of an apron.

WATER TURBINES.

After a brief interval, the chairman invited Mr. R. W. Weekes to deliver a paper of which he and Mr. A. Feiner were joint authors. The first part of this paper was reprinted on page 185 of our issue of August 10, and it is completed on page 217 of this issue. Owing to shortage of time, Mr. Weekes presented the paper in abridged form, but also showed a number of slides illustrating dams, power stations and turbines, of which Mr. Feiner gave brief descriptions. The first speaker in the subsequent discussion was Mr. T. A. L. Paton, who asked the authors if they had considered the costs of hydro-electric schemes as compared with thermal power stations, and whether they had figures. In reply, Mr. Feiner said that Mr. Paton was probably in a better position to answer that question than he was, and quoted some published figures, which he believed were taken from one of Mr. Paton's papers, showing that the capital cost of a hydro-electric scheme was something like 85*l*. to 100*l*. per kilowatt, as compared with 75*l*. per kilowatt for a thermal power station. Those figures did not take account of amortisation, which extended over a very much longer period for a hydro-electric station, which he thought would last much longer than a thermal station.

Another speaker referred to the floating-lever mechanism for governing, which, he said, was similar to the device used in steam turbines, and asked if there was anything analogous to the "hunting" of a steam turbine in the control of water turbines. In reply, Mr. A. Feiner said that the basic element of the governor was a dashpot, which helped to bring the speed back to the normal; but the major difference between the water-turbine governor and the steam-turbine governor was the size of the servo set. Basically, the problem was the same, except that with water turbines there were greater forces to be dealt with. The next speaker expressed the view that not too much emphasis should be laid on the capital cost of hydro-electric schemes, because it was necessary to use one natural resource when another was restricted, even if a slight increase in cost were involved. To this remark, Mr. Weekes replied that the cost of the machinery used in a hydro-electric scheme represented a very small part of the total capital cost. In practice, it was found that when the cost of the cement, steel, etc., used on the civil engineering side of the scheme was included and a true balance between thermal and hydro-electric generation costs was drawn, while everything might appear to favour the hydro-electric scheme, the actual costs of civil engineering work had increased so greatly in recent years that the financial advantage was not so great as had been anticipated. On the other hand, with hydro-electric generation we were not using our diminishing supplies of coal, so that the expenditure of labour on a hydro-electric scheme was a very good investment for the future.

Dr. A. P. Thurston asked whether cavitation troubles had been overcome, to which question Mr. Feiner replied that experience over the last 40 or 50 years had certainly helped towards the solution of the problem but it had been by no means solved; every case had to be considered from the cavitation standpoint, particularly with high-speed machinery.

The next speaker, Dr. A. Alan Taylor, asked for information regarding the runaway speeds of the different types of turbines and inquired if there was any possibility of reducing them in order to ease the problem of the generator designer. With reference to the Bonneville power station, in the United States, having 10 Kaplan turbines, he asked if it would not have been more economic to have used about eight turbines having fixed blades. Mr. Feiner replied that roughly the runaway speeds in an impulse turbine were about 80 per cent. above normal speed; in the low-speed Francis turbine about 60 per cent.; in the high-speed Francis turbine from 125 to 130 per cent.; and in the Kaplan turbine something like 200 per cent. The machinery, however, was quite capable of dealing with overspeeds when they occurred. Mr. Weekes, dealing with the question concerning the Kaplan turbines used in the Bonneville scheme, said it was a matter of economics, in which civil engineering probably played the most important part. There were fluctuations of the rate of flow daily and throughout the year, and there could be no doubt that by using Kaplan turbines the best available output could be obtained from a group of machines. The reason for using all Kaplans, instead of some Kaplans and some turbines with fixed blades, was that the machinery cost was so small in relation to the civil-engineering costs that the operators preferred to have the greatest degree of flexibility rather than to install a number of units which had to be run at a fixed head as well as a fixed output. Mr. Paton said that in this country hydro-electric schemes had to justify themselves by selling electricity to the B.E.A. at the same price, or at a lower price, than it could be supplied by thermal stations. That was in fact done in Scotland.

There being no further speakers, the chairman adjourned the meeting, after complimenting the authors on their paper and proposing a vote of thanks. In the afternoon, visits were arranged to the offices of Messrs. Thomas Nelson and Sons, Limited, publishers; to the works of Messrs. Bruce Peebles & Co., Ltd.; Brunton's (Musselburgh), Limited; and to the Naval Construction Research Establishment at Rosyth.

High-Ash Coals.

In session A, which was continued under the chairmanship of Sir Claude Gibb, two papers were read in succession and discussed togethe-. These were "The Use of High-Ash Coals in the Electricity Supply Industry," by Dr. A. Alan Taylor, and "The Design of Large Boiler Plant for Using High-Ash Coal," by Mr. W. G. Marskell. They were reprinted in the issue of Engineering for August 10, on pages 188 and 189, respectively.

At the chairman's invitation, Dr. I. G. C. Dryden, of the British Coal Utilisation Research Association, Leatherhead, opened the discussion and gave a brief account of work undertaken by the Boiler Availability Committee. An analysis had been made of boiler deposits and, in particular, of the method by which sulphur trioxide was formed. Recirculation had been mentioned by Mr. Marskell as being still under investigation. The reduction in fuel-bed temperature so obtained was important but moisture had also been shown to have important effects. Dr. Taylor had said that smoke adsorbed the sodium oxides. It was probable, also, that the smoke particles acted as nuclei for the condensation of volatile alkalis. The more sulphur there was, the greater was the tendency for the deposits to bond.

Professor T. R. Cave-Browne-Cave, who was the next speaker, said that the two papers admirably fulfilled the purpose which the Organising Committee had had in mind when they decided that the use of high-ash coal was of great importance and ought to be discussed. Dr. Dryden's observations on the chemical aspects of the problem drew attention to the value of having such matters discussed by the British Association. The method of dealing with high-ash coals, whether derived from the mine itself or from open-cast workings, or as the waste from washeries, was a problem in itself. He was doubtful whether it was right to try to adapt the normal type of boiler to deal with coals of higher and higher ash content and asked whether it was not better to start afresh and design a boiler specifically for coals of really high ash content and let it consume all the enormous amount of waste which was available from washeries and workings. It used to be said, also, that the most efficient way of using the energy of coal dug in the Midlands for power purposes in London was to transport the coal there by rail. That was true with coal of reasonably low ash content but, if one were using coal of 30 per cent. ash content, 30 per cent. of what was pulled all the way from the Midlands to London was worse than useless and was very expensive to dispose of. He pleaded, therefore, for the development of a special type of boiler which would deal with the very high-ash content coals and could be sited at the pits.

Dr. Taylor, in reply, said that although it was at one time more economical to transport coal in trucks from the Midlands to London than it was to transmit electricity there, that was not so to-day and, in fact, the British Electricity Authority was planning to build a very extensive grid system which would result in large tonnages of coal being consumed in the Midlands, and the electricity so produced being transmitted to London instead of the coal. The higher its ash content, the less economic it was to transport coal, and when Professor Cave-Browne-Cave suggested that special boilers should be designed for high-ash coal it should be remembered that unless large quantities of such coal were available close to the burning point, the construction of special boilers was hardly warranted. There was much to be said for Mr. Marskell's suggestion of mixing inferior coal with better if it could be done thoroughly and if the mixture could be made consistent in quality. This would be preferable to transporting a lot of coal from different sources twenty or thirty miles away to a central point.

Mr. Marskell, replying to the question with regard to special boilers for the utilisation of slurry, said such plant existed, although it was the firing equipment rather than the boiler itself that was special. Such boilers worked very efficiently although conditions in this country were not always suitable for them. A large quantity of low-grade material had to be available at one point as it could not be economically transported, and that meant a very large single source or a number close together. That was not common in Britain although it was so on the Continent. The supply of fuel had to be continuous and, as the output of the washeries was not continuous because of shift work, storage arrangements were necessary. Furthermore, the current had to be put into the grid, and the British Electricity Authority had views on that. Dr. Dryden could rest assured that they were familiar with the points which he had raised and did apply the lessons learned from such investigations as he had described whenever possible. Re-circulation was an old story: it had been practised on boiler plant thirty years ago with the object of reducing temperatures, but recent investigations indicated that recirculation on chain grates did not materially alter the fuel bed temperature for the reason that the fuel bed was too thin. At this point the discussion was unavoidably closed.

Presidential Address to Section G.

On Friday morning, August 10, the two sessions A and B of Section G combined to hear Sir Claude Gibb, C.B.E., F.R.S., deliver his presidential address entitled "Two Thousand Years of Engineering." We reprint the address, abridged, on page 219 of this issue. The vote of thanks to the President was proposed by Professor T. R. Cave-Browne-Cave, C.B.E., who first explained that the Council of the Association had suggested that, in this Festival year, the presidents of sections should review the progress in their subjects over the period 1851-1951, but Sir Claude always gave full measure and had reviewed 2,000 years of engineering. The President, in his response, said that it had become evident to him that to cover just the period from 1851 to 1951 would mean starting off in the middle of fantastic developments in engineering.

After a brief interval, the meeting was resumed and the President first apologised for a slip in his address which stated that Alex Graham Bell, the inventor of the first practical telephone, was of the U.S.A. He had been reminded of the fact that Graham Bell had been born in Edinburgh.

Printing in Edinburgh.

The President then invited Mr. A. G. Curr to deliver his paper on printing, which covered the history of the printing and publishing industry in Edinburgh from the earliest times to the present day. Printing, the author said, was generally accepted as the most important single industry in the city, which, during the last hundred years or so, had built up and maintained a reputation for the production of accurately and attractively printed books. No single factor was responsible for this development; there were many reasons for the natural growth of printing in Edinburgh, several of them interdependent. The University, with its famous School of Surgery, and the Law Courts, were probably the two institutions which directly and indirectly exerted the greatest influence. Simultaneously with the growth of printing there developed the papermaking industry in the valleys of the Esk and the Water of Leith, the manufacture of paper making machinery, the construction of printing and bookbinding machinery, and type-founding.

In the course of the discussion which followed the reading of the paper, Dr. Ezer Griffiths, F.R.S., said he had heard nothing about the teaching of printing in Edinburgh and he asked how the printing machinery constructed in this country compared with that of Continental manufacture. To the latter question Mr. Curr replied that much depended on the particular type of machinery referred to. Of the actual printing machinery, that built in this country was the equal of what was found in the United States and was better than that produced in Germany, but, on the other hand, the production of bookbinding machinery was almost entirely in the hands of the Americans and the Germans, although, at the present time, some progress was being made in this country. A well-known engineering firm in England had calculated how many machines they could produce in a year, and when they communicated with the United States they had been staggered to find that the total number of machines used in the world was so small that it would not pay a business in this country to manufacture them. In many fields of the industry one country was famous for a particular type of machine and the total demand was not sufficient to justify world competition from three or four different countries. One of the present difficulties was that many printers were looking for a particular type of machine made only in the United States, and as it was impossible to import the machine into this country they had to produce without it.

Mr. C. Wright, the next speaker, said he had the impression that Edinburgh was especially associated at the end of the Eighteenth Century with the publication of popular technical works and the development of popular technical education, and that James Ferguson had been particularly connected with that and was the author of a number of works. Dr. A. P. Thurston, who followed, expressed the opinion that it was of great importance to draw attention to the necessity of producing bookbinding machinery in this country. His own books had been greatly delayed because it was not possible to get them bound. The next speaker, Mr. T. M. Dawe, expressed the view that the difficulty was not so much due to a shortage of machinery as to a shortage of labour, leather and binding materials. As one greatly interested in the printing industry he had been struck by the author's claim for accuracy, from which he had gained the impression that all the accuracy was in Scotland, but it should be remembered that the only Degree awarded to a printer's reader for his accuracy was that awarded to the printer's reader at the Oxford University Press. Whereas Edinburgh was quite entitled to claim the printing of the first Encyclopædia Britannica, it was an interesting fact that it had now found its way down to England and was being printed in London by a photographic process.

In his reply, Mr. Curr said that on the point of accuracy he would willingly admit that the first prize went to the Oxford University Press, but the claim which he had been making for Edinburgh was that the standard of all readers was very high. He did not deny that there was accuracy in the South, but that was not so 50 years ago. The reason the printing had come to Edinburgh was because the South was not so accurate.

Mr. Dawe here interposed the remark that not all the accuracy was in Edinburgh; it could be found in the South as well, where all the Bibles were printed by the Oxford University Press, in Oxford; and that Press, today and over the last 40 years, offered a guinea to any person who could find anything inaccurate in the spelling or the spacing or the margins of the Bibles which they produced.

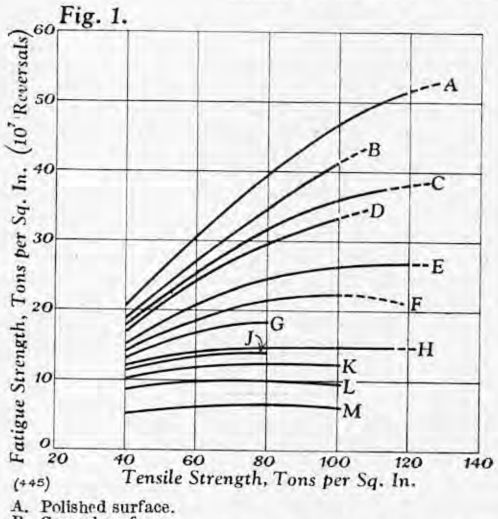
To this Mr. Curr replied that there was quite a big industry in the printing of Bibles in Edinburgh to-day, and Dr. J. Cameron Smail finally clinched the argument by pointing out that the printer at Oxford who was head of the whole organisation was formerly a student in evening classes in the Heriot-Watt College of Edinburgh University.

The Chairman, at this point, expressed regret that, owing to the lateness of the hour, he had to stop the war between the North and South of the Border. The meeting was adjourned until Monday, morning, August 13.

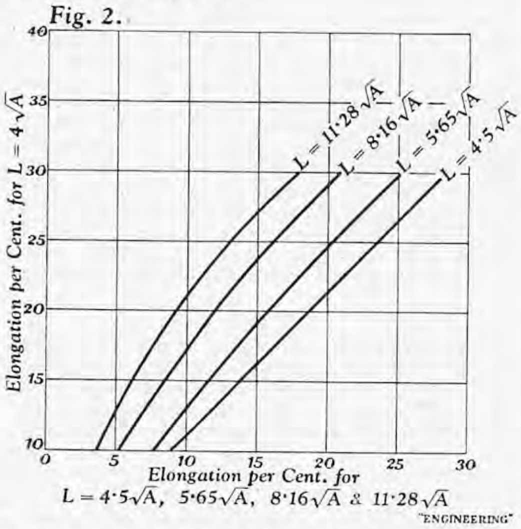
On the afternoon of Friday, members of Section G visited the works of Messrs. Brown Brothers and Company, Limited, and the Fountain Brewery of Messrs. Wm. McEwan and Company, Limited. On Saturday, August 11, a full-day excursion to the Loch Sloy scheme of the North of Scotland Hydro-Electric Board was undertaken.

(To be continued.)

NICKEL ALLOY STEELS.



