

THE DOWLAIS FOUNDRY OF GUEST KEEN BALDWIN'S IRON & STEEL CO., LTD.

On July 7, on the occasion of the re-opening of the Guest Memorial Hall, originally built at Dowlais, Glamorgan, in memory of Sir Josiah John Guest, who died in 1852, a visit of inspection was made to the foundry of Guest Keen Baldwins Iron and Steel Company Limited, at Dowlais. The Hall, it may be added, used to be a workmen's institute and library, but since its return to the company by the military authorities after the late war, it has been reconditioned and rehabilitated as a social institute for the company's employees and their families. The foundry, in what is now known as the Ivor Works, Dowlais, is in process of being rebuilt and re-equipped; it is on the site of the Dowlais Works of the Guest Keen Baldwins Iron and Steel

company's main production, continued at Dowlais after the removal of the blast-furnaces and the steel melting shop and rolling mills to Cardiff, and descendants of the firm's original iron puddlers of nearly 200 years ago are still employed. The modernisation and extension scheme at the firm's iron foundry in the Ivor Works, at Dowlais, was deferred by the war of 1939-45, and latterly by the initiation, by the company, of the Margam development of the Steel Company of Wales, Limited. The scheme, however, is now in process of completion at a cost of some 250,000/. The works have a total area of 40 acres and all existing shops and structures no longer required have been, or are being, demolished and the ground cleared. The iron foundry occupies an area of 38,250 sq. ft., and its equipment comprises five cupolas and the associated sand-preparation, mechanical ramming and sand-slinging equipment, giving a weekly capacity of some 450 to 500 tons of castings. Four of the cupolas

is fitted with a bucket having a capacity of 18½ cub. ft. The bucket is hoisted between two vertical channels by means of an electric winch mounted on a low platform. The ascent, tipping and descent of the skip are fully automatic and are controlled by a time-delay system which comes into operation when the furnaceman pushes the starter button after charging the bucket. The spark arrester is of the Incandescent Company's dry type and consists of an expansion chamber fitted to an extension of the cupola stack. The dust which collects in the arrester is taken to ground level by the two down pipes fitted to each side, which can be seen in Fig. 2.

The foundry shop floor is served by seven electric overhead cranes having capacities of up to 40 tons. A sand-preparation plant, capable of dealing with 8 to 10 tons of sand per hour, has been installed by Augusts Limited, Halifax. The foundry knock-out sand is collected on an underground

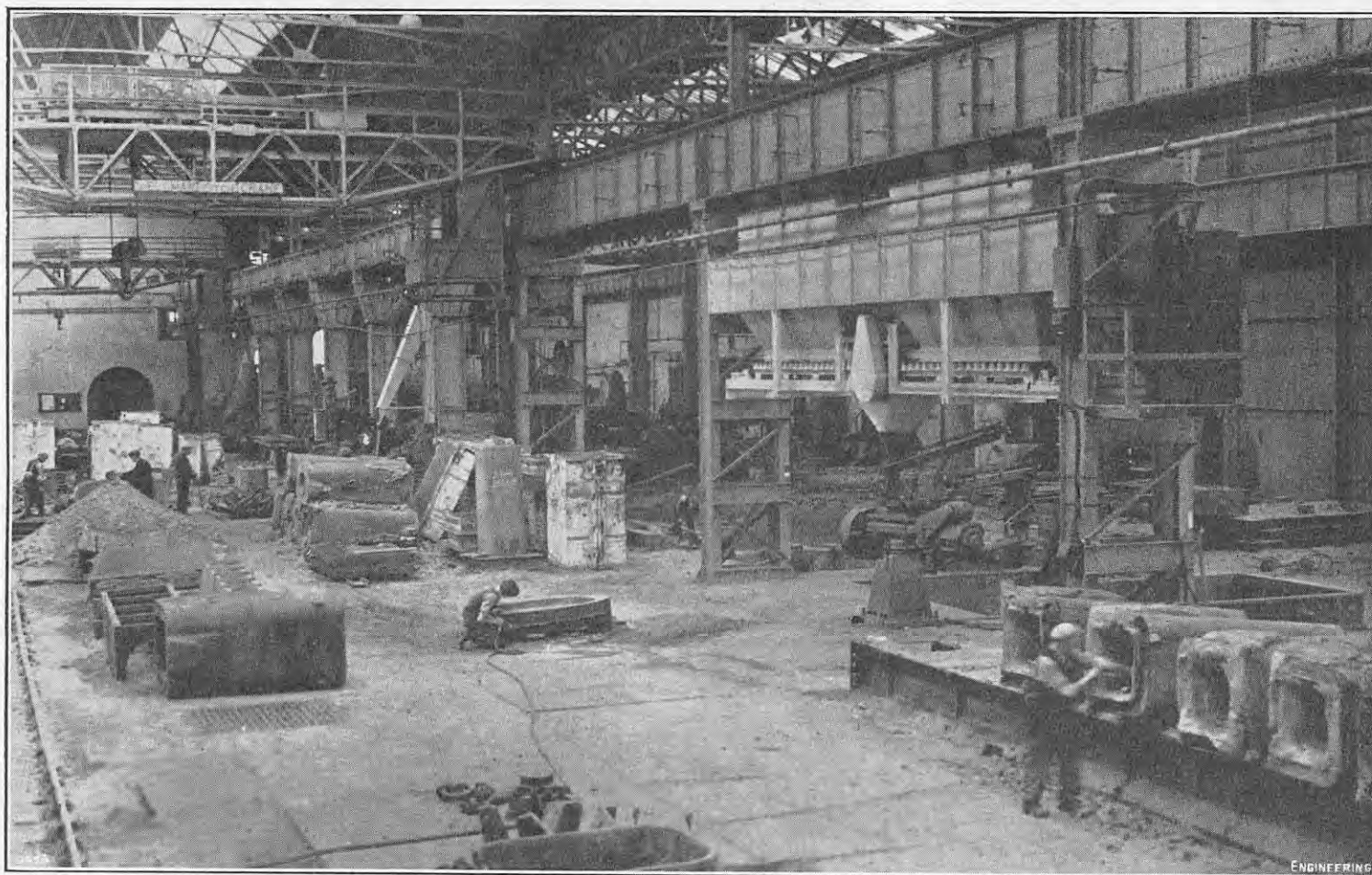


FIG. 1. GENERAL VIEW OF IRON FOUNDRY.

Company, first opened in 1759 for producing puddled iron, and in which some of the early developments in the iron and steel industry were perfected. In the first half of the Nineteenth Century, the Dowlais works was probably one of the largest iron and steel plants in the world and employed some 10,000 operatives. After the working out of the local iron-ore deposits, however, ore was imported from Spain in large quantities, and during the latter half of the Nineteenth Century, although business continued to expand, the company's technical advantages were gradually being offset by the uneconomic haulage of the ore from the Bristol Channel ports, and the return to those ports of its finished products for shipment to overseas markets. Finally, since 1935, when the company's new integrated iron and steel works were completed on a seaboard site at East Moors, Cardiff, the main operations of iron and steel manufacture have been conducted there.

The iron foundry operations, however, which had always been carried on side by side with the

have been in service for some time, but have now been reconditioned.