A. Polished surface.
B. Ground surface.
C. Surface roughened by two days' corrosion in fresh water.
D. Rough machined.
E. Surface roughened by 12 days' corrosion in fresh water.
F. Notch $\left(\frac{d}{r} = 4\right)$.
G. Fillet (D_1 = 19 mm., D_2 = 9·5 mm., rad = 0·5 mm.).
H. As-rolled surface (decarburised).
J. Profile keyway.
K. Notch $\left(\frac{d}{r} = 28\right)$.
L. Corrosion fatigue in fresh water.
M. Corrosion fatigue in salt water.



PROPERTIES OF NICKEL ALLOY STEELS.

A handbook* published recently by the Mond Nickel Company, Limited, summarises the mechanical properties of representative heat-treatable nickel alloy steels, and is intended as a source of reference on the subject for engineers, designers, metallurgists, and heat-treatment superintendents. The graphs reproduced from the handbook as Figs. 1 and 2, herewith, show, in the first case, the importance of good surface finish in taking full advantage of alloy steels, especially in the higher tensile ranges; and, in the second, the relationship between the elongation, per cent., for various standard lengths of tensile test pieces.

Table I.—*Gauge Lengths.*

—	Related to Diameter.	Related to Area.
Austria	5 D and 10 D	5·65 √A and 11·28 √A
Belgium	5 D	5·65 √A
France.. ..	7·23 D and 5 D	8·16 √A and 5·65 √A
Germany ..	5 D and 10 D	5·65 √A and 11·28 √A
Italy	5 D and 10 D	5·65 √A and 11·28 √A
Sweden	5 D and 10 D	5·65 √A and 11·28 √A
Switzerland ..	5 D and 10 D	5·65 √A and 11·28 √A
U.S.A.	4 D	4·5 √A

With the aid of the key to Fig. 1 it will be seen that the fatigue strength can be reduced appreciably by conditions that are only too common in practice and enormously by particularly adverse conditions. The fatigue strength of nickel alloy steels in reversed bending is on the average about 50 per cent. of the tensile strength, although at the higher tensile ranges there may be some falling off. It is not possible to cover the very wide range of variables which affect the different types of fatigue, but in order to provide some indication of the general effect of some of these variables, the Mond Nickel Company have abstracted data from various sources and presented them in the manner shown in Fig. 1, which relates to reversed bending fatigue.

These data should only be used as a guide, since the relatively small specimens used in a laboratory test do not always exactly tally with results obtained from actual components. The deleterious effect of contact with corroding media during actual stressing will be noted. Fretting can also be serious and may produce fatigue values in the same region as curves H, J and K.

Owing to the local "necking" which occurs in a tensile test, the ratio of the gauge length to the cross-sectional area (or the diameter) has an important bearing on the elongation expressed as a percentage, and it is obvious that the bigger the ratio the smaller will be the percentage elongation. At the same time, it has been established that, provided the above ratio is kept constant, i.e., that the test pieces are always geometrically similar and the steel is uniform, variation of the diameter has no effect on the elongation value. The gauge length customary in this country is 3·54 D, i.e., L = 4 √A (where L, A and D represent the gauge length, cross-sectional area and diameter, respectively). In other countries the gauge length used is as shown in Table I.

The International Organisation for Standardisation have recommended the universal adoption of a test-piece having the ratio L = 5·65 √A, i.e. L = 5 D. Meanwhile, some indication of the correlation of these different gauge lengths is given in Fig. 2, which the Mond Nickel Company prepared from B.S. Handbook No. 10 and from other data supplied by the Poldi Steel Company.

Variation in the reduction of area will affect the value of the elongation per cent. for a given gauge length, but for the sake of simplicity Fig. 2 is based on average values of the reduction of area for different elongation levels. Some indication of the effect of variation from the mean figures is given in Table II, which is based on differences of ± 5 in the values of the reduction of area. The effect of variations from these means is given in Table II. The values refer to hardened and tempered low and medium alloy steels and are not necessarily correct for the austenitic steels.

Table II.—Correction to Elongation for Variations in Reduction of Area.

Elongation, per cent., for 4 √A.	Reduction of Area, Average Value.	Correction to Elongation for Other Standard Test Pieces.			
		4·5 √A.	5·65 √A.	8·16 √A.	11·28 √A.
10	35	0·2	0·5	0·9	1·1
15	45	0·1	0·4	0·9	1·1
20	55	0·1	0·3	0·7	0·9
25	60	0·1	0·3	0·5	0·8
30	65	0·1	0·3	0·4	0·5

Add the correction if the reduction of area per cent. is 5 *less* than average.
Deduct the correction if the reduction of area per cent. is 5 *more* than average.

The Mond Nickel Company's handbook is confined to those heat-treatable nickel alloy steels that are used in the case-hardened or hardened and tempered condition. They are divided into two main groups, i.e., case-hardening and direct-hardening (or through-hardening), and in each case are given (*a*) specification details for the chemical composition, heat-treatment and mechanical properties; (*b*) representative tests which include the effect of mass; and (*c*) tempering diagrams (direct-hardening steels only). In comparison with the former edition of the handbook two main modifications have been made, i.e., the effect of size is now taken into account and the value for 0·1 per cent. proof stress has been substituted for the elastic limit.

* *The Mechanical Properties of Nickel Alloy Steels.* 1951. The Mond Nickel Company, Limited, Sunderland House, Curzon-street, London, W.1. [Gratis.]

METALLURGICAL MEETINGS IN AUSTRIA AND ITALY.

As already announced in our columns, the Council of the Iron and Steel Institute have accepted an invitation of the Austrian Iron and Steel Institute to hold a special meeting in Austria from September 5 to 19. Members will arrive at Gmunden, near Salzburg, on Thursday, September 6, and, on the following day, visits will be paid to steelworks at Linz and to two other metal works at Ranshofen, near Braunau-am-Inn. Saturday, September 8, will be spent on a visit to a magnesite works at Trieben, the party then proceeding to Graz, in Styria. On Monday, September 10, an official welcome will be extended to the visitors in the Stefaniensaal in Graz. This will be followed, in the afternoon, by a technical session, held jointly with the Austrian Iron and Steel Institute in the Stefaniensaal. Three papers have been specially prepared for the meeting, namely "The 2,000-Year Tradition of the Austrian Iron Industry," by Dr. R. Walzel; "The Present Metallurgical Bases of Austrian Iron and Steel Production," by Dr. B. Matuschka; and "Investigations into the Effect of Non-Metallic Inclusions on the Hot-Workability of Steel," by Mr. F. Rapatz and Mr. M. Strobich. In the evening a reception given by the Governor of the State of Styria, will be held in the Burg at Graz. On Tuesday, September 11, visits will be paid to the Montanistische Hochschule, Leoben, and other places of interest in the vicinity, and, in the evening, a reception by the Mayor of Graz will be held in the Redoutensaal. On Wednesday, September 12, members will visit the Erzberg ("Iron Mountain") and the programme for the next day, Thursday, September 13, will include excursions to works in Graz and at Kapfenberg, Kindberg, Weiz and Bruck. On Friday, September 14, members will proceed from Graz to Pörtschach, Carinthia, visiting, on the way, an iron and steel works and the Guild of Gun Makers, at Ferlach. In the evening a reception will be held by the Governor of the State of Carinthia, in the Park Hotel, Pörtschach. On Sunday, September 15, visits will be paid to works at Radenthein and Bleihütte Gailitz, and, in the evening, a dinner and dance will be held in the Park Hotel, Pörtschach. A departure will be made for Zell-am-See on Sunday, September 16, and members will leave on their return to London on the afternoon of Tuesday, September 18.

The detailed programme of the autumn meeting of the Institute of Metals, to be held, by invitation of the Italian Metallurgical Association, in Italy, from September 15 to 25, has now been issued. The main British party will arrive in Venice in the evening of September 15 and will be joined, later that night, by the members travelling from Pörtschach after attending the Iron and Steel Institute meeting in Austria. On Sunday, September 16, the meetings of the Institute of Metals and the Italian Metallurgical Association will be officially opened at 9.30 a.m. by the Mayor of Venice in the Doge's Palace. Later that morning a reception at the Ca'Farsetti Palace will be held by the Municipality of Venice and the afternoon will be spent on a visit to a glass factory and other places of interest in the vicinity of Venice. On the mornings of Monday, September 17, and Tuesday, September 18, scientific and technical sessions will be held in Venice at which eight papers will be presented, namely, "Copper-Nickel-Iron Alloys Resistant to Sea-Water Corrosion," by Mr. G. L. Bailey; "Friction in Wire Drawing," by Mr. H. G. Baron and Professor F. C. Thompson; "Some Wrought Aluminium-Zinc-Magnesium Alloys," by Dr. M. Cook, Mr. R. Chadwick and Mr. N. B. Muir; "Effect of Small Quantities of Cd, In, Sn, Sb, Tl, Pb, or Bi on the Ageing Characteristics of Cast and Heat-Treated Aluminium-4 per cent. Cu-0·15 per cent. Ti Alloy," by Dr. H. K. Hardy; "The Tensile Properties of Heat-Treated Aluminium-Copper and Aluminium-Copper-Cadmium Alloys of Commercial Purity," by Dr. H. K. Hardy; "The Influence of Alloy Constitution on the Mode of Solidification of Sand Castings," by Mr. R. W. Ruddle and Mr. A. L. Mincher; "The Adherence of Oxide Scales on Copper," by Mr. R. F. Tylecote; and "The Oxidation of Copper at from 350 deg. to 900 deg. C., in Air," by Mr. R. F. Tylecote. On the afternoons of September 17 and 18, iron, steel and other works at Porto Marghera, and aluminium, lead, zinc and other works in the vicinity will be visited. In the evening of September 17, at 9 o'clock, the Autumn Lecture, on "Electro-Chemistry and the Science of Metals," will be delivered in English by Professor R. Piontelli, and, in the evening of September 18, a joint banquet of the Italian Metallurgical Association and of the Institute of Metals will be held.

On Wednesday, September 19, the visitors will be divided into eight groups, the first of which will consist of those returning direct to London. Group 2 will leave Venice for visits to steel and non-ferrous metal works in Milan. Members in group 3 will visit works at Piave and Bolzano as well as Milan, and those in group 4 works in Turin as well as in Milan. The works and other tours for those in group 5 will include Florence; for members in group 6, Milan and Florence;

for those in group 7, Bolzano, Milan and Florence; and for members in group 8, Milan, Turin and Florence. Members partaking in the visits of groups 2, 3, and 4 will return to London on September 22, and those attending the visits in groups 5, 6, 7, and 8, will return on September 25.

COURSES FOR INSTRUMENT-MAINTENANCE MECHANICS.

THE syllabus and other particulars of a new scheme of courses and examinations in instrument maintenance have been drawn up by an advisory committee of the Department of Technology of the City and Guilds of London Institute. The advisory committee concerned included representatives of industry; the Society of Instrument Technology; the Ministries of Supply, Fuel and Power, and Education; the Service departments; the leading engineering professional institutions; and various associations concerned with technical education. The scheme is intended to meet the needs of mechanics and technicians concerned in the maintenance, repair and installation of the instruments used for process and production control in industrial plants and in H.M. Forces. Particular attention is given to the requirements of the chemical, iron and steel and petroleum industries, to fuel economy and to the needs of the Services, but the structure of the scheme is such that it will be found to have wide application. The scheme provides for a course of part-time study of five years' duration, with an intermediate examination at the end of the third year, and a final examination at the end of the fifth year. Provision is made for students holding an appropriate Ordinary National Certificate to enter the course at the commencement of their fourth year.

The courses to be provided under the new scheme will be held in technical colleges, and their actual organisation will be a matter for the college authorities. Courses are to commence next month in colleges in London, at Aston Technical College, Birmingham, at Workington Technical College, Cumberland, and at a number of other industrial centres where a sufficient demand has been shown to exist. When the scheme gets under way it is hoped that the appropriate training will be provided in all leading industrial centres. In courses of such character it is felt to be most essential that, throughout all stages, the co-operation of industry and the education authorities should be close and continuous. It need hardly be stressed that the dearth of adequately-trained instrument-maintenance mechanics has tended to be a serious handicap to the preservation and proper working of instruments actually installed, and a deterrent to the full application of instruments in situations where their correct use could be of distinct advantage. It is hoped, therefore, that the new scheme will go a long way to ensure the proper training and education of instrument-maintenance mechanics. Data concerning the regulations, syllabuses and curricula for the courses and examinations are obtainable, price 6*d*., from the Director, Department of Technology, City and Guilds of London Institute, 31, Brechin-place, London, S.W.7. Further information regarding the scheme may be obtained from the same address.

JUBILEE OF THERMOTANK, LIMITED.—We have received from Messrs. Thermotank, Limited, Govan, Glasgow, S.W.1, a brochure illustrating the development of the firm since its foundation in 1901 by the three brothers, A. W. Stewart, W. M. Stewart, and F. C. (afterwards Sir Frederick) Stewart. The first Thermotank installation, however, was built in 1897, and the first shipboard set was fitted in the Russian steamer Kostroma in the following year.

NEED FOR THE MODERNISATION OF MERCHANT SHIPPING.—Pleas for financial assistance to be given to shipowners, to enable them to bring their ships up to date, were made by Mr. Tom Yates, the general secretary of the National Union of Seamen, on August 13, at the union's annual conference in London. He stated that many classes of merchant vessels, from tramps to passenger liners, were now more than twenty years old and that the time was approaching when shipping firms would have to undertake very extensive modernisation programmes. In the very near future, it would no longer be an economical proposition to keep the older vessels running, and the building of additional ships could not, therefore, be postponed for long, if the British mercantile marine was to continue to provide adequate passenger and cargo services. In his opinion, shipowners were entitled to some relief with respect to the replacement and modernisation of their ships. That could be given in the form of taxation relief, subsidy, or on the lines laid down in the British Shipping Assistance Act, 1935, which provided for the buying by the Government of obsolete tonnage for breaking up, to enable the owners to effect modern replacements.

LABOUR NOTES.

A RECOMMENDATION by the national executive committee of the National Union of Mineworkers that pits should resume voluntary working on Saturdays in August was rejected by the Scottish area of the Union, by 100 votes to 16, at a special delegate conference in Edinburgh on Monday last, in spite of the fact that only two such Saturdays remained. It was decided to adhere to the agreement reached by the British coalfield conference in April, which provided that miners should have a rest from Saturday working during the summer months. In accordance with this decision, the Scottish area will not reintroduce until September 1 the practice which it has operated since early 1947 of working on eleven days each fortnight. This arrangement leaves the miners with every alternate Saturday free.

Strong disapproval was expressed at the delegate meeting of the Scottish area regarding the proposed new supplementary pension scheme for the industry. The representatives considered that the suggested payment of 10*s*. a week on retirement was very inadequate and also criticised the proposed 25*s*. a week for miners who had completed 40 years in the pits. It was decided to press for the acceptance, by the National Coal Board, of the original demands of the N.U.M. for an all-round supplementary pension of 40*s*. a week, with double contributions to be paid by the Board. Other decisions reached on this subject included one that all miners who had retired since Vesting Day should be included in the pension scheme, and another, that the clause in the scheme relating to the attendance records of the men should be abolished.

Opposition to working with Italians appears to be hardening in some mining areas, in spite of the serious shortage of colliery man-power. Miners at 87 of the 114 pits in the North-Eastern Division have refused to accept any of the Italians now leaving the national training centre at Maltby, although there are vacancies for unskilled men at 67 of the Division's collieries. At only 18 of these understaffed collieries would miners be willing to give the scheme for employing Italian labour a trial. Of the remaining 47 collieries in the Division, which have no vacancies at present for skilled men, miners at only nine would be willing to receive Italian assistance. Officials of the National Coal Board estimate that there are about 1,500 vacancies which could be filled by Italians if miners at all the 114 collieries in the Division were agreeable to the employment of these men. Up to the beginning of this week, 30 Italians have been allocated to four of the 18 pits with vacancies and the employees at which are willing to work with Italians. It is considered that, in the existing circumstances, the Division could not absorb more than about 300 Italian trainees altogether.

Various reasons have been given for the opposition to the use of Italian man-power in the mines, such as the men's distrust of foreigners as fellow employees, and fear of their being used to reduce wages or debase working conditions. One Yorkshire official of the National Union of Mineworkers has attributed the men's rejection of Italian assistance to the feeling that it is a waste of money to train foreigners for mining unless there is good reason for believing that they will remain in the industry, as it has happened in the past that foreigners have left the mining industry, after training, for easier employment elsewhere. In general, the opposition to the Italians appears to be causing some embarrassment to the Union's officials in the Yorkshire area. It is believed that an understanding that Italian recruits would be accepted willingly was partly responsible for the conclusion, in January last, of the agreement which conceded certain improvements in wages and conditions for the lower-paid miners.

The opinion that it was much better to employ Italians in the mines than to run the risk of injuring the nation's economic welfare by encountering a coal shortage, was expressed by Mr. W. E. Jones, the secretary of the Yorkshire area of the N.U.M., on Monday. Referring to the decline in colliery man-power figures, Mr. Jones stated that the number of miners leaving the industry, owing to age and other reasons, exceeded the number of newcomers by about 200 a week. This represented a loss at the rate of 10,000 men a year and it was plain that the nation's coal requirements could not be produced unless the position were rectified. It had to be borne in mind that a shortage of five million tons of coal would mean between one-and-a-half and two million unemployed. The up-grading of the lower-paid miners to the coalface depended upon an accession of recruits and the Italians were the most promising source of supply. Conditions of their engagement were that they would join the Union, and that they would be the first to be discharged in the event of a surplus of labour arising in the industry.

Employees in the engineering department of the Post Office are to receive increases in their wages, ranging from 6*s*. 6*d*. a week to 13*s*. a week, as the result of an award by the Civil Service Arbitration Tribunal, issued on August 13. In all, nearly 60,000 men and women in the engineering, supplies and motor-transport sections of the department will benefit from the advances in pay, which will be ante-dated to June 1. Technical officers will receive increases ranging from 9*s*. a week for those aged 21, to 13*s*. a week for those in receipt of maximum rates of pay. The new maximum rates for this grade will be 8*l*. 18*s*. in London, and 8*l*. 11*s*. in the provinces. In the supplies grades, porters, packers, watchmen, and storemen will receive increases ranging from 8*s*. to 10*s*. 6*d*. a week. Adult storewomen in these grades will receive advances varying from 6*s*. 6*d*. to 8*s*. a week.

Motor-transport mechanics will obtain advances of from 9*s*. 6*d*. to 12*s*. a week. Labourers in the engineering and motor-transport sections will receive an advance of 8*s*. a week, bringing the maximum rates for this grade to 5*l*. 12*s*. in London, and 5*l*. 8*s*. in the provinces. The Tribunal's award represents an average wage increase of approximately 10*s*. a week, compared with the offer of an average of about 5*s*. a week, recently made by the Postmaster-General. The Post Office Engineering Union had claimed increases which would have amounted, on the average, to some 25*s*. a week. If granted in full, the Union's claims would have resulted in an extra 16*s*. a week for labourers and an extra 30*s*. a week for technicians with more than one year's service. When the award was first announced, it was described by an official of the Union as being extremely disappointing. The Union's national executive committee met on Wednesday to consider the position. It was decided that a special national conference should be summoned to take further action.

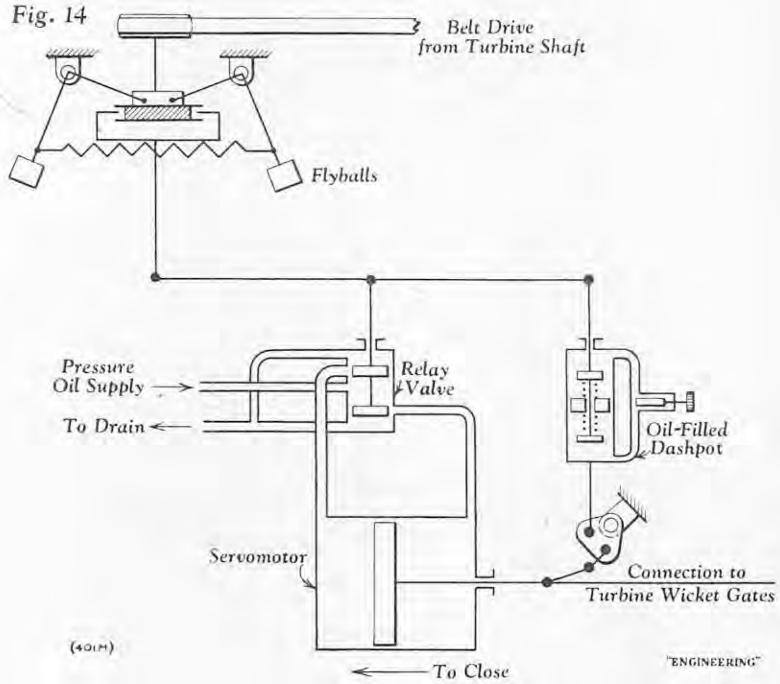
The efforts of the joint committee of representatives of the Railway Executive and the three railway unions, which was set up early in March to devise means of improving the railway services and to effect economies in working, appear to have met with little success. A meeting of the committee, the ninth to be held during the five months of its existence, took place in London on Friday last. The importance attached to the meeting was shown by the attendance of the chairman of the Executive, Mr. John Elliot, the labour relations officer of the Executive, Mr. W. P. Allen, and the general secretaries of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen. As previously, the meeting was held in private, and, although the discussions lasted for some hours, no announcement was made subsequently, beyond a statement that difficulties were being encountered and that another meeting would take place on August 20.

The two main issues which the committee are known to have discussed are an increase in the number of lodging turns and the extension of the eight-hour roster by one hour's overtime. All three railway unions, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association are represented on the committee, but only the first two are involved in these two issues. Although it was announced after the meeting on June 6 that an understanding had been reached between the two sides regarding lodging turns, nothing more has been heard of this tentative agreement. The adoption of either of these proposals would economise the use of skilled men by increasing the occasions on which members of train crews could work the return journeys of their trains, instead of going back to their depots as passengers. The proposals are, in consequence, strongly opposed by the men concerned. The Executive will meet representatives of the three unions on August 21, the day after the next meeting of the joint committee, to discuss the joint claims of the unions for an all-round wage increase of 10 per cent.

In order to stimulate the recruiting of the twenty thousand operating staff required by British Railways, a bonus scheme has been inaugurated by which railwaymen introducing newcomers in the civil-engineering, motive-power, signal, and telegraph sections of the railway service, in areas where vacancies exist, will be paid a bonus of ten shillings for each man accepted. An additional ten shillings will be granted in respect of each recruit who remains in railway employment for two months or longer. The scheme will remain in force until the end of October, when its continued operation will be reviewed.

WATER TURBINES.

Fig. 14



WATER TURBINES FOR HYDRO-ELECTRIC PROJECTS.*

By R. W. WEEKES, M.I.C.E., and A. FEINER, A.M.I.E.E., Assoc.I.Mech.E.

(*Concluded from page* 187).

THERE are obviously border-line cases where either of two types of turbines may be used. It is then necessary to consider a number of factors. Firstly, comparing impulse with Francis machines :—

(1) The Francis turbine with its draught tube makes use of the total static head between runner and tail-water, whereas the Pelton runner must, of necessity, be placed above the maximum operating tailwater level if it is to function under all conditions. This loss of head, which can sometimes be considerable, is really equivalent to a loss of efficiency.

(2) Where there are large fluctuations of headwater levels, the low specific speed Francis turbine can accommodate a head variation of approximately $\pm$ 35 per cent. about normal head without undue change in characteristics, whereas the impulse can only operate to about $\pm$ 20 per cent. of normal head to maintain reasonable efficiency.

(3) Efficiency favours the Francis above about 60 per cent. of full load but the impulse is much better at lower loads. Turbines for operating under high loads for considerable periods are, therefore, best of the Francis type (for example, for peak or base load operation), while, with widely fluctuating loadings and water availability, impulse turbines are most advantageously used. In the case of physically small size Francis turbines, the leakage losses through the peripheral clearances are a high percentage, resulting in excessive efficiency losses, thus minimising the natural advantage of higher efficiency.

(4) The higher speed of the Francis turbine usually reduces the generator costs and the overall dimensions of machinery and building, although additional excavation in hard ground may be very expensive. Also, when the developed power is small, the Francis type might operate at too high a speed for the generator design, and the impulse turbine is then to be preferred.

(5) The Francis type, with its large number of moving parts, is more subject to damage due to sand or other abrasives in the water. However, wear on the spear or nozzle surfaces of Pelton wheels can cause large reductions in efficiency due to jet distortion and spraying. Also, the fine splitter edges on the runner buckets can be easily worn. By the choice of proper materials for a Francis turbine, its disadvantages in this respect can be considerably reduced, and the less frequent overhauls needed are in its favour.

So far as Francis turbines, as compared with propeller turbines, are concerned :—

(1) Higher efficiency favours the Francis over the fixed-blade propeller only slightly, but the Kaplan turbine is much more efficient than either of these over a wide range of load, except at the very peak of the Francis curve. The Kaplan type is also superior for wide fluctuations of head, and the gain in efficiency is considerable.

(2) The higher speed of the propeller turbine reacts in its favour in a similar way to that of the Francis turbine as compared with the impulse turbine.

(3) The setting with respect to tailwater favours the Francis turbine, which therefore requires less expensive excavations.

(4) With the machine unloaded and the turbine wicket gates fully open, passing a maximum quantity of water, the relationship between the gates and the runner blades may be such that the runaway speed achieved by the propeller turbine (especially the Kaplan) is higher than that of the Francis. This may result in a more expensive generator, since the rotating parts which must be designed to withstand the stresses at runaway speed may necessitate a reduction in diameter and increase in length of the machine.

(5) The cost of the Kaplan turbine, with its complicated blade mechanism and control apparatus, far exceeds that of the Francis and fixed-blade propeller types.

As prime mover, the turbine has to be regulated to provide a constant speed under varying loads when driving an alternating-current synchronous generator in order to maintain a constant frequency. Also, arrangements must be made in the case of such machines to ensure that, where the electrical energy is fed into an interconnected power system, the load between the various machines feeding the network is correctly apportioned. The speed change is the signal normally adopted for automatically varying the quantity of water to the turbine, the speed measuring device being the governor actuator. By means of distributing valves the actuator causes one or more servomotors to operate the mechanism varying the flow to the turbine, as shown in Fig. 14. In the case of Kaplan turbines, the runner vanes are operated at the same time to take up their correct position.

For propeller and Francis turbines the flow is regulated by means of the wicket gates, and with the impulse turbine the movement of the spear performs the same function. With the impulse turbine, an alternative means is to deflect part of the jet continuously, but this is only advisable where the water quantity passed through the turbine has to remain constant, since the continual wear on the deflector tip causes spreading of the jet in time. This, together with the non-uniform jet shape, leads to a reduction in efficiency and increased wear on the runner buckets.

The governor speed-measuring device usually consists of flyballs driven directly by the turbine shaft, or through gearing or by belt, or by an electric motor running in synchronism with a permanent-magnet generator coupled to the shaft of the generating unit. The last system is most useful in cases where the layout does not readily permit a convenient juxtaposition of turbine and governor, since only a three-core cable forms the interconnection.

Means are usually provided on the governor for varying the speed either locally by hand or from a remote point by electric motor. The range of adjustment normally lies between + 5 per cent. and − 15 per cent. of normal speed, and this enables synchronising and loading of the generator to be carried out. Similarly, a hand-operated speed-droop device, capable of varying the speed between full-load and no-load by up to about 5 per cent. of normal speed, is included with the governor, the generator of which is running in parallel with other generators. The characteristic of the load-speed curve thus obtained enables the turbine to take its proper share of the load.

Automatic governors are not required for asynchronous alternating-current induction generators which are held in step by the power system frequency of which they are only a very small part. The turbine regulating mechanism is merely set to the required opening and the power generated is fed into the system.

It is obvious that, on a change of load, the change of speed is dependent upon the load change, the time required to alter the input energy, and the inertia of the rotating parts. The load change is determined by external conditions. The minimum time in which a governor can act to change the water quantity depends upon the lost motion of the moving parts, which include both the oil-pressure system and the mechanical connections to the turbine. For a full stroke of the governor servomotor, the minimum time is of the order of one second. Normally, however, this is not the limitation since sudden changes in the rate of flow of water are accompanied by pressure variations (known as water hammer) resulting from the transformation of kinetic energy into potential energy, or vice versa, and the time necessary to keep the pressure regulation within safe limits (for example, $\pm$ 30 per cent. of normal pressure) becomes the effective time. However, a pressure increase or reduction also affects the speed of the set, and this must be considered. Further, the change of speed itself affects the speed regulation because, due to the change in efficiency, there is a reduction in turbine output : for load rejection this assists speed regulation but for load acceptance the position is worsened. This condition is, in effect, determined by the characteristics of the runner.

With the load change, governor time, pressure change, and turbine characteristic fixed, the only variable is the inertia of the rotating parts. By increasing the inertia, the time taken to reach a particular speed is prolonged and the speed rise at any intermediate time is therefore lessened. The permissible speed fluctuation depends upon the type of load on the station, but normally a speed rise of about 30 per cent. for instantaneous full-load rejection is considered a maximum. When full load is rejected from the turbine, the speed rise has no effect upon the equipment supplied by the station, since the generator would be disconnected from the load. Part-load rejections are, therefore, more important. Only in exceptional circumstances would the instantaneous rejection of more than about 25 per cent. of full load be expected, and the corresponding speed rise would be about 4·5 per cent. of full speed. As it is practically impossible to apply any appreciable load instantaneously, speed drops are not normally so important as speed rises. Under certain conditions they do assume importance as, for example, when two machines are feeding a system, and due to a fault in one generating set it is brusquely disconnected.

Where pipelines are very long, the rate at which flow can be safely decreased is so low that the provision of sufficient flywheel effect in the rotating parts is economically or practically unjustifiable in order to obtain reasonable speed regulation. Means are then usually adopted to reduce the operating time on the turbine in one or more of the following ways :—

(1) A by-pass valve is coupled to the casing of the turbine so that a constant quantity is passed through the pipeline irrespective of the quantity actually required by the turbine itself. The wicket gates or spear may thus be operated as quickly as possible. This is particularly useful when a constant quantity of water is needed downstream of the turbine in such cases as irrigation projects where power production is incidental. Excellent speed rises and drops are obtained in this way, but otherwise the scheme has little to recommend it as it is wasteful of water. A similar system is that previously described for water quantity control by continually deflecting part of the jet of an impulse turbine.