The fifth cupola is shown in Fig. 2, on page 34. With the exception of a superimposed spark arrester, this is of Whiting design and has been built by the Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, the manufacturing representatives of the Whiting Corporation of New York in this country. The height of the cupola from the floor to the base plate is 6 ft., from the floor to the charging sill 28 ft., to the top of the cupola 46 ft., and to the top of the spark arrester, 62 ft. The diameter of the shell is 75 in. and that of lined interior 48 in. up to the charging sill, and 63 in. above this; the lining is made of high-grade Stourbridge refractory. The melting rate is between 6 and 7 tons per hour. The cupola is fitted with eight 7½ in. by 12 in. flared rectangular tuyeres, designed to give an even blast distribution to the melting zone. Rigid cast-iron drop-bottom doors are fitted to the mild-steel base of the cupola, supported by four rolled-steel joists. The skip hoist

conveyor and transferred to the sand-plant bunker. The prepared sand is delivered throughout the length of the foundry on a conveyor and is "ploughed off" into a number of bunkers as required. Three sand slingers, supplied by Foundry Plant and Machinery, Limited, Glasgow, have been installed, together with pneumatic rammers. The largest of the sand slingers is shown in Fig. 3, on page 34. The total radius of the machine's ramming arm, which is in three parts, is 20 ft. Special slip rings are fitted on the main column for the electrical connections, so that the arm can rotate freely through 360 deg. A 25-h.p. motor, fitted on the front section of the arm, drives the sand impeller, giving an output of from 700 to 900 lb. of sand rammed per minute. All the electric motors fitted on the machine are of special light-weight type so as to minimise the effort required of the operator. Fully automatic switch-gear is provided so that all motors are controlled by push buttons on the head of the sand slinger. Other moulding-shop foundry equipment installed

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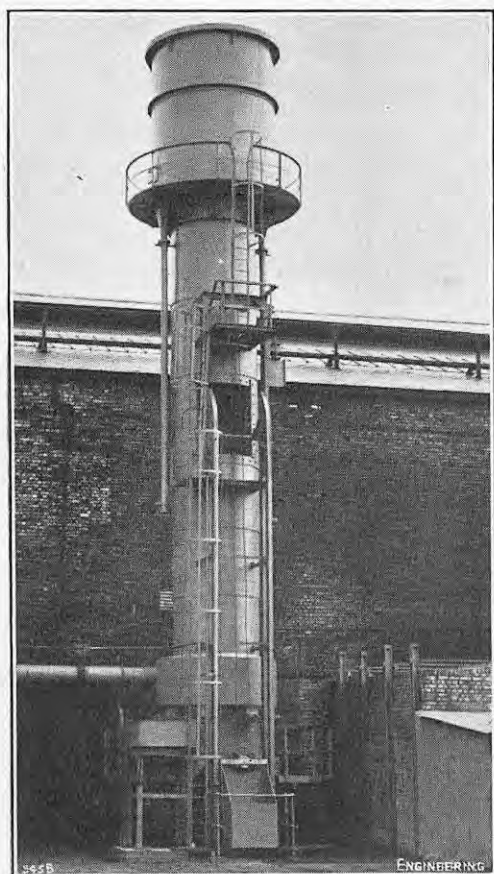


FIG. 2. WHITING CUPOLA.

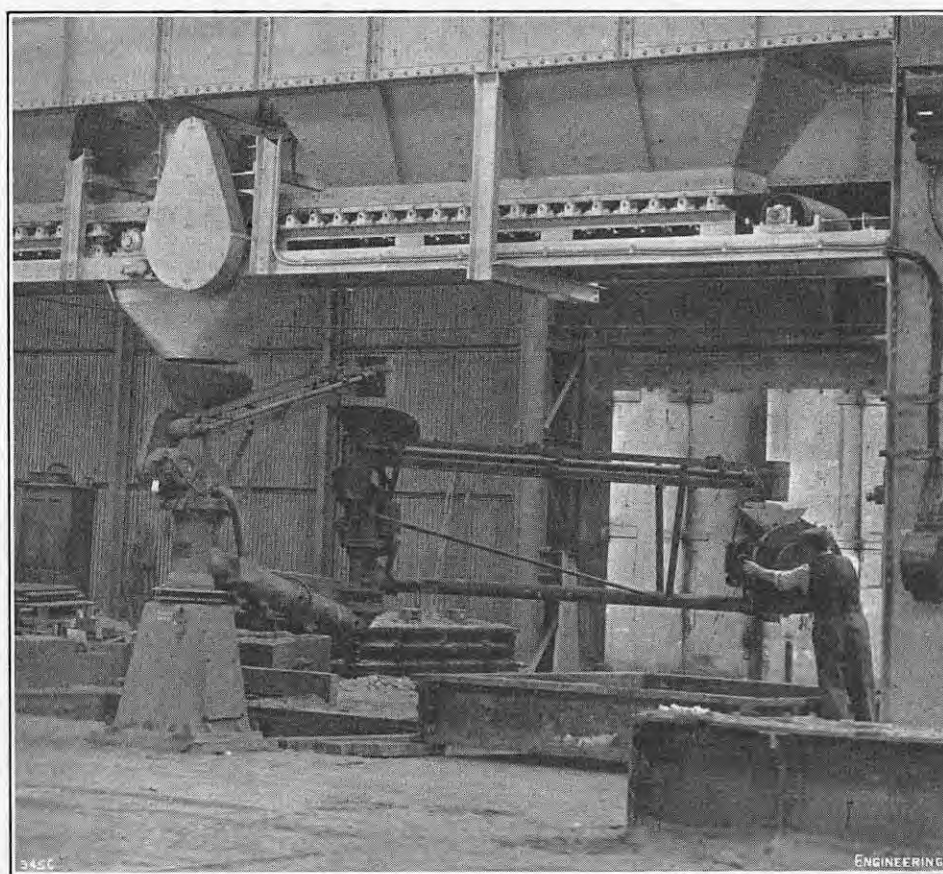


FIG. 3. SAND SLINGER.

includes a 10-cwt. sand-oil mixer supplied by the Fordath Engineering Company, Limited, West Bromwich. The core and mould drying stoves are fitted with automatic temperature control.

Adjoining the iron foundry is a brass foundry which has an area of 12,600 sq. ft. It is equipped, at present, with three oil-fired metal-melting furnaces ranging in capacity from 200 lb. to 600 lb., and giving a weekly output of 5,000 lb. New equipment shortly to be installed, however, will enable a production of 10,000 lb. a week to be achieved. The shop is served by one three-ton electric overhead crane; and a drying stove, fitted with automatic temperature control, and pneumatic ramming equipment are provided.

The Dowlais iron foundry, for many years, has produced 4-ton, 10-ton and larger ingot moulds and other high-grade iron castings for the use of the Guest Keen Baldwins Company and their associates. The foundry is equipped to undertake jobbing castings from a few pounds in weight up to 20 tons and, in addition to the iron and steel trade, it serves the textile-machinery, machine-tool and weighing-machine manufacturing industries. Special moulding-box work is undertaken for the tube industry, and intricate castings for annealing furnaces for the non-ferrous metal industries are also executed. Both open and covered sand castings are made and can be supplied in either hematite or composite iron grades, according to requirements. In addition to ingot moulds and other articles already mentioned, iron castings produced at Dowlais include slag-ladle pots of up to 12 tons capacity; port-end chills for steel melting-shop tilting furnaces; hydraulic rams, cylinders, and pipes of up to 24 in. in diameter; steam valves; brackets and pedestals; brake drums and hoist drums, and flywheels up to 10 tons in weight. The brass foundry produces phosphor-bronze sleeves and bearings, locomotive brasses, worm-wheel blanks, electric collector shoes, glands for hydraulic machines, hydraulic rams, copper

tuyeres for blast furnaces, and other equipment. The drawing office, pattern shops and machine shops are equipped to deal comprehensively with clients' requirements; it is claimed, in fact, that from a rough sketch of a piece of equipment needed, a finished article can be produced without recourse to other establishments or technical advice. The Ivor works include also a colliery-arch bending plant for the fabrication of wide-radius arches and the reconditioning of damaged and distorted pit arches.

"NEW LABORATORIES AT KING'S COLLEGE, UNIVERSITY OF LONDON." ERRATA.—Our attention has been drawn to two errors, which we regret, in the above article on pages 23 and 24, *ante*. The name of the architect is the late Mr. S. J. B. Stanton; and Professor J. T. Randall's reference (in the concluding paragraph) was to the physics laboratories, not the engineering laboratories, of King's College as being "considerably older than those of the University of Oxford."