(2) The by-pass valve may be connected through a dashpot so that it is caused to open only for relatively large changes of load, and then at the same rate as the gates or spears close. The valve then closes in such a time as to restrict pressure rise. Such a valve is called a pressure regulator or relief valve ; two are shown in Fig. 15, on page 218. Since failure of the regulator could cause a catastrophe, some turbines are equipped so as to increase the turbine closing time if the regulator fails to function, thereby restricting the pressure rise to safe limits at the expense of speed rise.

(3) In the case of impulse turbines, a simpler arrangement is, firstly, to deflect water quickly and then to follow up by closing the needle at a much slower rate and to such a degree that the jet is just clear of the deflector. This system is known as dual regulation. An alternative method, which is patented, disperses or breaks up the jet instead of deflecting it. This is achieved by introducing slightly slanting vanes into

* Paper read before Section G of the British Association at Edinburgh on Thursday, August 9, 1951. Abridged.

WATER TURBINES FOR HYDRO-ELECTRIC PROJECTS.

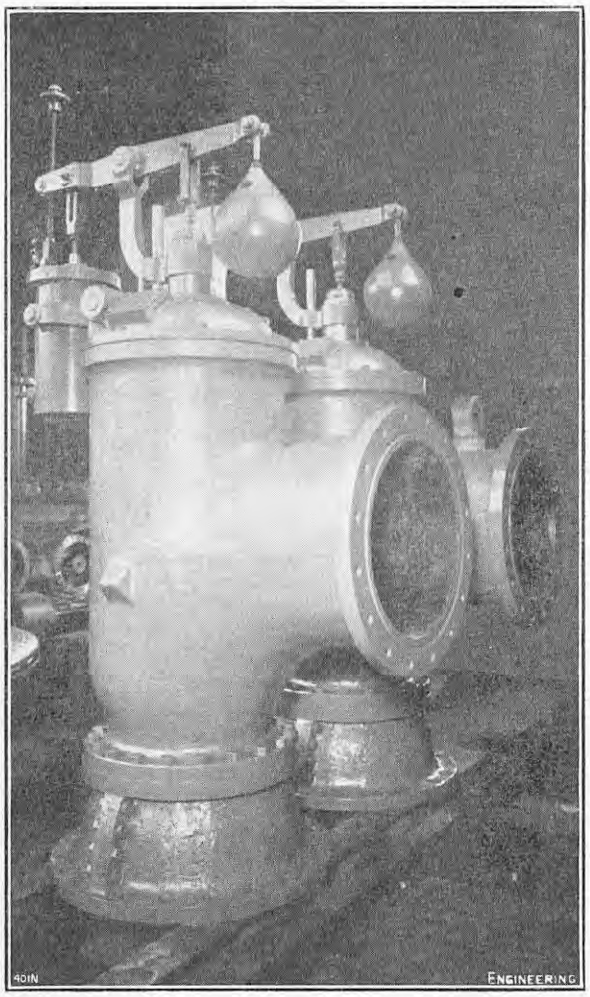


FIG. 15. PRESSURE REGULATORS.

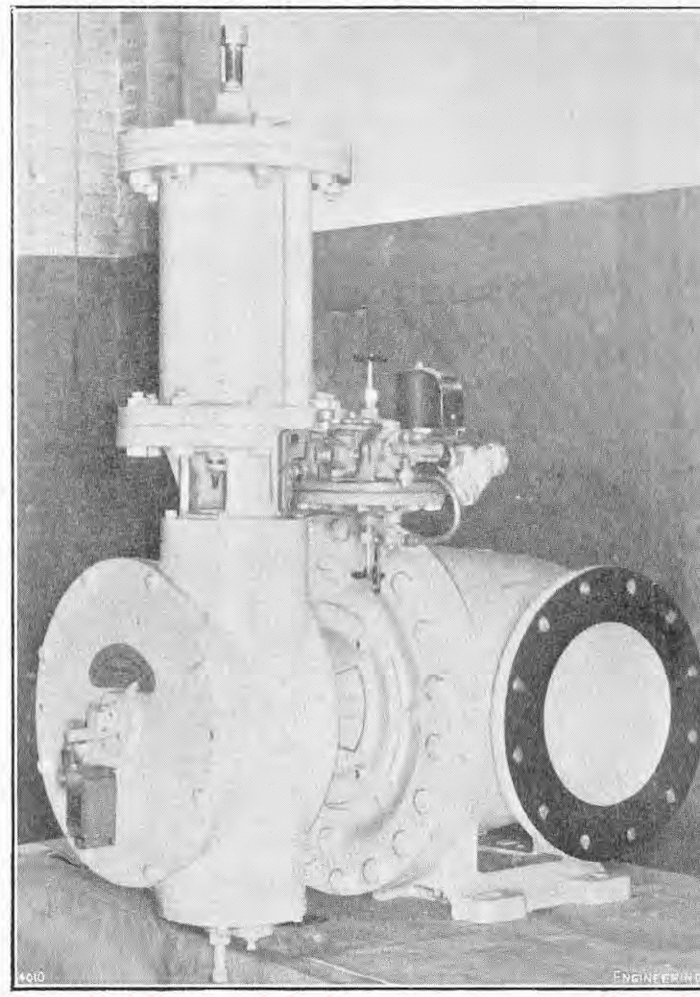


FIG. 17. HARLAND-MORGAN SMITH "ROTOVALVE".

the jet through the needle bulb. When the needle has taken up its correct position, the dispersing vanes are withdrawn within the needle, the tips lying flush with it.

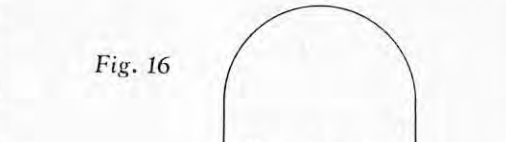
(4) In order to reduce the effective length of pipeline between turbine and intake, a surge chamber may be introduced into the pipeline as close as possible to the turbine. On sudden rejection of load, the water rises in the tank and absorbs the energy released by the flowing water column when changing its momentum. On sudden load demand, the water stored in the chamber supplies the additional quantity of water required until the water column in the upstream pipeline has had time to accelerate.

There are other auxiliaries usually necessary for use with turbines. An important part of the automatic governor equipment is the oil pumping and storing apparatus. A typical scheme for providing a reliable oil supply is shown in Fig. 16. The oil pump may be driven by belt from the turbine shaft or by individual electric motor. The compressed air for keeping the oil under pressure in the accumulator may be supplied by using the oil pump as an air pump, or more usually from a separate compressor. The oil pressure is generally between about 200 and 300 lb. per square inch. Smaller turbines use an oil pump without a receiver, the servomotor being held closed by a spring.

Pumps are also required when external oil circulation is necessary for the bearings, or with grease-lubricated main-shaft bearings. Main and standby pumps are provided for the purpose, the main pump being driven either mechanically from the turbine shaft or by alternating-current motor, whereas the standby pump would be driven normally by a direct-current motor. Where possible, water for cooling the lubricating oil is taken from the main pipeline, but when heads are above about 400 ft. or very low, the water has to be pumped from the tailrace or, in the latter case, boosted from the main pipeline.

Pumps are necessary when drainage and leakage water cannot be readily expelled from the power station by gravity. Such pumps are sometimes designed also to de-water turbine draught tubes and outlet chambers when high tailwater levels make it impossible to allow access to the insides of the turbines for inspection purposes. In turbines where the wicket gates are under pressure in the shut-down condition,

Fig. 16



due to the omission of a shut-off valve at the turbine entry, and leakage water past the main shaft and gate glands cannot be drained under gravity, main and standby motor-driven pumps controlled by float switches are necessary.

For indication, alarm, and shut-down purposes, pressure, temperature, level and flow devices having electrical contacts are often necessary. Another important safety device is the overspeed governor, which trips out the generator and shuts off the water supply to the turbine when the speed of the generating set reaches about 30 per cent. over-speed. This is necessary in order to restrict the rapid rise in voltage and frequency in the event of a governor failure. A shut-off or isolating valve immediately before the turbine is always advisable where a pipeline feeds the turbine, for not only does it act as a back-up protection in the event of the turbine running away, but it serves as a means of isolating the turbine for inspection purposes without having to de-water the penstock, and it conserves water which might otherwise leak past the wicket gates. In low-head installations, where the forebay is very close to the turbine, sluice gates at the pipe entry are satisfactory, but they are only closed in an emergency or to permit inspection of the water passages. Even in such cases, turbines have been provided with isolating wicket gates, in addition to the regulating wicket gates, so as to permit work on the turbines to be carried out while water is passed downstream through the cases and discharge regulators acting as synchronous by-passes. Turbine shut-off valves may be operated mechanically by hand, or by electric motor, or by hydraulic or pneumatic servomotors actuated by electric, hydraulic or pneumatic means. Generally, one of the following types of valves is used: butterfly, which is not drop-tight and presents a permanent obstruction to the water flow; sluice, which has high friction losses, causes a disturbance to flow by the creation of eddy currents, and is conducive to the creation of water-hammer effects when closing against full flow; spectacle-eye, which is expensive and large, demanding a great deal of space below and above the water passage; Larner-Johnson, which is expensive, long between flanges, and, apart from one patented design, tends to slam shut; and rotary, which combines the advantages of requiring only small forces to operate it, compactness, simplicity and certainty of control, negligible wear on sealing faces, elimination of water-hammer, and a friction loss equivalent only to that of an equal length and cross-section of straight pipe. A rotary valve of the hydraulically-operated type is shown in Fig. 17, herewith.

In view of their simplicity, the small number of auxiliaries required, and the ease with which water turbines may be run up and shut down, hydro-electric power stations are pre-eminently suitable for local or unattended remote automatic control by one "start" and one "stop" push-button. The saving in labour costs where a group of stations is controlled from one central point is considerable.

TWO THOUSAND YEARS OF ENGINEERING.*

By SIR CLAUDE GIBB, C.B.E., F.R.S.

ENGINEERING is much older than any history that has come down to us, for it stretches back to the beginning of civilisation. With the growth of the first civilised countries, problems arose in the cultivation of the land, and in transport. Engineers were called upon to provide irrigation schemes, reservoirs, canals, docks and harbours. The rulers of the day required them to build palaces and great monuments, examples of which are the Pyramids. Temples had to be erected. These presented great problems for the engineer. To shape the large blocks of stone used for their construction, tools had to be designed and built, and here again, the engineers displayed much skill and ingenuity.

During the Third and Second Centuries B.C., Greece furnished a number of eminent engineers, records of whose engineering feats have been passed down to us. Ctesibius Alexandrinus invented a two-cylinder force pump; the remains of one are in the British Museum. Hero of Alexandria was possibly a follower of Ctesibius, and his researches brought him into the fields of mechanics, catoptrics, pneumatics, surveying, geometry and stereometry. By the engineer he is remembered for his original idea of a reaction turbine, and also for his hydraulics. The modern surveyor owes his theodolite to Hero, who called his own instrument the dioptra. Archimedes was another Greek genius; he laid the foundation for our knowledge of specific gravity, and of the principles of leverage and the water screw. The mathematical problems which he solved are of vital importance to the engineer to-day.

The development of the Roman Empire set the engineers great tasks. The greatest achievement of Roman technical work was the making of roads. With the decline of the Roman Empire, little progress in engineering was made until 1629, when Giovanni Branca, of Rome, published information on a new steam engine. This was, in fact, a steam turbine which operated on the impulse principle.

About this time, coal mines in Great Britain were becoming deeper, and difficulties were being experienced in pumping out water, and raising the coal. Engineers turned their attention to the design of an engine for this purpose, and in 1663, the Marquis of Worcester described a method of raising water by the use of steam. During the next century, the reciprocating piston engine made its appearance, and the names of Papin, Savery, Newcomen, Beighton, Smeaton and Watt will always be associated with its development. Progress in all branches of engineering, from then on, developed rapidly. Steam engines were fitted into river boats in this country, in America and in France. In 1819, the Savannah, a vessel of 300 tons, fitted with a single-cylinder steam engine driving paddle wheels, crossed the Atlantic from America to Europe; but some years had to pass before vessels and machinery of adequate strength and power were available to inaugurate the transatlantic service.

Henry Cort had discovered in 1783 a process for producing wrought iron by puddling, and rolling it into plates and bars, an invention which provided a new material for engineers. The history of iron ships began in 1787 with an iron canal barge. The first iron steam vessel was the Aaron Manby, which David Napier navigated from the Thames to the Seine in 1822. Screw propulsion was also introduced about this time. Engineers were also concentrating on improved land transportation. Trevithick, Blenkinsop, Hedley, and George Stephenson will be remembered for their work in constructing steam locomotives for coal haulage. Stephenson also constructed the locomotive which drew the first public passenger train in the world, on the Stockton and Darlington Railway, in 1825.

These developments in the steam engine had been made possible by the work of the engineers and physicists who did preliminary work on determining the laws of steam. Watt discovered that the latent heat of steam is nearly constant for any pressure within the range of steam-engine practice, and that, consequently, the greater the steam pressure, and the greater the range of expansion, the greater will be the work obtained from a given weight of steam. He also invented the steam-engine indicator. Count Rumford carried out experiments on frictional heat, and, in 1824, Sadi Carnot published his pamphlet which gave us the pressure-temperature cycle. Carnot's ideal diagrams, with isothermal and adiabatic lines, represented very closely the action of the steam in engines of that period, but he failed to recognise that heat disappeared in the process of producing power, in an amount equivalent to the external work done.

Joule, in 1849, established the indestructibility of energy, the mechanical equivalent of heat and the existence of the absolute zero of temperature. In the following year, Sir William Thomson (afterwards Lord Kelvin) deduced the absolute zero of temperature from Carnot's cycle and reached the same conclusion as Joule. Thomson, Rankine and Clausius continued the work by giving the subject mathematical treatment and it is to these physicists that we are indebted for the discovery of the laws of thermodynamics, and to Clausius for the introduction of the term "entropy."

The beginning of the Nineteenth Century was also an important period in the history of electricity. Although magnetism had been known since ancient times by the Chinese and the Greeks, little use was made of it. One of the first references to its use for practical purposes occurs in the description of Columbus's first voyage to America in 1492, when he used a compass. Little was achieved during the next 300 years until Volta discovered, in 1799, that electricity could be obtained by chemical action, and produced the voltaic cell giving a steady low-tension current. Rapid progress in electrical research was thus made possible, resulting in discoveries by Oersted, Ampère, Faraday, Davy, Sturgeon, Ohm, Henry and finally Faraday again in 1831, when he made the greatest contribution to the development of electrical science by constructing the first magneto-electric machine. Further developments were made by other inventors, and, by 1844, one of the first effective industrial electric generators was constructed for an electro-plating works at Birmingham. Another field of development was that of the telegraph. Attempts had been made in the Eighteenth Century to introduce the electric telegraph, but it was not until 1837 that success was achieved independently in the United States by Samuel Morse, and in England by Wheatstone and Cooke, who installed, in 1843, the first public electric telegraph line between Paddington and Slough.

By 1850, reciprocating steam engines were in general use both on land and sea; the preliminary laws of thermodynamics had been established; the steam locomotive was in use and passenger train services were being inaugurated in different parts of the country; important developments had been made in electricity; electric generators had been constructed and the electric telegraph services were in use; wrought iron had been discovered and was being used for the construction of boilers, steam engines, ships and bridges.

With the success of the electric telegraph on land, the first submarine cable was laid in 1850 between Dover and Calais; and, after many attempts, a transatlantic telegraph service was established in 1866 between Ireland and Newfoundland. It was operated by the Atlantic Telegraph Company. In the early days, the transmitting speed was 15 letters per minute, since increased to over 2,500 letters per minute. The transmission of speech was next attempted, though it was not till 1876 that a practical telephone was invented by Alexander Graham Bell. At the British Association meeting held at Glasgow, in that year, Graham Bell, in conjunction with Lord Kelvin, brought it to the Association's notice. Within a few years, telephones were in use in all the advanced countries in the world.

Even more revolutionary was the transmission of power by electricity. The first proposals for electrical transmission concerned electric lighting, and it was this development that led the way to the transmission of power. The electric arc-light, first demonstrated by Humphry Davy in 1809, had been turned into a practical commercial possibility by Foucault in 1844, but, while it was used for lighting railway stations, docks, etc., it was not ideal for indoor lighting.

Many inventors attacked the problem of making an incandescent electric lamp, but without success, and it was not till 1878 that Sir Joseph Wilson Swan made such a lamp and exhibited it at Newcastle. T. A. Edison was also working on the problem and he patented his process in 1879. Companies formed by the two inventors were amalgamated in 1885 to form the Edison and Swan United Electric Light Company. The first opportunity given to the public of seeing electric incandescent lighting on a large scale was at the Crystal Palace Electrical Exhibition, in 1885.

Edison saw that the possibilities of electric lighting were dependent upon the efficient supply of current from a generating station, and set himself the task of designing a reliable dynamo. In 1879, he produced a dynamo to give electric current at a constant pressure of 110 volts. These dynamos were designed to be driven either by a pulley and belt, by a steam engine, or by coupling the armature shaft directly to the crankshaft of a steam engine. Edison also worked out the (by no means obvious) system of distribution by cable and wiring circuits.

The first public lighting supply was opened at Appleton, Wisconsin, in 1881, and in the same year the first station in England was opened at Godalming, in Surrey. In the following year, the much larger Pearl Street station, New York, was opened with six generators, with an eventual lamp connection of 6,000 to 7,000 lamps. By the end of the year, nearly 80 electric companies were founded in England, though few had actually gone into operation. In 1883, the first public electric railway was opened, between Portrush and Giant's Causeway in Ireland.

When central-station electric lighting by direct current was first established, it was found that there were many towns and places where the demand was so scattered that it did not pay to put down the heavy feeders and distribution mains required on the direct-current system. Attention was therefore directed to the possibilities of alternating-current supply. Many different types of alternators were designed by Gramme, Westinghouse, Ferranti, Kapp, Parker, Mordey, and Messrs. Ganz of Budapest. Ferranti especially devoted his attention to the design and construction of large alternators for public electric supply, and installed a number of them in power stations in London. The Deptford station will always be associated with the name of Ferranti, for it was there that he gave a lead to the world by installing single units of 10,000 h.p., generating at the unheard-of pressure of 10,000 volts.

In the early days of electric lighting, it was usual for the generating unit to be driven by a belt from some kind of steam engine. Semi-portable engines of the agricultural type were generally employed, and there was a serious need for some form of high-speed engine for direct drive. One of the earliest high-speed direct-coupled engines was made by Peter Brotherhood, who arranged his three-cylinder engine to drive a dynamo directly from either end of the crankshaft. This was soon superseded by the Parsons epicycloidal steam engine of 1877, which, in turn, was outclassed by the Willans central-valve engine. The latter was displaced by the Bellis double-acting high-speed compound engine.

While this evolution of the reciprocating steam engine was taking place, the final solution, namely, the steam turbine, was being brought to practical success by Sir Charles Parsons. He patented his first turbo-dynamo in 1884, and it was this little machine, of only $7\frac{1}{2}$ kW, which led the way to the large central-station turbo-alternators built to-day. Parsons developed the turbine chiefly in relation to electricity generation, and many small turbo-generators were built for supplying current for lighting purposes in ships, factories, hotels, etc. After the incorporation of condensers in 1891, the turbine rivalled the reciprocating engine in efficiency and was rapidly adopted for power stations. By 1912, turbo-alternators for an output of 25,000 kW had been constructed; to-day single units of over 200,000 kW are in operation.

The commanding position of the steam turbine is due mainly to its high thermodynamic efficiency; in large sizes, it gets more work out of coal than can be got by any other prime mover, due to its ability to take full advantage of the high pressure and high temperature steam conditions now in use, and the adoption of regenerative feed heating, in which steam is tapped from the turbine at successive stages of the expansion to heat the feed water on its way back to the boiler.

Parsons also attacked the problem of adapting the turbine to marine propulsion, and, after many disappointments, was equally successful. He constructed a small launch, the Turbinia, in 1894, which was fitted with a single turbine driving one propeller. On trials the speed attained did not give the expected result due to propeller cavitation. New turbines and new propellers were fitted which ultimately enabled a speed of 34 knots to be obtained. During the naval review at Spithead in 1897, the Turbinia was demonstrated before a fleet representing not only the British Navy but the sea-power of other leading nations as well. Her performance focused the attention of the Admiralty on the possibilities of turbine propulsion, and they entrusted Parsons with the construction of a 30-knot turbine destroyer, H.M.S. Viper. In the following years, the turbine was tried in various vessels of the Navy with such success that, in 1905, a Committee on Naval Design advised that turbines should be used exclusively in all classes of warships.

Meanwhile, the first turbine-driven passenger vessel, the King Edward, was built in 1901 for service on the Clyde; she was followed by cross-channel boats, and later by vessels for the Liverpool-Canada passenger service. In 1906, the Lusitania and Mauretania were each fitted with four turbines totalling 70,000 h.p. To-day, the turbine is the recognised prime mover for all the navies of the world, as well as for all the fastest ocean liners. It made possible the construction of the Queen Mary, Queen Elizabeth, and many others. The introduction by Parsons of gearing between the turbines and the propellers enabled the size of machinery to be reduced, and increased its efficiency.

To use fuel directly in a cylinder, instead of the more usual cycle of fire, boiler and cylinder, attracted the attention of inventors from the earliest days, but the arrival of the practical steam engine put an end for a time to work in this direction. It was not till the Nineteenth Century, when coal gas became available, that inventors once again took up the subject. Coal gas provided a suitable and readily available fuel, and in 1823 Samuel Brown constructed the first commercial

* Presidential address to Section G (Engineering) of the British Association for the Advancement of Science, delivered in Edinburgh on August 10, 1951. Abridged.

gas engines. Progress after this became rapid, due to the attention of many more inventors, till in 1876 Otto produced the famous "Otto silent gas engine," completing its cycle in four strokes. Two years later, Dugald Clerk produced his two-stroke engine which, for large powers, tended to be the more favoured.

Although large units using blast-furnace gas were developed, with efficiencies greater than steam in suitable circumstances, to-day it is regarded merely as a step in the evolution of the petrol and oil engines. Petroleum in large quantities had been discovered in 1858 in the United States, and the increasingly wide distribution of petroleum oils, particularly the paraffin oils and lamp oils, focused attention on the possibility of using oils as fuel instead of gas. The earliest oil engine to achieve success was that of Priestman, introduced in 1885; followed the next year by Daimler's engine, which used an oil so volatile that a carburettor would serve to charge the incoming air with combustible vapour, and which ran at high speed, enabling bulk and weight to be lessened and power increased. The Daimler engine marks the beginning of the modern petrol engine. Many inventors contributed to the development of the oil and petrol engine, one of the most notable being Rudolf Diesel, who, in 1895, produced an engine which, while able to use crude oil, gave a remarkably low fuel consumption and high efficiency. The Diesel engine was developed for use on heavy road-transport vehicles and, in the larger sizes, as a rival to the steam turbine for marine propulsion, where it found many advocates. Much attention has also been paid to its use on railway traction, and the number of Diesel main-line locomotives is growing rapidly.

The effects of the petrol engine were most revolutionary in the field of transport, first on the roads and then in the air; its lightness in relation to power made it pre-eminently suitable for this purpose. Daimler at first intended his engine to be used for stationary work and for the propulsion of boats, but in 1886 he fitted it to a bicycle. The results were so successful that, three years later, he built another engine for a road vehicle. This was the beginning of the great motor industry. The year 1896 saw the founding of the English Daimler Motor Company, and in the same year the Ford Motor Exhibition was held in the Crystal Palace, London.

These early cars were frequently unreliable, but the mechanical design was quickly improved as a result of practical experience on the road. Other improvements, such as better systems of ignition and cylinder cooling, pneumatic tyres, and streamline body construction have done much to popularise the motor car. By 1928, the output of high-speed internal-combustion engines exceeded by more than ten times the total horse-power of all power stations, ships and railways. Again, at the World Power Conference in Berlin in 1930, it was stated that the number of motor cars on the world's roads was some 30 millions, with an output of at least 600 million h.p. To-day, self-propelled vehicles are used for practically all forms of transport.

One of the most notable applications of the petrol engine is in aviation. It was not till the Eighteenth Century that flight was achieved by the use of hot-air balloons. Thereafter considerable experimental work was undertaken with power-driven model aeroplanes, the first model to rise under its own power and land safely being constructed in 1857. With the rise of the motor-car industry and the availability of a light and reliable prime mover, attention was directed to the possibility of controlled power flight.

The Wright brothers, who had been carrying out extensive gliding experiments, designed a motor and propeller to suit their machine, and in December, 1903, were able to rise in the air and fly for a distance of 25 yards. This was the first flight of a machine fully controlled. Progress was rapid, and successful machines were constructed in 1909 in England by Cody and by Roe. In the same year, the world was startled by the first successful flight across the Channel by a Frenchman, Louis Bleriot. With the advent of World War I, technicians, factories and Government funds were made available for urgent development work and a huge British aircraft industry was built up in an incredibly short time. Between 1914 and 1918, Great Britain manufactured over 50,000 aeroplanes, most of the engines for which were constructed in this country. The reliability of the aeroplane was demonstrated by the flight across the Atlantic, in 1919, of Sir Arthur Brown and Sir John Alcock. Soon afterwards, regular air services were introduced between London and Paris. Between the two world wars, much research and experimental work was undertaken, particularly by Air Commodore Sir Frank Whittle, on jet-propulsion gas turbines for aircraft, and in May, 1941, the first aeroplane fitted with such an engine made its first flight.

Probably the first working gas turbine was constructed by Armengaud and Lemale in Paris in 1904, and a second machine was constructed by Brown Boveri and Company in 1906. Thereafter, gas turbines were used merely as auxiliaries or as a convenient source of obtaining power from otherwise waste energy, and not as serious competitors for power generation. Serious consideration was again given to the subject about 1935, when many steam-turbine manufacturers began investigations. The war slowed up these developments, but, as a result of the progress made in the use of gas turbines for aircraft, manufacturers in this country and abroad turned their attention again to the possibility of building successful industrial gas turbines. A number of firms have built experimental gas-turbine units from which important data have been obtained. On the Continent, gas turbines for outputs up to 27,000 kW are in operation, and in this country machines for outputs up to 15,000 kW are nearing completion. During 1950, gas turbines were used as prime movers to drive a motor car, a motor launch and locomotives.

The first idea of wireless communication was suggested by James Bowman Lindsay, of Dundee, in 1845, who proposed to use the earth or sea as a conductor, but on account of the very weak electric currents involved and the lack of sufficiently sensitive apparatus to detect them, this means of communication made little progress. During the latter part of the Nineteenth Century, several British scientists conducted experimental research relating to radio-telegraphy, notably Clerk Maxwell, Sir Oliver Lodge, Professor D. E. Hughes and Admiral Sir Henry Jackson. It is, however, to Senator Marconi that we are indebted for his inventions in 1895, which made long-distance wireless telegraphy possible. He conducted his original experiments in Italy, and in 1896 came to England. By 1899 he had established wireless communication between England and France, and two years later had bridged the Atlantic. A regular transatlantic telegraph service was established during the next seven years.

Following on the success of the wireless telegraph, experiments were commenced almost immediately on the possibility of radio telephony. The most important inventions relating to this subject were, perhaps, the thermionic valve invented by Dr. J. A. Fleming in 1904, and the three-electrode tube invented by Dr. Lee de Forest in 1906. During 1914-1918, radio-telephony was used widely by the fighting forces, and valve techniques were developed rapidly to enable communication to be made with aircraft. By 1919, important experiments had been conducted by the Marconi Company and telephonic speech was established between the United States and Paris, and between Ireland and Canada. In the same year, experimental broadcasting transmissions were commenced in England, which culminated in the forming of the British Broadcasting Company in October, 1922, and the setting up of regional stations.

The first details of a method to transmit actual images was disclosed in 1880 by Carey, an American, but it was not until 1926 that the most successful proposal was described by John L. Baird. Baird used a scanning disc which carried two spirals of lenses, and the reflected light from the illuminated object was caused to affect a photo-electric cell. In 1929, the B.B.C. and the Baird Television Company commenced a public television broadcasting service from Alexandra Palace, London. It is expected that television broadcasting programmes will be available throughout the country by 1952.

During recent years, considerable attention has been directed to the work of the scientists investigating nuclear energy, and to the possibilities of adapting this new source of energy to commercial work. The beginning of this era goes back to 1789, when a German scientist, Martin Heinrich Klaproth, discovered a substance which he named uranium. Over 100 years elapsed before its peculiar properties were observed by Wilhelm Röntgen, who discovered X-rays, but it was not till 1896 that Becquerel identified the phenomena as radio-activity. The release of this information aroused interest in other scientists, notably Professor Curie and his wife Marie Curie, and G. C. Schmidt. These scientists, working independently, discovered radioactive properties in thorium, polonium and radium, and Debierne discovered, in 1899, actinium. Chiefly because of the work done by Lord Rutherford, we know that these substances are spontaneously disintegrating into a series of radioactive substances, each of which is of lower atomic weight than its parent element. Many other scientists contributed to our knowledge of radioactivity, but it is to Lord Rutherford that we are indebted for much of the pioneer work leading to the release of nuclear energy.

In 1942, the first atomic pile or nuclear reactor was put into operation in America and the first man-controlled release of atomic energy was achieved. During the war, considerable progress was made due to the concentration of scientific personnel, and the spending of sums of money which, in peace time, would have seemed enormous. Since 1945, atomic energy research establishments have been put into operation in this country; at Harwell, under the direction of Sir John Cockcroft, and at Sellafield under Sir Christopher Hinton.

And now 1951. We have seen the evolution of the steam turbine and its use on land and sea; the turbo-alternator for the generation of electricity; the distribution of electricity to factories and homes, and the manufacture of the thousands of miscellaneous electrical appliances; the internal-combustion engine and its use on land, sea and in the air; the telegraph service; the telephone; wireless broadcasting; television; the gas turbine; the motor car; the aeroplane and finally nuclear energy. But in addition to these outstanding developments there have been many thousands of inventions relating to almost every branch of industry, such as machine tools, the typewriter, calculating machines the gramophone, the bicycle, and the mechanisation of coal mining and agriculture.