BICYCLE FACTORY FOR INDIA.—A bicycle factory associated with Raleigh Industries, Ltd., Nottingham, was opened near Ansansol, West Bengal, on June 21, by the Indian Deputy Minister for Commerce and Industry, Mr. D. P. Karmarkar. The factory has been built for Sen-Raleigh Industries of India, Ltd., and has a floor area of 125,000 sq. ft.; the design is based on that of the Raleigh plant at Nottingham. The initial capacity of the new factory is 100,000 machines annually, and is to be increased in due course to 200,000; the potential demand for bicycles in India is estimated at 500,000 machines a year.

TUBE RAILWAY CARS WITH SHUNTING CONTROL EQUIPMENT.—A new type of car, which is fitted with simplified driver's control equipment, is being introduced on London Transport's Northern and Bakerloo lines. This will enable one cab on each three- and four-car unit to be eliminated, thus giving increased passenger accommodation and reducing the station stop time. The equipment is housed in a cabinet let into the end panel of the car and is sufficient for all normal shunting movements. The cabinet also contains an automatic coupler and a trip cock, which enables shunting to take place on tracks where train stops are installed.

LITERATURE.

Structural Theory and Design, Vol. II.

By J. MCHARDY YOUNG, B.Sc. (Glas.). A.M.I.C.E., M.I.Struct.E. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 25s.]

In any branch of engineering practice, the development of improved materials of construction, the introduction of novel methods of design, and the parallel expansion of analytical theory make it virtually impossible for the ground to be fully covered in one text-book. Even if an author does not restrict himself to one volume, he has to decide whether to deal exhaustively with one particular phase of the subject or to range more superficially over the whole field. The intention in the present volume, it is stated, is to strike the happy mean between books which are "either too academic or ultra-practical," in a treatise intended to cover the ground-work required by students preparing for professional examinations in the theory of structures.

In many respects, the author admirably meets the specification which he has set for himself, so that, perhaps, it may seem not quite fair to draw attention to points of omission; but this second volume purports to deal with "advanced theory and design suitable for the student specialising in structures and for the practising structural engineer." The immediate requirements of students are, for better or worse, precisely defined by the conventional examination syllabus, which necessarily must be restricted to the well-established classical theories; but the practising engineer is now looking hopefully to text-book writers for a more disinterested presentation, more authoritative guidance, and firmer lines on theories of plastic design and prestressing than anything that is yet on record in the technical Press or professional proceedings. It is true that the author goes a little outside the scope of some of the very early authorities on structural theory by giving a chapter on structural connections, but

the reader will look in vain for any reference to Batho's work on the partition of the load in riveted and welded joints, which was fully developed in the reports of the Steel Structures Research Committee, published over 15 years ago, and which is of considerable importance in the design of connections to resist fatigue. As a text-book for students, however, there is much in this work to be commended.

Neuere Methoden zur Statik der Rahmentragwerke und der Elastischen Bogensträger.

By ALBERT STRASSNER. Wilhelm Ernst and Sohn, Hohenzollerndamm, 169, Berlin-Wilmersdorf, Germany. [Price DM 22.50].

THIS is the first instalment of the fifth, enlarged and revised, edition of a comprehensive treatise which is little known in this country, for the reason, perhaps, that the theoretical background is much more complete than in some of the well-thumbed German hand-books of ready-made formulae. Although the book is introduced by the rather transient title of "New Methods," it is unlikely that British engineers will be particularly interested in the author's analytical methods, which are essentially classical in outlook, in that the algebra is well developed before he begins to discuss approximations and carry-over factors. In this volume, which deals with continuous frames and arches, the special feature is the treatment of what may conveniently be called the continuous rigid-frame bridge, in which girders and piers may be of variable cross-section. A complete set of tables is given, from which influence lines can be readily computed for any likely form of variation in cross section. This is a form of construction with which German engineers were the first to exploit the flexibility of welded steelwork, and which was widely used to give a "new look" to structural designs on the Continent long before the first tentative experiments were made with rigid-frame bridges farther west. Now that the novelty has worn off, such forms are likely to be adopted with more confidence in this country; and, since they combine economy of steel with elevations of architectural merit, engineers should appreciate the methods of design analysis offered here.

Three-Phase Motors: Theory and Operation.

By T. F. WALL, D.Sc., D.Eng., M.I.E.E. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 30s. net.]

THE object of Dr. Wall's book, of 232 pages, is to give a simple and compact account of the theory, operation and application of three-phase motors suitable for the requirements of advanced students and electrical engineers. Those familiar with Dr. Wall's writings on other electrical subjects will expect a treatment which is well balanced between the theoretical and practical sides and they will not be disappointed; though they will not find the comparisons of constructional details which often appear in electrical text-books and which can be easily made by studying trade publications.

The book first deals very fully with the induction motor, which, the author states in his preface, was estimated some years ago to be responsible for about 80 per cent. of all industrial electric drives in this country; probably this proportion is even higher to-day. The first six chapters are devoted to this type of machine, dealing with principles, the circle diagram, starting and braking, squirrel-cage motors, power factor and its control, applications, speed control and special problems. The next chapter deals with the "Selsyn" and "Electric Shaft" systems for which numerous applications are found in instrument and heavy engineering practice. In the former, it will be remembered, the angular movement of one three-phase rotor is made to follow exactly that of another similar rotor,

situated some distance away, the stator windings of both being energised from the same supply, and the rotors being connected by a three-core cable. In the electric shaft system, two or more induction motors are made to run in exact synchronism, as if they were mechanically connected by a shaft or gearing. As one example of the many possible applications of this system, the author mentions the case of a travelling loading bridge, the two legs of which are propelled by separate motors coupled on the electric-shaft system. The need for exact synchronism in this case will be obvious.

The Schrage motor is a three-phase commutator motor having characteristics similar to those of a shunt-wound direct-current motor, and, therefore, giving a wide range of speed control combined with high efficiency and simplicity of operation. Its applications, however, are limited to small and medium powers owing to the high cost of the commutator system in the larger sizes. Dr. Wall includes a chapter explaining the principles and characteristics of this motor and deals similarly with the synchronous motor, and various types of commutator motors. Three-phase and two-phase symmetrical component analyses are dealt with in two appendices, and other appendices relate to synchronous reactance and the measurement of braking torque by the running-down method. Tables of trigonometrical ratios and of circular and hyperbolic functions of radians are included. A comprehensive index concludes the volume, which can be recommended to the class of readers for which it is intended.

The Measurement and Control of Temperature in Industry.

By R. ROYDS, M.Sc., M.I.Mech.E. Constable and Company, Limited, 10-12, Orange-street, London, W.C.2. [Price 25s. net.]

SOME years ago, Mr. Royds published a book, on the measurement of steady and fluctuating temperatures, which has latterly become somewhat out of date, mainly on account of developments in the field of automatic regulation and control, but to an important degree also in respect of recent methods, often involving electronic devices, for estimating exceptionally high or transient temperatures. Pyrometric apparatus designed by instrument-making firms has undergone corresponding improvement, while fundamental work on the realisation of an internationally-acceptable scale of temperature is influential throughout industry.

To a large extent, Mr. Royds's new book is an extension of his earlier one. It starts with a review of standard temperature scales and then deals successively with expansion and electrical resistance thermometers, thermocouples and their associated circuits, and pyrometers based on total radiation, optical and photo-electric principles. In most cases, an outline of the underlying theory is combined with a description of typical apparatus marketed by instrument makers, and a similar mode of presentation is adopted in the following chapter, where attention is directed, first to various types of galvanometers commonly used as indicators of electrically-measured temperature, and, secondly, to a selection of industrial equipment for temperature recording and control. Miscellaneous methods of imprecise temperature estimation, such as calorimetric pyrometers, Seger cones and temperature-indicating pigments, comprise the subject-matter of a short chapter which is followed by summarised accounts of the procedures adopted by experimental engineers to measure the mean temperatures of metal walls in heat engines and boilers, and the fluctuating or transient high temperatures attained by internal-combustion engine gases, cutting tools and vehicle brakes.