There seems little doubt that a tendency in the future will be towards large-scale railway electrification where it can be carried out economically. This tendency may well be hastened by the application of nuclear energy, on a large scale to the production of electrical energy. The production of electrical energy from fissile material is, even in the light of our limited experience to-day, a practical possibility. With the prevailing costs of coal and petroleum, and of uranium or other fissile materials, it is doubtdul whether electricity could be produced, at the moment more economically than by well-established methods: yet it requires but a small improvement in the method of using the heat generated by fission to enable atomic energy to compete with present-day practice. To justify the high initial cost of an atomic energy plant the production of electrical energy by fission must be carried out on a large scale. Electrification of railways and other large-scale usage of electricity will automatically result.

For a long time now, I have advocated the rational usage of our greatest national asset—coal. It is unlikely that, in the future, our available supplies of coal will increase; on the contrary, they are likely to become less year by year. Economics will therefore force us to use coal more economically and I foresee high-pressure gas mains supplying heat to home or industry, the complete abolition of the open coal fire, the increased use of slow-combustion heating in homes, using coke or other residual fuels, gas turbines living up to their names and using gas, and the use of coke, gas or tar, and of course, high-ash coal residues for generating electricity in central power stations.

Work is now being undertaken in this country in burning methane, which occurs in small proportions in the large volumes of air used in mine ventilation and it may be that, in the future, by using a high degree of pre-heat prior to combustion, the miner's greatest enemy, firedamp, will be used for the benefit of man.

Without any doubt, in my opinion, the jet or gas turbine-cum-jet will be used to the exclusion of all other means of propulsion for all types of aircraft. This type of prime mover meets the requirements so admirably that it is difficult to see how any other form of power unit can compete. On land, the gas turbine is more sorely pressed by its competitors and I doubt if any prime mover other than the steam turbine will be used for very large powers. I do think, however, that the gas turbine will, to a great extent, supplant the Diesel engine. There is no difficulty in making gas turbine units of 100 h.p. which could easily be fitted to motor cars within the space now occupied by petrol or Diesel engines. The major remaining problem requiring solution to enable the gas turbine to take its place in our everyday life is that of a compact, low-cost and highly efficient regenerative heat exchanger. The consideration given to this problem during our present meetings is an indication of its importance and likely solution. Once a purely rotating prime mover has been found suitable for a given application, it always becomes possible to supplant an alternative reciprocating type, and there is little doubt that, within the next 50 years, the gas-turbine motor car will be used to the exclusion of all others.

Man's standards of living and comfort have increased only as he has made mechanical power his servant in increasing degree. Electricity provides the most convenient way of supplying that mechanical power, and, if the nations of the world are listed in the order of electricity consumption per head of population, the list will be found to coincide with the nations listed in the order of living standards. Incidentally, nations listed in the order of protein percentage in their daily diet gives again the same sequence. Inevitably, as nation after nation strives for improved standards of living and comfort, there must be a tremendous expansion in the use of electricity. A consumption per head in Great Britain of five times our present usage still would not produce demand saturation.

Large-scale use of electricity for pump-produced rain and for soil heating, as a means of combating in some degree the vagaries of weather, thus helping to solve our ever-growing food shortages, is certain to come. Supersonic-frequency electronically-produced vibrations will become an everyday thing in our industrial, domestic and medical life. The thermionic valve will become an increasingly integral part of our life between 1951 and 2051.

HEAT TRANSFER DURING CONDENSATION OF STEAM.*

By H. HAMPSON.

WHEN a pure vapour condenses on a clean cooled surface which it readily wets, a continuous film is formed and the shape and inclination of the surface determine the local thickness of the film and the rapidity with which the liquid in it is removed. The film retards the transfer of the heat of condensation to the cooled surface, and becomes a major factor in limiting the flow of heat to the cooling medium on the other side of the surface. With reasonable assumptions, Nusselt evolved a very satisfactory analysis of the properties of the film, and for condensation under these conditions his analysis is an accurate guide to the resistance to heat flow imposed by the film. Two of the assumptions he made were (i) that there was an isothermal surface behind the film, and (ii) the film flowed over the surface in a smooth viscous manner under the influence of gravity. Regarding assumption (i), due to the heating of the cooling liquid behind the surface, its temperature rise, in most cases, is reflected in the change of temperature of the surface at different positions; the effect of this is usually small, since it is customary to limit the temperature rise of the cooling fluid. Respecting assumption (ii), however, it is found that with long surfaces the film becomes turbulent—the criterion of the change is Reynolds number (4 × rate of mass flow per unit width of the stream ÷ absolute viscosity), and the heat flow per unit area, like the resistance to fluid flow, increases several-fold. Moreover, on vertical flat surfaces and tubes it has been found that ripples develop on the surface of the film when it has attained a given thickness—which is quite small—and it is found by most experimenters that, as a consequence of this surface disturbance, the heat transfer rate for the film given by Nusselt's analysis is increased by 20 per cent. It is interesting to note that a static film of sine-wave shape in transverse section, with a ratio of maximum to minimum thickness of 4 : 1, will give approximately this increase over that of a film of uniform thickness. As a practical condition, it is essential that both the surface and the condensing fluid shall remain chemically clean if a film is to be maintained continuously. The liquid may, of course, be capable of dissolving and removing all contaminants as it flows away, and thus maintain the required surface condition.

Nusselt neglected any temperature difference between the vapour and the surface of the film, which may be due to molecular movements across this interface; it has been suggested that this may be of importance at very low pressures, particularly on film surfaces which are not flat. There must be some thermal potential at the surface of the film, changing to accommodate the variation of heat flow. Experiments to clear up this point still leave the matter unsolved, since the measurement of the temperatures cannot be made directly. The effect is negligible for all practical purposes. The heat-transfer rate for the film will obviously depend on the film thickness, and this, in turn, will be affected by the amount of liquid in the film which has come from the higher parts of the surface, i.e., the length of the surface will materially affect the total heat flux. It is thus not possible to quote a value for the surface heat-transfer coefficient, except in relation to the physical conditions, the fluid concerned and the geometry of the surface; moreover, it will depend on the rate of condensation, that is, on the rate of heat flow. In this respect, film-wise condensation is distinctly different from the other mode, namely, drop-wise condensation.

A very different regime exists when the surface on which condensation is taking place is not wettable by the liquid. In the case of drop-wise condensation, the mechanism by which the liquid forms on the surface, and first becomes visible as minute droplets, is still obscure and is referred to later. The remaining part of the process is one of steady growth of the drops by the acquisition of more liquid, partly by condensation on the drop—a small proportion—and partly by coalescence. The pattern of the drops on an undisturbed surface shows a regular and almost uniform growth of the drops, their spacing is equally regular and symmetrical, with the exception that a few drops seem more acquisitive than others, become larger and thus grow quicker than the surrounding drops. Fig. 1, on page 221, shows the appearance of the surface during "ideal" drop-wise condensation; the largest drops are about 3 mm. in diameter. Coalescence is rapid, and can barely be followed by the eye or normal-speed cinema camera. The drop which touches and absorbs the surrounding drops quickly becomes large enough for the gravity force to overcome the cohesion between drop and surface, and the drop rolls down. One has only to watch a window pane in the rain to appreciate the subsequent history. Areas of the surface which have been denuded by coalescence or drops rolling down, are momentarily optically clear, but quickly become misted, due to the formation of minute droplets. The speed with which the process is repeated depends on the temperature difference between the vapour and the surface, and this determines the heat flow. It will be appreciated that it is across these spaces which appear to be free of drops that most of the heat transfer is taking place. The surface heat-transfer coefficient is independent of the heat flux for this type of condensation, but Gnam's experiments showed it to decrease uniformly with decrease of vapour pressure; this is still to be confirmed.

So far it has been assumed that a pure vapour is condensing on the surface. Any contaminant in the vapour, including a non-condensable gas, will eventually affect the mode of condensation. Unless precautions are taken, the usual mode is one which is intermediate between drop-wise and film-wise, and is described as "mixed" condensation. In practice, the purely drop-wise or film-wise modes of condensation are usually found to be transitory ones, and the customary mode is one of "mixed" condensation during which small irregular areas of liquid, resembling flattened drops, are separated by narrow lanes which appear to be free of liquid. When steam is the condensing vapour the surface heat-transfer coefficients for the film-wise or mixed modes will usually be found to be less than one-tenth that for the purely drop-wise condition. In view of this it is customary to design apparatus pessimistically for film-wise condensation. This also insures the designer against failure of the plant to perform its duty—but at an appreciably greater initial expense—if there is a possibility of an increased quantity of non-condensable gas over the design value.

The "ideal" drop-wise mode of condensation can only be obtained on a carefully prepared surface. Such surfaces and the processes taking place on them have always presented tantalising problems to the research worker. The great divergence of the properties of substances (particularly organic substances) in thin layers, compared with the bulk properties under otherwise similar conditions, has led to considerable disparities between the conclusions drawn from experimental work. Experiments with the condensation of a vapour on a metal wall require the maintenance of chemical uniformity of the surface and fluids involved. Nevertheless, the considerable reduction in the surface area required for a given duty—particularly when high heat flow rates are required—justifies the persistent exploration of the drop-wise process.

For drop-wise condensation to occur it is essential that the metal surface be contaminated by a promoter. The function of the promoter is to reduce the surface tension of the vapour-metal interface, while not reducing proportionately the tensions of the liquid-metal and liquid-vapour interfaces. It is essential that the promoter should be strongly adsorbed on the metal surface so that it is not easily torn away by the condensate as it rolls off. The most generally effective promoters are the fatty acids, in the majority of metal surfaces, but other promoters are more effective on specific metals and their alloys; they are typified by their strongly polar molecules. A typical promoter-metal combination which has been very successful is benzyl-mercaptan on copper or its alloys, and zirconium has been found to take up and retain the fatty-acid promoters more readily than other metals. It is almost impossible to prepare a metal surface without some oxidation taking place, but in the few cases where the surface has been prepared in a manner intended to prevent oxidation from the air, no perceptible difference in performance has been noticed with steam as the condensing medium. It is known that the layers of oxide will have different densities depending on the ambient conditions during formation, particularly if water vapour is present. The shorter duration of life of drop-wise condensation on a copper-plated surface after continued use and repolishing, may be accounted for by the different structures of the surface layers exposed. There is little direct knowledge of the influence of the solid surface or of the contaminating layers in this field in spite of the work of Bowden and co-workers on metal surfaces, and of Langmuir and Blodgett on contaminating films.

A large number of tests have been made at Queen Mary College, University of London, with a moderate degree of repeatibility, on metal surfaces prepared with emery paper in such a way as to leave abraded surfaces with different degrees of roughness, for comparison with surfaces polished mechanically and electrolytically. The general conclusion was that all abraded surfaces gave approximately the same duration of "life" of drop-wise condensation to a metal surface, but that this life was only a fraction (one-half to one-quarter) of the life of a mirror-polished surface. It was also found that previous polishing of copper or brass surfaces with magnesium powder to give complete wettability, before treatment with an oleic-acid promoter, gave a greater uniformity of life and the longest lives.

The maintenance of the ideal drop-wise condition, by injection of the oleic-acid promoter in a suitable solvent non-miscible with water, was possible but not invariably successful; injection of benzyl mercaptan was always successful on copper or brass surfaces, but in the experiments in which this substance was used there was a gradual reduction up to 10 or 15 per cent. in the surface heat-transfer coefficient over a period of 10 days. Xanthates and dithio-phosphates are effective, and the synthetic resins such as Bakelite and the silicones give drop-wise condensation, but have the disadvantage of low thermal conductance of the layer. In all cases, the admission of small quantities of air or nitrogen (up to 0·3 per cent. by weight) increased the duration for which a surface gave purely drop-wise condensation. It was found advantageous to inject a solvent of the promoter periodically in the early stages. This caused a very distinct but transitory change in appearance of the surface, and resulted in a temporary reduction in the heat flux. The effect was to repair those parts of the surface showing signs of breakdown to mixed condensation, but ultimately to cause earlier and more uniform breakdown of the surface. Figs. 1 to 4, on page 222, reproduced from four separate frames of a cinematograph film, illustrate the effect of an injection of solvent; while Fig. 5 shows the effect of an excess of the promoter.

With film-wise condensation, almost the whole temperature difference between the vapour and the solid surface is used for driving the heat through the condensate film; and this temperature difference must increase sufficiently to overcome the additional effect of increased film thickness as the heat flow increases. This means that the metal surface must be brought to temperatures which are much lower than the vapour temperature. On the other hand, with drop-wise condensation, the temperature of the metal surface cannot be uniform; it will be different under the drops compared with the spaces between them, the difference depending on the size of the drops. This temperature will fluctuate as the drops form or roll down, and a mean value must be defined with respect both to time and position (or area), in order to estimate the surface heat-transfer coefficient. Typical overall heat-transfer coefficients for the two modes and large heat flows are shown in Fig. 6, and the steam-side coefficients in Fig. 7. In Figs. 6, 7 and 8 the heat-transfer coefficients are given in B.Th.U. per hour, per sq. ft., per deg. F. units, and these figures refer to tests made on a vertical copper plate of conductivity K = 125 B.Th.U. per hour, per ft., per deg. F., and dimensions 5 in. high, 3 in. wide, and 0·252 in. thick. The cooling water entered at a temperature of 60 deg. to 68 deg. F., and flowed through a narrow passage behind the plate. The pressure on the steam side was in all cases atmospheric, and the steam approached the surface in a direction normal to it. The temperature of the metal surface used in calculating Fig. 7 was the mean for six positions, as found by putting the thermocouples in series.

When small quantities of a non-condensable gas are present in the vapour, the gas is carried to the cooled surface as a mixture, and must diffuse back from it in the reverse direction to the flow of the mixture. The increased partial pressure of the gas at the surface reduces the saturation temperature of the vapour, and there is a consequent reduction in the overall temperature drop across the film or drops. It follows that there will be a reduction in the heat-transfer coefficient. The magnitude of the reduction is dependent on the mode of condensation. For the film-wise mode the effect on the overall heat-transfer coefficient is small, since the additional resistance due to the diffusing gas is small compared with the resistance of the condensate film. For a heat load of 100,000 B.Th.U. per square foot per hour, the reduction in steam-side coefficient, for a 5-in. vertical surface, amounted to 33 per cent. for an addition of 2 per cent. by weight of nitrogen to the steam. With drop-wise condensation, the added resistance due to gas is relatively very high, and reduces the surface heat-transfer coefficient to one-sixth of the value for gas-free steam when 0·1 per cent. by weight of nitrogen is present. Fig. 8 shows the effect for a small experimental surface. Colburn and Hougen examined the effect analytically and experimentally in reference to the film-wise condition, and they devised a method for design which equated the heat carried to the cooled surface (by mass transfer of the vapour and sensible heat in the gas) to the heat passing through the film. The latter was calculable from Nusselt's expressions for any given geometry of the surface.

If γ_{sg}, γ_{lg} and γ_{sl} represent the interfacial tensions equivalent to the surface molecular forces at the solid-gas, liquid-gas and solid-liquid interfaces, the liquid will contract into drops if

$$Z = \gamma_{sg} - \gamma_{lg} - \gamma_{sl} < 1,$$

Z being the spreading coefficient.