The admixture, in these concluding chapters, of widely-known work, carried out, in some cases, many years ago on plant, and with apparatus,

that could justly be regarded as obsolete to-day, together with relatively recent research employing the resources of a modern laboratory, exemplifies some of the difficulties that have confronted the author in attempting to revise and alter his earlier work. Though enough new material has been added to warrant a change of title, the text is still predominantly concerned with purely experimental and scientifically precise measurement of temperature rather than with the common run of industrial practice. In particular, the attention given to temperature measurements throughout refrigerating, food-processing and materials-finishing engineering is regrettably disproportionate to the importance and the peculiar problems of those industries to-day. The author's discussion of industrial temperature control, similarly, is so far from being comprehensive as probably to disappoint many readers who may judge the contents of this book solely from its title. Among industrial engineers and physicists, such disappointment will be the keener for the inference from what Mr. Royds has, in fact, written, that he could produce a first-rate book on a subject which is in need of fundamental and systematic treatment.

Water: A Study of Its Properties, its Constitution, its Circulation on the Earth, and its Utilization by Man.

By SIR CYRIL S. FOX, D.Sc., F.G.S. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 30s. net.]

THE average untravelled inhabitant, of the British Isles is inclined to take water for granted, though the supply problems of the larger cities have tended in recent years to induce a more intelligent concern with this truly vital subject; but in India water is of a greater and a permanent significance. Sir Cyril Fox has spent more than 30 years in India in the service of the Geological Survey, and his interest in water possibly owes at least as much to that sojourn as to his training as a geologist. At all events, the interest is evident, and has resulted in a book that will appeal to the novice in geology and engineering without, we believe, losing its attraction for the more knowledgeable reader.

The pattern of the book follows closely that indicated by the sub-title, there being three main sections, each of three chapters, dealing respectively with "The Natural History of Water," "The Work Done by Water," and "The Utilisation of water." It is typical of the broad range of Sir Cyril's survey that he opens with a philosophical examination of the words which, in various ancient and modern languages, convey the idea of "water"; an approach which those interested can find explored farther in Isaac Taylor's classical work on *Words and Places*. The step from philosophy to facts (with a strong leaning towards statistics) is soon taken, and thereafter the book develops into a remarkable compilation of highly various information. The quantities involved in considering water as an element on a global scale may be found difficult to assimilate—to quote two examples, "On page 33 estimates have been given of the discharge of twenty great rivers, and it is seen that their annual discharge averages somewhat over 2,500 cubic miles" and "The total rainfall on the land was computed at about 24,000 cubic miles (23,903 exclusive of snow (6,060 cubic miles))." In discussing land erosion, Sir Cyril computes that rivers carry into the sea some 9,000 million tons of silt annually, or 0.9 cubic mile, to which is to be added a further 0.2 cubic mile of solids in solution. These figures are given on page 79 of the book, and on page 105 they are quoted again, but incorrectly as 9 and 2 cubic miles, respectively; an error which emphasises the advisability of prefixing a nought before the decimal point in fractions that are less than unity. There are other instances in the book (especially in connection with place-names) where the proof-reading leaves something to be desired.

TORQUEMETER FOR INDUSTRIAL APPLICATIONS.

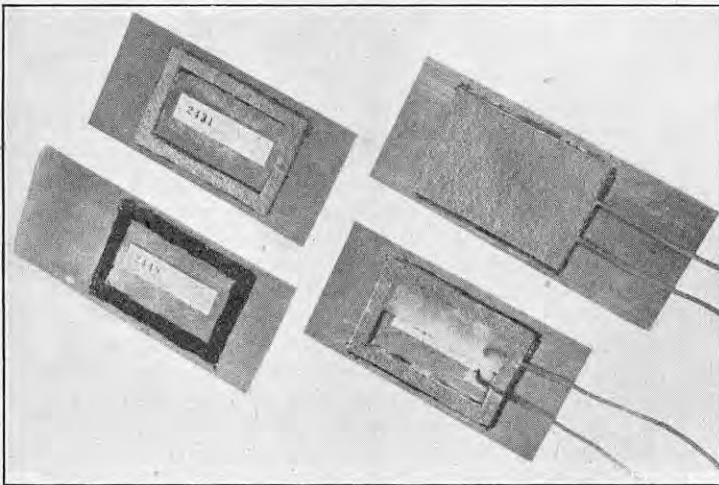


FIG. 8. STAGES IN PROOFING STRAIN GAUGE.

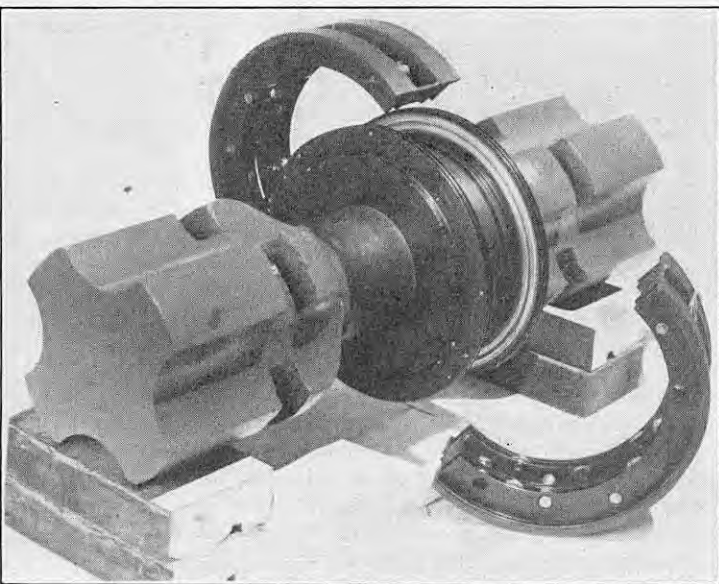


FIG. 9. ASSEMBLY OF TORQUEMETER.

TORQUEMETER FOR INDUSTRIAL APPLICATIONS.

By R. B. SIMS, B.Sc., A.M.I.Mech.E., and
A. D. MORLEY.

(Concluded from page 21.)

THE methods of attaching the electrical resistance strain gauges to metal surfaces, and the factors which determine the choice of adhesive, have been discussed elsewhere.* The proofing of the gauges in a torquemeter against water, steam and oil is particularly important, since the gauge chamber beneath the slipping unit cannot be completely sealed. None of the published methods of proofing these gauges has given satisfactory protection over long periods. The following method, which owes much to Mr. W. Bagshawe, of the B.I.S.R.A. laboratory, has been used successfully, and it has the advantage of being clean and simple to apply, and allows the gauge to be inspected and tested without destroying the components of the seal or endangering the gauge.

The seal is provided by a casing fabricated from sheet rubber and bonded over the gauges directly to the metal surfaces. Successive stages in the proofing are illustrated in Fig. 8, herewith. The gauge is first bonded to the shaft with a suitable adhesive, the area round it is cleaned and degreased, and two coats of Linatex Solufix No. 9 cement are then applied to the metal as shown in the bottom

left corner of Fig. 8. The area covered should be slightly greater than the rubber seal which is to be bonded to it and the cement should be allowed to dry between each coat. A rubber case is formed from $\frac{3}{4}$ -in. Linatex sheet, two pieces forming the sides of the casing (top left, Fig. 8) and a third the cover. The rubber is cleaned and degreased with carbon tetrachloride and the underside of the first piece coated with Solufix No. 7 cement; this cement is also applied to the surface of the No. 9 cement previously applied to the metal. The two surfaces are brought together after being allowed to dry in air for about 20 minutes, and the joint is hammered to ensure a good bond. Two rubber-covered leads are now soldered to the gauge tags and brought through slots in the second piece of rubber forming the sides of the box. The joints between the two rubber sheets and the leads are made with No. 7 cement and hammered down.