Equilibrium will result if

$$Z = \gamma_{lg} (\cos \phi - 1).$$

The value of the contact angle in the case of conden-

* Paper read before Section G of the British Association at Edinburgh on Monday, August 13, 1951.

HEAT TRANSFER DURING CONDENSATION OF STEAM.

Fig. 1. Drop-wise Condensation Before Injection.

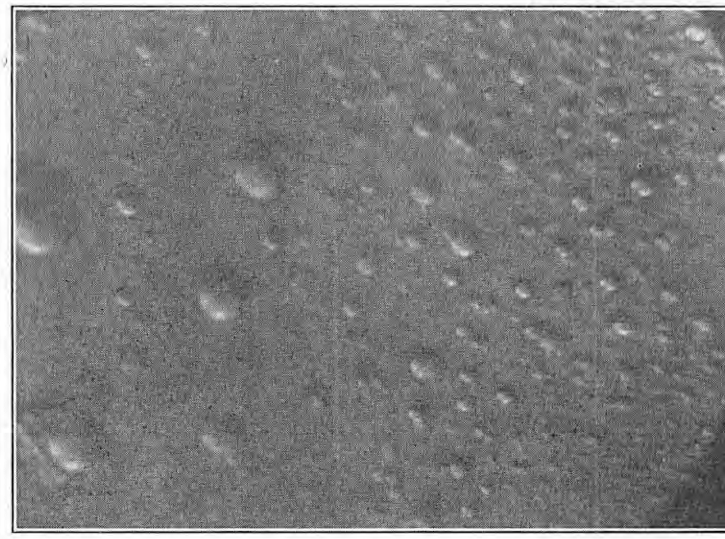


Fig. 2. Two Seconds After Injection.

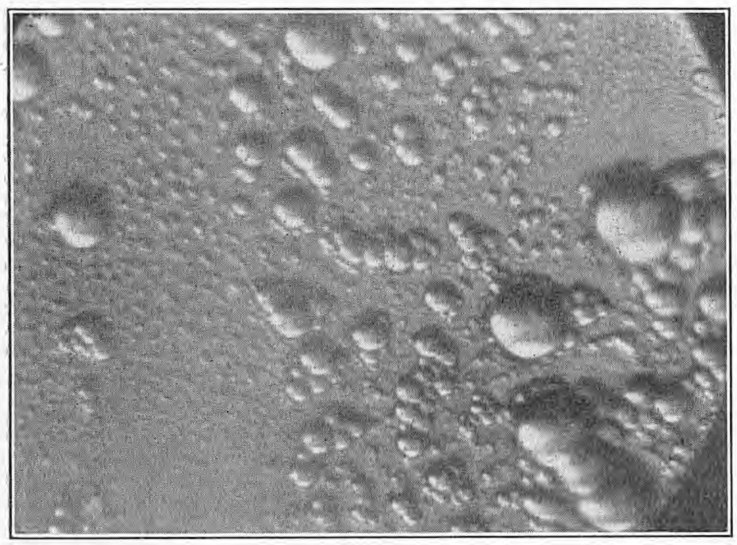


Fig. 3. Ten Seconds After Injection.

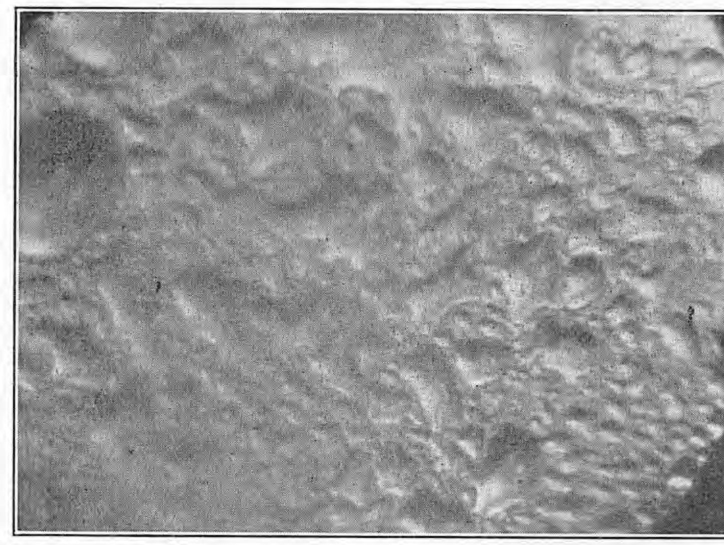


Fig. 4. Ten Minutes After Injection.

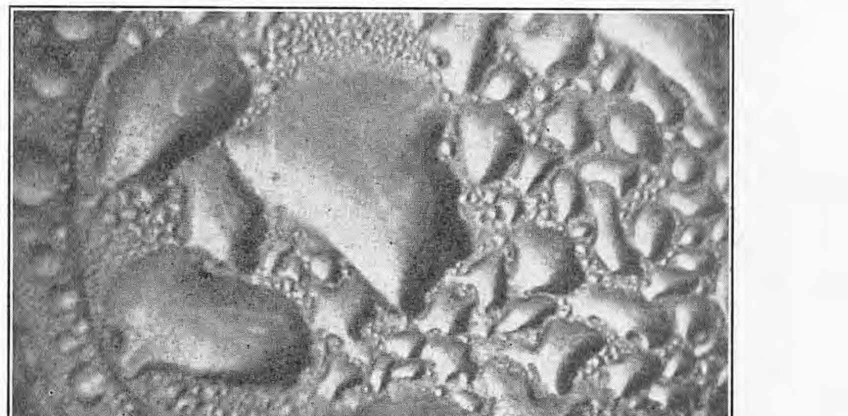


Fig. 5. Condensation With Excess of "Promoter."

sation depends on the promoter used. From experiments made at room temperature, it appears to be independent of the metal; the latter only determines the duration of dropwise condensation after treatment with the promoter, since the bond between the metal and promoter occurs by the replacement of the hydrogen in the carboxyl group by the metal.

It may be assumed that the smallest drops result from the break-up of a film, which forms from the contact of minute droplets, growing on the nuclei at the ends of the crystallites of metallic oxide on the plate surface. The whole surface will in turn be covered by one or two monolayers of the metallic soap or other promoter, just sufficient, in the case of ideal dropwise condensation, to cover completely the interstices between the prominent corners and edges of these crystallites. It is suggested that droplets touch almost simultaneously, and coalesce into an unstable film, which immediately breaks up into the drops of smallest size so far seen on the plate. Jakob estimated that the unstable continuous layer of liquid formed is about 0·001 mm. in thickness, and if this breaks uniformly, into drops having a contact angle with the plate of 90 deg., the resulting drop size will be about 0·012 mm. in diameter. This is very nearly the minimum size of drop which can be resolved photographically at a magnification of 40 diameters, according to Gnam.

It will be appreciated that due to the transient nature of the heat flow through the drops, it is not possible to calculate exactly the amount of heat passing through the drops at any moment. If it is assumed, however, that there is a steady flow condition through the drops, an estimate of this part of the total heat flux can be made. It is necessary to include the metal plate as part of the heat-flow path, as otherwise there would be an infinite rate at the edge of the drop; the plate, therefore, has been taken as equivalent to a sheet of water, of proportionately smaller thickness in the ratio of the thermal conductivities of the plate and water. The surface of the drop presented to the steam was taken as one isothermal surface, and the back of the plate as the other. It was then possible to calculate, by relaxation methods, the heat flow through the drop in terms of the overall temperature difference, the thermal conductivity of the water and the relative thickness of the plate. The result is given in Fig. 9, and for the specific case of a $\frac{1}{8}$-in. thick copper plate, in Fig. 10. From cinematograph photographs of the surface, the distribution by size of the drops over a typical area of the surface (an average value for 32 succeeding frames) was found to vary very little with heat load and is shown in Fig. 11. The ordinate of this figure is the derivative of area covered to drop size, so that the area under the curve represents the area covered by countable drops, that is, down to 0·005 in. diameter; this was found to be 55 per cent. of the whole area.

The heat transfer rate through all drops between sizes a and b is thus given by

$$Q = \frac{4}{\pi} K \Delta \theta \int_a^b \phi_1 (D) \frac{\phi_2 (D)}{D} dD.$$

where ϕ_1 (D) ΔD is the fractional area covered by

HEAT TRANSFER DURING CONDENSATION OF STEAM.

Fig. 6.

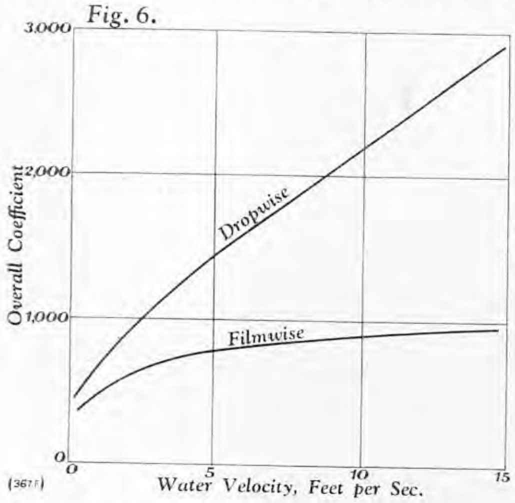


Fig. 7.

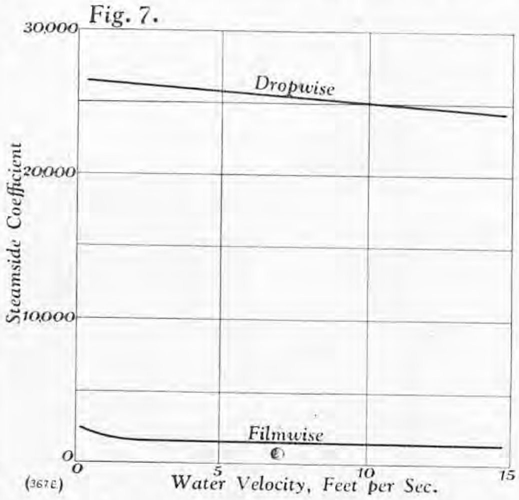


Fig. 8.

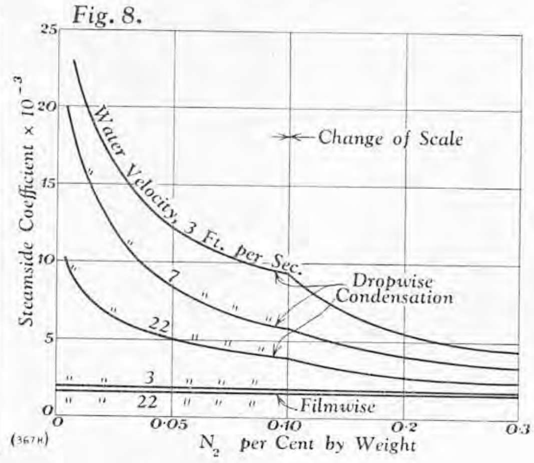


Fig. 9.

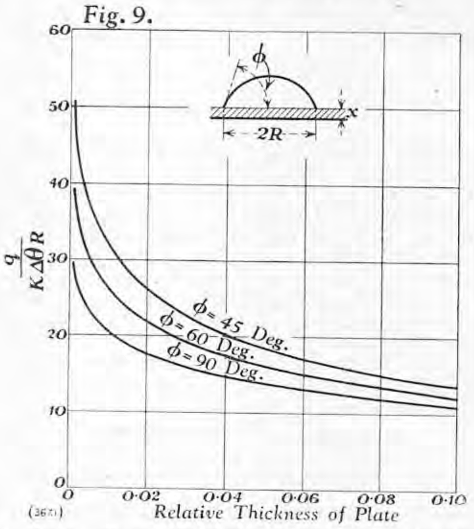


Fig. 10.

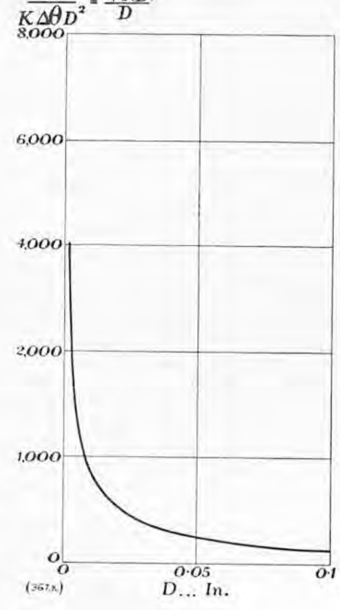


Fig. 11.

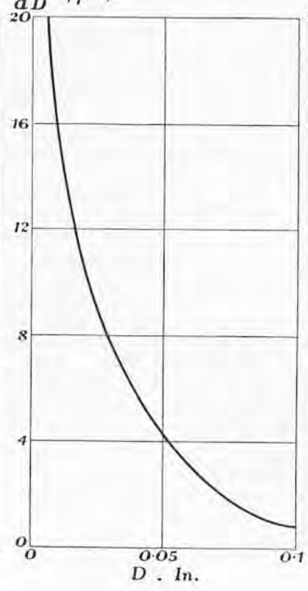
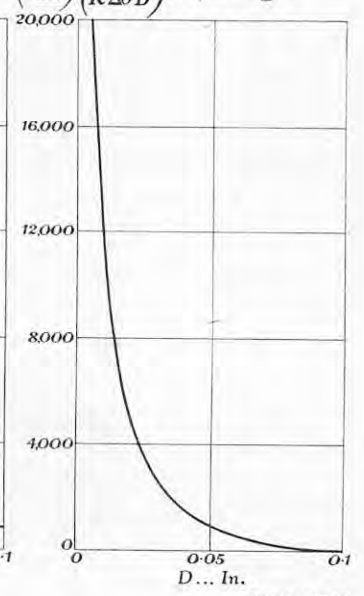


Fig. 12.



"ENGINEERING"

drops having diameters between D and D + ΔD plotted in Fig. 11, and ϕ_2 (D) is $\frac{q}{K \Delta \theta D}$ plotted in Fig. 10. $\Delta\theta$ is the temperature difference between the isothermal surfaces, q is the heat-transfer rate through each drop of size D, and K is the thermal conductivity of water. When the expression

$$\frac{4}{\pi} K \Delta \theta \phi_1 (D) \frac{\phi_2 (D)}{D} dD.$$

is plotted against the drop size, the area under the curve gives the heat transferred through all drops countable. This is given in Fig. 12 for the same typical case as for Figs. 10 and 11, and was found to be only 15 per cent. of the total heat transfer.

It now remains to estimate how the rest of the heat passing through the whole surface is transferred. The equivalent conditions of the remaining surface can only be a matter of conjecture as discussed above; but the assumption that it was entirely free of drops gave the closest estimate to the experimental value. This would indicate that the thermal resistance of whatever film exists between the drops must be very small indeed. An alternative assumption that the drop size distribution would produce a straight line between D = 0·005 and D = 0, giving the area of surface unaccounted for under drops, would give a rather lower value of surface heat-transfer coefficient than was found experimentally. In view of the transient nature of the phenomenon, the correlation is good. Experiments are now being made, with reduced heat flux and increased cyclic time of drop formation, in order to find the consistency of the drop distribution, and to check the correlation between calculated and experimental values of the heat-transfer coefficient.