The space over the gauge is now filled with Di-Jell and covered with a small piece of polythene sheet (bottom right, Fig. 8) to prevent the Di-Jell from contaminating the joint face between the cover and sides. This joint is prepared as before with No. 7 cement and the cover hammered in position. The completed proofing, shown in the top right corner of Fig. 8, affords a protection against steam and water. The insulation resistance of two gauges bonded to a steel cylinder with Araldite cement and proofed in this way was taken over a period of three months while the cylinder was immersed in water. With cold water, the insulation resistance exceeded 500 megohms and this fell to 25 megohms when the water was heated to 75 deg. C., due to the temperature effect on the insulating properties of the adhesive.* The insulation resistance returned to

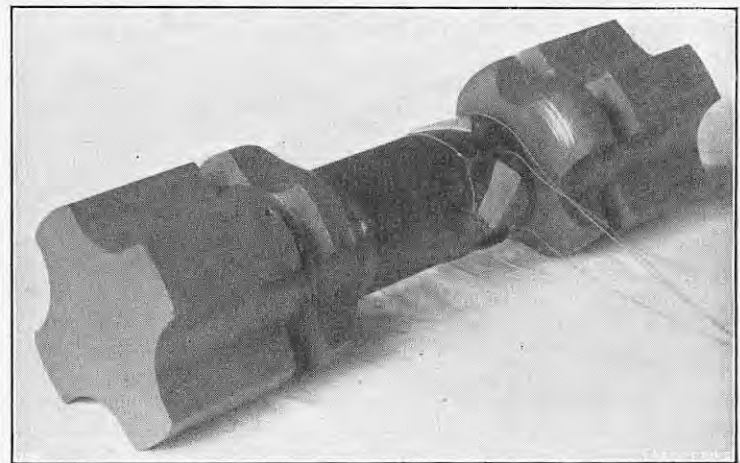
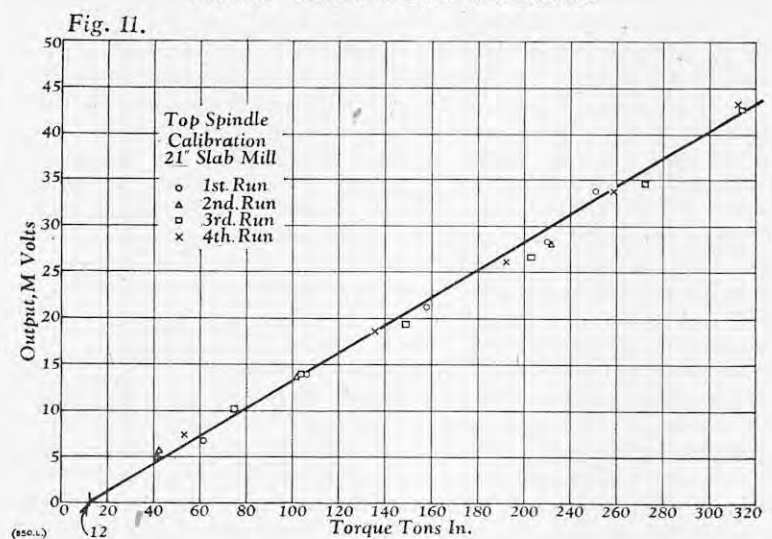


FIG. 10. STRAIN GAUGES IN POSITION.



500 megohms when the water cooled. An excess of oil and grease may eventually penetrate the rubber sheet, and if a long-term protection is required under these conditions the rubber should be protected by a Neoprene proofing.

In the event of gauge failure, an examination can be made by slitting the cover joint with a sharp knife. A faulty gauge may be removed and replaced by a new one without disturbing the walls of the box. The reproofing then only involves refilling with Di-Jell and remaking the cover joint.

With the strain gauges connected in the network shown in Fig. 7, page 21, *ante*, either null or out-of-balance methods may be used to measure torque. The out-of-balance method has been chosen for the present design because it is the only practical method which gives a continuous indication. A simple direct-current circuit may be used, consisting of a battery supply of about 100 volts and a galvanometer to indicate the out-of-balance current, but this is too delicate an instrument for general industrial use and usually it must be replaced by a 50-micro-ampere meter; an arrangement which will give a useful indication of torque only when the shaft is stressed in shear far beyond accepted engineering practice. Such shafts are discussed later; direct-current circuits which may be used with them have been described.*

In general, the surface shear strains in rotating shafts are too small to give accurate torque measurements on a simple direct-current circuit, and some form of signal amplification must be used. A four-channel power supply, a 500 c.p.s. oscillator, and alternating-current amplifiers suitable for this purpose have been designed by A. L. M. Douglas and P. R. A. Briggs,† and an alternative system due to Briggs has been described in the article in *ENGINEERING* previously mentioned. A recording potentiometer

* "Loadmeter for Industrial Mills," by R. B. Sims, J. A. Place, and A. D. Morley. *ENGINEERING*, vol. 173, page 116 (1952); *Electric Resistance Strain Gauges*, by W. B. Dobie and P. C. G. Isaacs, English Universities Press (1948).

* Sims, Place and Morley, *loc. cit.*

† *Inst. Pract.*, December, 1948.

meter may be employed unless large rapidly fluctuating torques are expected, when the response of this form of equipment will probably be too slow to record the peak values.

In deriving the output of the torquemeter in terms of the elastic constants of the shaft and the electrical parameters of the circuits, it will be assumed that there is pure tension in the shaft and that it is not distorted beyond its elastic limit. Tensile strains will be considered positive and compressive strains negative. The strain gauges attached to the shaft are matched in resistance before bonding, so they may be assumed to have equal resistances, denoted by R' . Let V , I and R represent potential differences, current and resistance, respectively, the suffixes AB, BC, CD and DA denoting values between the terminals A, B, C and D of the network in Fig. 7, and the suffixes n and m the input and output values, respectively.

If ϵ_x and ϵ_y are principal strains in a perfectly elastic body, and $\epsilon_x = -\epsilon_y$, then the strain system is equivalent to a pure shear strain γ of magnitude $2\epsilon_x$ in a plane inclined to an angle of $\frac{\pi}{4}$ rad. to the principal planes. Conversely, an axial shear strain in a shaft will be equivalent to tension and compression strains $\frac{\pi}{4}$ rad. to the axis, so that, with the arrangement of strain gauges shown in Fig. 7, two gauges 1 and 3 will be compressed and two, 2 and 4, will be extended.

The constants l and k cannot, however, be measured readily and, as k is small, the approximation

$$\frac{\Delta R'}{R'} = \frac{1}{2} \nu \gamma \quad (3)$$

will be used here. Hence $\Delta R_{AB} = -\Delta R_{DA} = \frac{1}{2} R' \nu \gamma$, and, substituting into equations (1) and (2),

$$V_{AB} = \frac{1}{2} V_n (1 + \frac{1}{2} \nu \gamma) \text{ and } V_{DA} = \frac{1}{2} V_n (1 - \frac{1}{2} \nu \gamma) \quad (4)$$

and the effective resistance of the network is $R_n = R'$. These values have been derived on the assumption that the torquemeter output is on open circuit. If an ammeter of resistance R_m , or any other resistive load of this value, is connected across the output terminals, then, from Thevenin's theorem, the current in the load is

$$I_m = \frac{V_{AB} - V_{DA}}{R_m + R_n}$$

Substituting from equation (4), the meter current becomes

$$I_m = \frac{\frac{1}{2} V_n \nu \gamma}{R' + R_m} \quad (5)$$

For a solid shaft transmitting a torque G , it may be shown that $\gamma = \frac{16G}{\pi d^3}$, where d is the diameter of a solid shaft and Q the modulus of rigidity of the material; and, on substituting into equation (5),

$$I_m = \frac{8 V_n \nu G}{\pi d^3 Q (R' + R_m)} \quad (6)$$

The output voltage on open circuit is

1 and 2 (say) will increase in resistance by $\frac{1}{2} \nu R \epsilon_b$ and gauges 3 and 4 will decrease by the same amount. Bending apart, the network shown in Fig. 7 may be arranged either as shown or with gauges 2 and 4 and gauges 1 and 3 reversed in position relative to the terminals A, B, C and D. Where there is bending, only the arrangement shown in Fig. 7 is possible; otherwise, an additional potential difference $V_m = \frac{1}{2} V_n \nu \epsilon_b$ will appear at the output terminals. If the plane of bending is unchanged but the gauges are rotated through $\frac{\pi}{2}$ rad. so that the diameter

on which they are attached lies in the neutral plane, there will be no resultant strain in the gauges, provided that a symmetrical crossed gauge system is used, as shown in Fig. 6, page 21, ante. This system has not been used on the mill spindle in Figs. 9 and 10, opposite, because it is held in semi-universal couplings, where the bending is negligible. A displaced gauge system has been used, therefore, as it is easier to proof. Any output voltage ΔV_m due to bending will be cyclic if the flexure is due to a gravity load on the shaft, but will be constant in sign and dependent on speed if the deformation is due to eccentric loading.

The gauge factor ν and the modulus of rigidity Q in equations (6) and (7) are rarely known to within ± 5 per cent.; hence the overall accuracy when using these equations to derive torque from a measurement of current or voltage may be in error by as much as ± 10 per cent. If measurements of a high order of accuracy are required, it is advisable to calibrate the torquemeter.

Calibration of torque in terms of the out-of-balance voltage of the strain-gauge network were made on the two spindles of an industrial mill, using a calibration rig and the torquemeters described above. The calibration of the upper spindle is shown in Fig. 11, opposite. The scatter is considered small in view of the fact that the mill is equipped with plain brass roll-neck and pinion bearings. A line through the experimental results in Fig. 11 intersects the torque axis at 12 ton-in. and gives a measure of the static friction in the mill bearings. This agrees well with other determinations of bearing friction. The mill spindles are of cast steel with a turned portion 10 in. long and 7 in. in diameter between the wobbler universal couplings. The calculated outputs of the torquemeters were 0.158 mV per ton-in. for both spindles. These figures are to be compared with the experimental values of 0.154 and 0.141 mV per ton-in. for the upper and lower spindles, respectively.

Calibrations for eight other strain-gauge torquemeters built recently are given in Table I, as an additional guide to the accuracy to be expected. It is clear that, where instruments are required to an accuracy closer than 5 per cent., the torquemeter must be calibrated. In the examples 1 to 8, quoted above, deadweight loading of a torque-arm has been used, but this is practicable only in a laboratory. A calibration rig is described below, which is capable of exerting a torque of 500 ton-in.

The calibration rig consists of a fabricated torque arm with adapter plates at one end which enable it to be attached to a shaft at, for example, a suitable coupling. The load is applied to the other end by a jack, bearing on a trunnion and incorporating a stainless-steel tube to which four strain gauges are attached in the form of a load-measuring network. This loadmeter is calibrated directly in a universal testing machine, using a battery monitored by a sub-standard voltmeter to supply the gauges, and a potentiometer to obtain a calibration in terms of millivolts output per ton. The torque applied to the shaft has been measured to better than ± 0.4 per cent. by this simple equipment.

In an alternative arrangement which has been used, a simple tension link replaced the jack and the load was applied from an overhead crane. The load in the link was measured by a strain-gauge network similar to that on the jack.

The effect of temperature changes on an electrical resistance strain gauge measuring network has been described in the report cited above, in connection with load-measuring systems. The equations given there for correcting a calibration for temperature will apply equally to the torquemeter. In general,

TABLE I.—CALIBRATIONS OF TORQUEMETERS.

Length, In.	Diameter, In.	Material.	Resistance of Gauges, Ohms.	Resistance of Meter, Ohms.	Method of Measurement.	Bridge Potential Difference, Volts.	Gauge Factor.	Calculated I, Amp. per Ton-In.	Measured I, Amp. per Ton-In.	Max. Torque Measured, Tons-In.
26	2.25 —	Alloy steel, Cr. Ni. yield strength = 55 tons per sq. in.	2,435	872	Direct current	100	2.15	2.67	2.79	17.188
26	2.25 —	"	2,435	860	"	100	2.15	2.67	2.62	17.188
2	1.35 1.2	Mild steel	2,500	853	"	100	2.20	12.82	12.7	0.964
2	1.35 1.2	"	2,500	861	"	100	2.20	12.82	12.7	0.964
2	1.35 1.2	"	2,500	853	"	100	2.20	32.25	33.1	0.964
2	1.35 1.2	"	2,500	861	"	100	2.20	32.25	34.5	0.964
3	1.00 #	Beryllium copper	2,500	600	"	69.3	2.15	50.45	50.05	0.712
3	1.00 #	"	2,500	600	"	69.3	2.15	50.45	50.02	0.796

The modulus of rigidity has been taken as 5,150 ton-in.⁻² for the steel shafts and 3,120 ton-in.⁻² for the beryllium-copper.

The resistances $R_{AB} = R_{DC} = R_{CD} = R_{DA} = R'$ when the shaft is not strained. When torque is transmitted, the resistances of the gauges will change so that R_{AB} becomes $R_{AB} + \Delta R_{AB}$; R_{BC} becomes $R_{BC} + \Delta R_{BC}$, and so on. If the indicating meter is removed from the circuit

$$V_{AB} = V_n \left[\frac{R_{AB} + \Delta R_{AB}}{R_{AB} + \Delta R_{AB} + R_{BC} + \Delta R_{BC}} \right] \quad (1)$$

$$\text{and } V_{DA} = V_n \left[\frac{R_{DA} + \Delta R_{DA}}{R_{DA} + \Delta R_{DA} + R_{CD} + \Delta R_{CD}} \right] \quad (2)$$

If ϵ_1 and ϵ_2 are the natural strains along and normal to a strain gauge, then, as Bamberger and Hines* have shown,

$$\frac{\Delta R'}{R'} = l \epsilon_1 + k \epsilon_2$$

where l and k are constants for small strains in Nichrome wire. The value of k depends largely on the gauge construction, but it is usually very small in comparison with l . In uniaxial tension or compression

$$\frac{\Delta R'}{R'} = \epsilon_1 (l - \lambda k) = \nu \epsilon_1$$

and ν is a constant, termed the gauge factor, which depends upon the strain-resistance characteristics of the gauge wire and Poisson's ratio λ for the steel cylinder. The value of ν supplied for each gauge by the manufacturers is a sampled mean from each batch of gauges.

For electrical resistance strain gauges arranged to measure shear strains

$$\frac{\Delta R'}{R'} = \frac{\gamma}{2} (l - k), \text{ since } \epsilon_1 = -\epsilon_2 = \frac{1}{2} \gamma.$$

The output current in terms of torque given in equation (6) will represent closely a calibration curve taken with a direct-current indicating system. The voltage on open circuit in equation (7) will represent the calibration of a balanced potentiometer, and also, to a close approximation, the case where the bridge is fed with alternating current, and the output is taken to the grid of a valve via a transformer. Equations (6) and (7) are linear relationships with torque and, in addition, the voltage relationship in equation (7) is independent of the gauge resistance, and thus has the advantage of being completely independent of temperature—a point discussed in detail below.

These equations have been derived on the assumptions that the shaft is not subjected to axial stress or to bending. If the shaft is subjected to an axial compressive strain of ϵ_a , all the gauges will change in resistance by $\frac{1}{2} R' \nu \epsilon_a$ and the balance of the bridge will not be affected.

Equation (6) will then become

$$I_m = \frac{8 V_n \nu G}{\pi d^3 Q \left[R' \left(1 - \frac{\nu \epsilon_a}{2} \right) + R_m \right]}$$

but, since ϵ_a is unlikely to exceed 0.0005, the correction for this effect may be neglected in most measurements of torque based on a measurement of current, while those based on a measurement of potential difference will not be affected because they are independent of the bridge resistance.