IDLER SUPPORT FOR CONVEYOR BELTING.—Messrs. Richard Sutcliffe, Limited, Universal Works, Horbury, Wakefield, have introduced a novel idler support for conveyor belting, known as the "hammock" idler. The single roller is a rubber tube, which runs on bearings at the ends and the tension in which can be adjusted to suit the material being conveyed. The idler has been designed to lengthen the life of rubber belting and to give an efficiency greater than that of standard idlers with three or five pulleys. It enables the belt to adopt its natural curve, spillage is decreased, and the load is kept to the middle of the belt.

PLASTIC-SHEATH TELEPHONE CABLES IN DENMARK.

A NEW all-plastic type of carrier-frequency multi-quad underground cable is being laid by the Copenhagen Telephone Company as part of a large scheme of expansion of the Company's communications system. Two cables, one for each direction of transmission, have been developed and manufactured by the Telegraph Construction and Maintenance Company, Limited, at their Telcon Works, Greenwich. The cables are insulated and sheathed with Telcothene—a tough and flexible synthetic thermoplastic based on polythene, which is unaffected by water—and are designed to provide 48 speech channels per pair in a frequency band from 12 kc. to 204 kc., giving a total of 1,152 circuits for the two 12-quad cables. Further experimental work is in progress on the use of carrier-type Telcothene cables and it is evident that a target of 60 speech channels per pair will be achieved, thus giving some 1,440 circuits using two 12-quad cables.

Conductors 0·040 in. in diameter and weighing 25 lb. per mile, were chosen instead of the usual 0·050 in. (40 lb. per mile) as the distance necessitates an intermediate repeater. To minimise crosstalk, a high degree of balance is required; this is obtained partly by careful manufacture, needed especially for the smaller size, and partly by special balancing in the field. Each copper conductor is insulated by an extrusion of Telcothene to a diameter of 0·102 in., opposite cores in any one quad being coloured similarly for identification of pairs. Four cores are laid up round a separately-extruded Telcothene cord to form the quads, which are left unfilled so that there are air spaces in the interstices. Different suitable lengths of lay are used for each quad. Twelve quads are laid up, three in an inner layer and nine in an outer layer, and bound together with a thin Telcothene tape. Over this is extruded a tubular Telcothene sheath, 0·065 in. in radial thickness, which is applied sufficiently tightly to lock the quads lightly into position to ensure, during subsequent processing and laying, the stability essential with a high-grade balance. A screen of thin copper tapes is lapped over the sheath and is protected by alternate layers of compound and bitumenised paper tape.

For laying in a trench, the cable is served with compounded jute, armoured with two steel tapes each 0·030 in. thick, and finished with two compounded hessian tapes. The overall diameter is about 1·63 in. and the weight is 4 tons per mile. For drawing into ducts, the cable is finished with an outer sheath of polyvinyl chloride, 0·10 in. in radial thickness, extruded directly over the copper-tape screen; the overall diameter is then about 1·35 in. and the weight 2·2 tons per mile.

The dielectric constant of Telcothene being 2·3, the capacitance and low-frequency attenuation of these cables are greater than for the normal paper-insulated type; but, because of the low power-factor, the attentuation rises more slowly with frequency, so that, at 200 kc., it is no greater than for paper-insulated cable with the same size of conductor. For 60 db. attenuation, maximum repeater spacing with 25-lb. conductors is about 12 miles for 48-channel working; with 40-lb. conductors, it is about 16 miles for 48-channel working, or 14 miles for 60-channel working. The dielectric losses at high frequencies being almost negligible, it will be possible, as development proceeds, to operate a larger number of communication channels per pair of wires than with any other known cable. The light weight of the cables greatly facilitates installation; it is stated that two lengths of 250 m. each were pulled into the trench in half an hour, the maximum tension being only about 400 lb., a fraction of what the cable will stand without harm. It can be laid, therefore, in about one-fifth of the time required to lay lead-covered paper-insulated cable of the same size under similar conditions.

A method of jointing by injection moulding has been developed, suitable for use in the field, the heat required being supplied by current from a 2-kW generator driven by a petrol engine. A butt joint is made between the conductors in a small electric welder, using fluxless solder, after which the insulation joint is made in each quad as a whole. A quad is placed in a small mould, which is then heated internally by warm gas, a Telcothene charge being heated in an injector at the same time. When correct temperatures have been attained, the injector is placed over the injection hole of the mould and its piston is released. Immediately Telcothene is seen to emerge from the spew holes, cold air is blown on to the mould to hasten cooling; the mould is then opened and the completed quad joint removed. All quads having been jointed and laid into position, a Telcothene tube, previously slipped over the cable sheath, is slid back into place. By similar technique, using a ring mould, the tube is welded to the sheath on each side of the joint, after which the screen, armour, etc., are replaced and made good. Joints can be blocked by injecting compound into the Telcothene tube.

Fault liability with these cables is low, but should mechanical damage cause penetration of the sheath without damaging the insulated conductors, circuit continuity is maintained, though any ingress of water would reduce the carrier frequency facilities until a repair could be made. Wet cable can be dried in the usual manner by the passage of dry gas. To enable sheath faults to be detected and located, bare copper wires have been included in the cable to provide an insulation guard circuit, operating an automatic alarm. The cables have been designed to permit, if desired, the feeding of power through them to intermediate repeater stations. Equipment is being supplied by Messrs. Philips' Telecommunication Industries, of Holland.

TRADE PUBLICATIONS.

Belting.—We have received from Gandy, Ltd., Wheatland Works, Seacombe, Wallasey, Cheshire, a catalogue and price list of their hair, cotton, balata, leather, rubber and conveyor belting and accessories, brake-lining materials, etc. The catalogue includes some notes on the design of belting.

Maintenance of Carbon Brushes.—A pamphlet published by the Morgan Crucible Co., Ltd., Battersea Church-road, London, S.W.1, deals informatively with the precautions which should be taken in order that the carbon brushes used on the commutators of electrical machines should operate satisfactorily.

Speed-Reduction Mechanism.—Sanderson Brothers and Newbould, Ltd., Attercliffe Steelworks, Sheffield, have issued an illustrated catalogue describing the principles and constructional details of their Heliocentric speed reducer, which gives single-stage reduction ratios between 20 to 1 and 80 to 1. Tables of dimensions are given and various applications are illustrated.

Metalclad Oil Switches.—Messrs. Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2, have sent us particulars of two metalclad oil switches, one of which is intended for use as a feeder isolator and the other as a ring main unit. Both are designed to carry a load current of 400 amperes at 6·6 kV or 11 kV and have a rupturing capacity of 250 MVA.

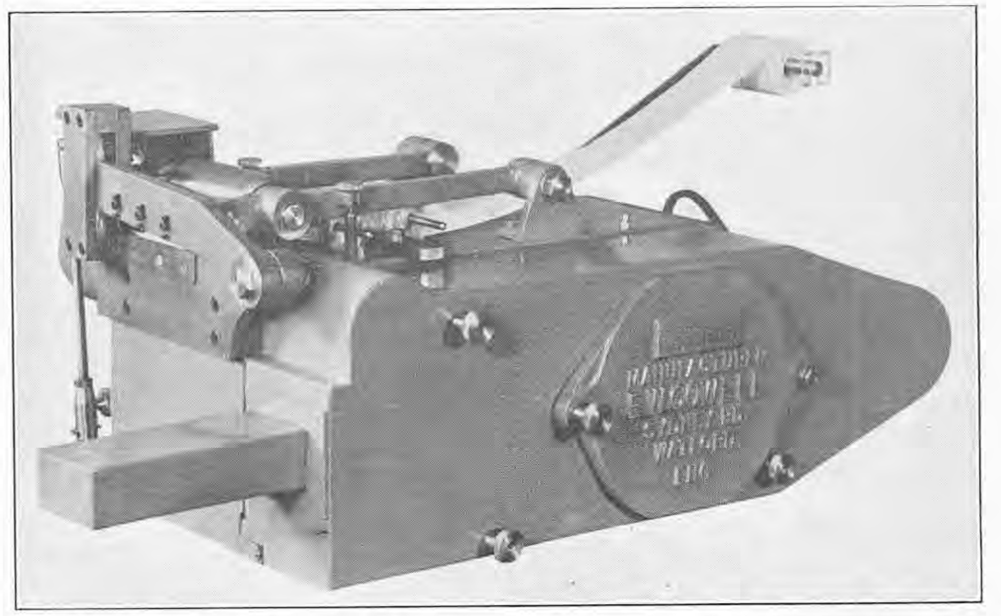
Crushing, Grinding, Screening and Mixing Machinery.—The Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, have issued a well-illustrated booklet giving particulars of their jaw crushers, rotary crushers, crushing rolls, grinding mills, vibrating screens, centrifugal air separators, batch mixers and blenders, dust filters, etc.

Spline-Hobbing Machine.—We have received a leaflet from David Brown Machine Tools, Ltd., Britannia Works, Sherborne-street, Manchester, 3, describing the construction and giving particulars of the David Brown-Muir MT-V spline-hobbing machine, which can accommodate spline shafts up to 35 in. long. It can be used also for cutting spur gears up to 15 in. in diameter and 45-deg. helical gears up to 10 in. in diameter.

Rotary Pumps.—We have received from Drysdale & Co., Ltd., Yoker, Glasgow, W.4, an illustrated brochure giving particulars and describing the operating principles of their rotary vacuum pumps for the paper, textile, chemical and food industries, their air and water extraction pump for use with paper-making machinery, and their air and condensate extraction pump for removing vapour and water from vacuum-return steam systems.

Centrifugal and Axial-Flow Fans.—The Airscrew Co. and Jicwood, Ltd., Weybridge, Surrey, have issued two booklets, one of which gives particulars of centrifugal paddle-blade fans for handling air containing dust, fumes or other impurities; they are manufactured in capacities ranging from 500 cub. ft. to 40,000 cub. ft. of air per minute. The other booklet, on axial-flow fans, includes specifications and performance data, and notes on the construction, selection, inspection and testing of fans.

AUTOMATIC SHEARING MACHINE.



AUTOMATIC SHEARING MACHINE.

THE accompanying illustration shows an automatic shearing machine developed by Mr. E. W. Cowell, 7A, Sydney-road, Watford, Hertfordshire, for cutting strip material, such as belts, wire, tape, rubber, gummed paper strips, etc., into pieces of a predetermined length. The strip, or strips, to be cut is fed through a pair of intermittently-rotating feed rollers; the amount through which the rollers rotate can be regulated, and thereby the length of the strip which is fed through them can be adjusted within a range of 0 to 24 in., 0 to 12 in., or 0 to $1\frac{1}{2}$ in., depending on the type of machine, which is made in three versions, Series A, Series B, and Series C. In all machines, the maximum width of strip which can be accommodated is 4 in. At the end of the intermittent movement of the feed rollers, shears cut the material, and while the shears return to the open position, the feed rollers rotate again, after which the cycle is repeated.

The machine can be supplied for operating from a direct-current, single-phase or three-phase alternating-current supply. An electric motor drives, through a belt and reduction gearing, a crankshaft on one end of which is a crank disc. A crankpin is mounted in a slideway on the crank disc in such a way that the throw of the crankpin can be adjusted to any value within the limits set by the slideway; a graduated scale is provided to indicate the throw. In Series A and B machines, the crankpin drives, through a connecting rod, a steel bar reciprocating in a slideway. On the upper edge of the steel bar are cut rack teeth which engage with a pinion attached to a roller clutch, which transmits the drive in one direction only to the feed rollers, geared together, through which the work is fed. During one half-revolution of the crankshaft, therefore, the rollers are rotated by an amount determined by the throw of the crankpin; during the second half-revolution the rollers are stationary. The maximum stroke of the rack is 6 in.; the pitch diameter of the pinion being half the diameter of the feed rollers, this gives a maximum length of strip feed of 12 in. in one crankshaft revolution.

The cutters can be supplied in any form suitable for the material to be cut; ordinary shears are used for flat materials. On the Series A machine, the cutters are operated, through a coupling rod and a tappet lever, by a cam on a shaft driven through gearing from the crankshaft at half crankshaft speed. The camshaft carries two cams, one with a single lobe and one with two lobes, either of which may be engaged with the tappet lever. With the double-lobed cam in action, the two lobes engage with the tappet lever alternately so that one cut takes place at every half-revolution of the camshaft, i.e., at every revolution of the crankshaft, thus giving a maximum strip length of 12 in. at a rate of 6,600 cuts per hour. With the single-lobed cam engaged, one cut will occur during every two revolutions of the crankshaft and, therefore, the length of strip cut is twice that obtained when using the double-lobed cam; a maximum strip length of 24 in. is possible, at a rate of 3,300 cuts per hour. In the Series B machine, the cutters are operated by a single-lobed cam mounted directly on the crankshaft, giving a maximum length of cut of 12 in. at a rate of 6,600 cuts per hour.

In the Series C machine, the rack and pinion are eliminated; the crankpin is connected by a rod to the lower end of a lever attached to the driving side of the clutch and swinging through a maximum arc of 60 deg. The maximum feed length in this case is limited to approximately $1\frac{1}{2}$ in., but the machine can be driven at a considerably higher speed, giving a maximum cutting rate of 20,000 cuts per hour per strip. It is interesting to note that the prototype shearing machine, which was of the Series C type, is used by de Havilland Propellers, Limited, for producing the $\frac{1}{8}$-in. pellets, from several strips of synthetic rubber material, for filling the leading-edge and trailing-edge cavities of hollow steel propeller blades, as described on page 194.

BOOKS RECEIVED.

British Iron and Steel Federation. Statistical Year Book for 1950. Part I. *Statistics of the Iron and Steel Industry of the United Kingdom for* 1950. [Price 7s. 6d.] *Statistical Year Book for* 1949. Part II. *Statistics of the Iron and Steel Industries of Overseas Countries for* 1949. [Price 15s.] Offices of the Federation, Steel House, Tothill-street, London, S.W.1.

Commonwealth of Australia. Second Annual Report of the Commonwealth Scientific and Industrial Research Organization for the Year Ending 30th June, 1950. L. F. Johnston, Commonwealth Government Printer, Canberra, Australia. [Price 9s.]

Union of South Africa. Electricity Supply Commission. Twenty-Eighth Annual Report of the Electricity Supply Commission for the Year ended 31st December, 1950, *with a Brief Review of its Activities up to 30th April*, 1951. Offices of the Commission, Escom House, Rissik-street, Johannesburg, South Africa.

United States National Bureau of Standards. Circular No. 509. *Bibliography of Books and Published Reports on Gas Turbines, Jet Propulsion, and Rocket Power Plants.* By ERNEST F. FIOCK and CARL HALPERN. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 20 cents.]

Principles and Methods of Sheet-Metal Fabricating. By PROFESSOR GEORGE SACHS. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 10 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 80s. net.]

Metal Processing. By PROFESSOR ORLAN WILLIAM BOSTON. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7·50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 60s. net.]

Differential Equations. By PROFESSOR H. B. PHILLIPS. Third revised edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 3 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 24s. net.]

Motion and Time Study. By PROFESSOR MARVIN E. MUNDEL. Prentice-Hall, Incorporated, 70, Fifth-avenue, New York, U.S.A. [Price 4 dols.]; and George Allen and Unwin, Limited, 40, Museum-street, London, W.C.1. [Price 40s. net.]