For a shaft in which there is pure bending, let the diameter on which the strain gauges are attached be normal to the neutral plane of bending. If ϵ_b is the maximum strain due to bending, then gauges

* *Expt. Stress Analysis*, vol. 2, page 116 (1944).

however, the correction is small and may be neglected in all but the most precise measurements.

It will be seen from equation (6) that the output of the unbalanced strain-gauge network is proportional to the applied bridge potential. Any variation in this potential will produce a proportional error in the indication of the torquemeter.

The output of the torquemeter may change slowly over the first few days, due to creep in the gauges and the adhesive, particularly if Durofix is used. After this period of ageing, changes in the calibration with time should be negligible.

If reasonable accuracy is to be achieved in a calibration of torque against current, the microammeter (or milliammeter with alternating-current circuits) should be to B.S. No. 89. Instruments of inferior quality are liable to give very large errors in the first 5 per cent. of full-scale deflection, and friction in their movements contributes substantially to hysteresis in the calibration when the loading is reversed.

When the strain gauges are supplied with alternating current and an amplifier is used in the load-indicating circuit, the gauge network must be balanced for capacity and resistance. A multi-core tough-rubber sheathed cable should be used, therefore, otherwise drift may occur if the cables are disturbed after balancing, due to a change in the capacity of the circuit. A common alternating-current system has one terminal of the bridge earthed at the electronic circuit. A leakage path exists, therefore, between the slipping unit and the amplifier, which may vary the zero of the indicating meter unless a stable "earth" connection is provided between them.

For the highest accuracy, a direct-current supply from a stabilised source should be used, and these may be built to give less than 0.02 per cent. variation from their rated voltage. With care, therefore, and using a vernier potentiometer, it should be possible to measure torque to an overall accuracy of better than ± 0.5 per cent. with this design of torquemeter. This accuracy, however, is far in excess of the requirements of industry, and ± 1 to ± 2 per cent. may be obtained with simple and robust continuously indicating equipment.

THE CENTRAL VALLEY PROJECT, CALIFORNIA.*

(Concluded from page 5.)

THE production of hydro-electric energy has been an important element in the use of the water resources of the Central Valley basin. In 1945, the 74 plants in the basin had a total installed capacity of 1,775,000 kW. They supplied about 90 per cent. of all the electrical energy used in the Central Valley basin and the adjoining coastal area, including the San Francisco Bay region. Independent developments of this kind in the various parts of the basin were logical and satisfactory so long as local water supplies were adequate to meet local needs and could be used without adverse effects elsewhere.

The annual run-off into the valley since 1904 has varied from an estimated maximum of more than 60,000,000 acre-feet in 1906-07 to a recorded minimum of less than 8,500,000 acre-feet in 1924. A 40-year average of 33,000,000 acre-feet has been estimated for the period 1903-04 to 1942-43. An average of 18,000,000 acre-feet was recorded for the seven-year period of critically low run-off which occurred between October, 1927, and September, 1934. Rainfall records, which began in 1849 in Sacramento, indicate that seven-year period to have been the driest in the 95 years of record. In the future, as in the past, irrigation of the east-side of the upper San Joaquin Valley will depend largely upon utilisation of the vast ground-water basins of the area. The combined capacity of these basins is sufficient to provide carry-over storage for periods much longer than the seven-year period mentioned above; consequently, the dependable water supply which can be developed in this area will not be limited by the supply available during the seven-year critical period, as in most other portions of the Central Valley.

* We regret that, in the previous instalment of this article, the illustrations on Plate I were wrongly numbered; they should have been Fig. 3 and Fig. 4.—ED., E.

THE CENTRAL VALLEY PROJECT.

Fig. 5.

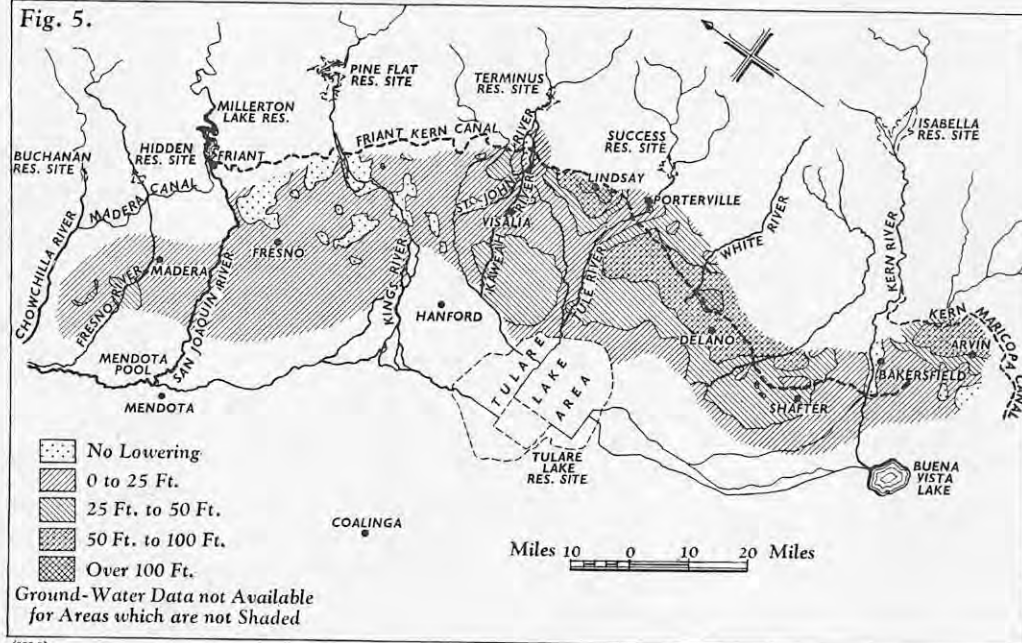
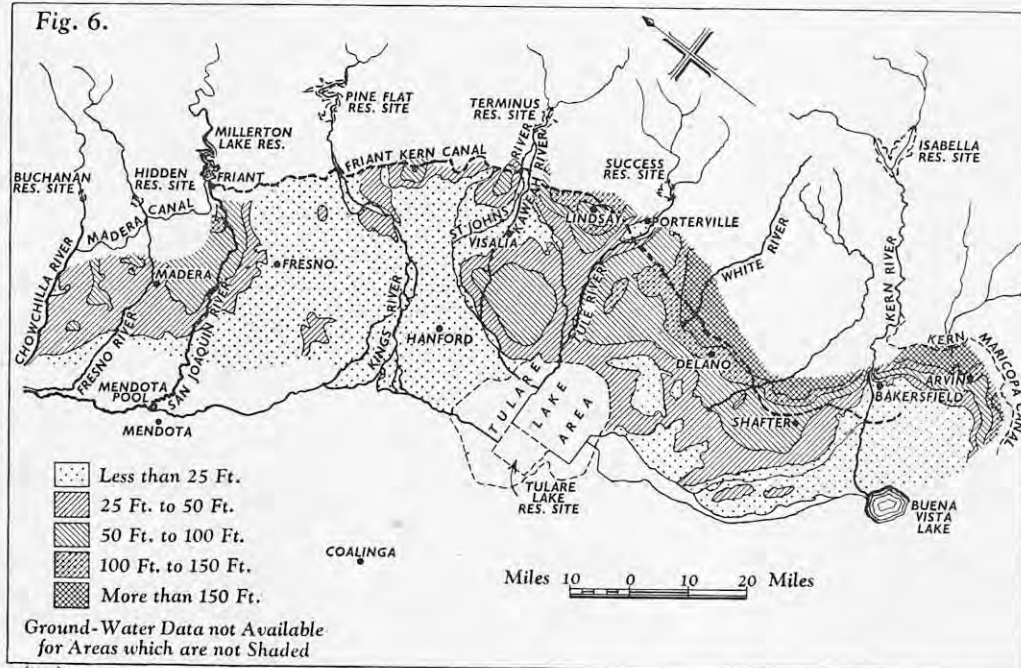


Fig. 6.



SAN JOAQUIN VALLEY.

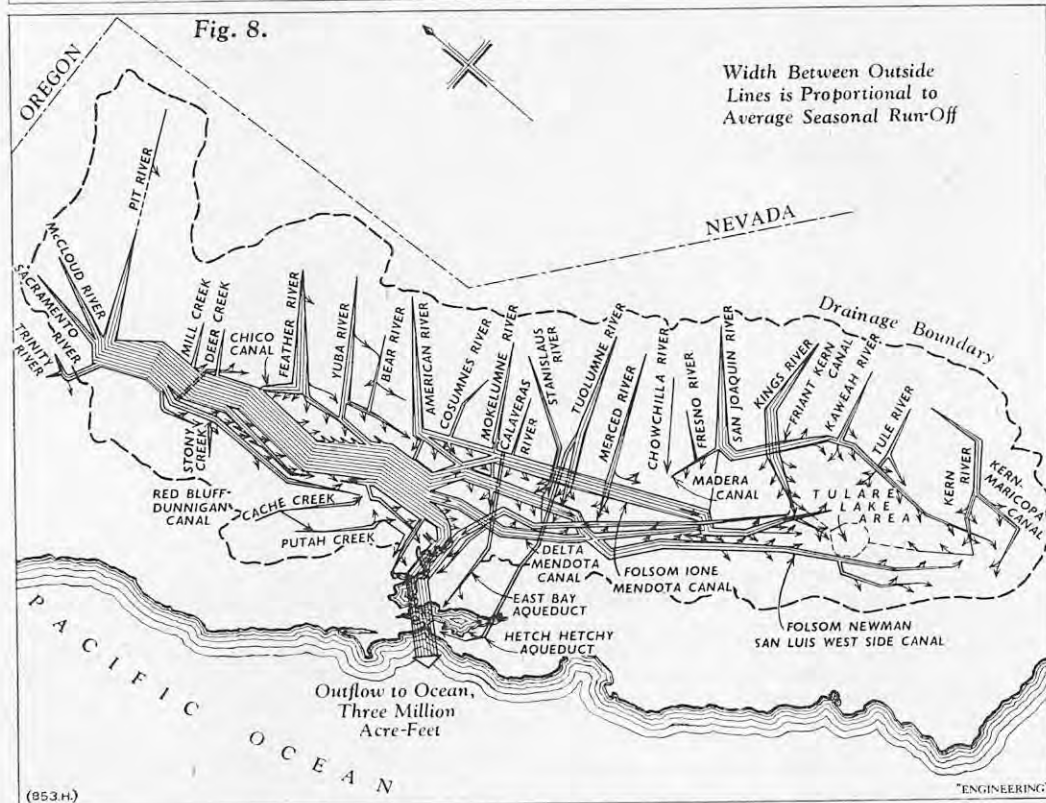
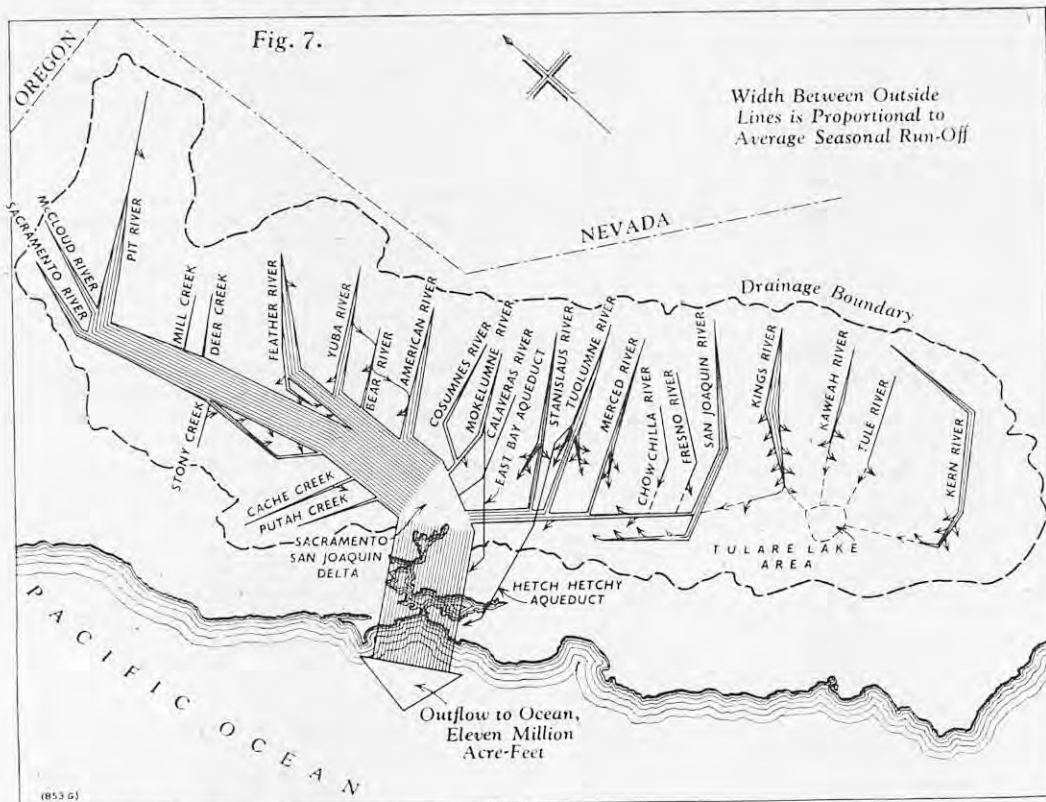
The great ground-water reservoirs of the east side of the upper San Joaquin Valley are supplied by the winter and surplus spring run-off by percolation into the flat alluvial cones of the major streams. The combined total capacity of these ground-water basins has been estimated by the California Division of Water Resources at 20,000,000 acre-feet within the range of feasible pumping lifts. Pumping during the summer and autumn months utilises the ground-water supply, and makes room for the stream flows of the following year. During periods of sub-normal run-off the ground water in these basins is materially lowered and pump lifts are increased. In certain areas the ground water is recharged only from distant sources, and continued heavy pumping has so depleted the ground-water supplies as to threaten the irrigation development dependent upon them. In general, these are areas which are not on the alluvial cones of the major streams, and to a considerable extent the water-bearing sands of these basins are overlain with clay or hardpan which prevent direct percolation. It may be difficult to replenish the supply in these basins, and it may prove necessary to use surface supplies for irrigation of a considerable acreage of these lands.

In Figs. 5 and 6, on this page, are shown ground-water conditions in the upper San Joaquin Valley. The lowering of the water due to over-pumping during the 18 years 1921-39 is shown in Fig. 5 and

the depth to ground-water in the autumn of 1939 in Fig. 6. These two illustrations show the need for ground-water replenishment or importation of irrigation supplies for areas lying away from the principal rivers. One of the major functions of Central Valley Project surface reservoirs and canals in the east-side upper San Joaquin Valley will be to facilitate the replenishment in wet years of the ground-water basins after they have been depleted by pumping in periods of subnormal stream flows.

Ground-water data for the west side of the upper San Joaquin Valley are very meagre, but it is known that the water level was being lowered each year under the demands of more than 190,000 acres of irrigated land. In some sections the rate of lowering was as much as 10 ft. a year. The wells are between 1,200 ft. and 2,500 ft. in depth, with water levels from 200 to 500 ft. below the ground surface. Present supplies are probably being pumped from water which has accumulated over a period of many years. It is estimated that the present supply is not adequate to provide a dependable yield for more than 70,000 acres of irrigated land. The remaining 120,000 acres now irrigated would have to go out of production, had the Central Valley Project works not been put into effect. The California Division of Water Resources has estimated that underground basins in the Sacramento and lower San Joaquin Valleys have a total combined capacity of 6,000,000 acre-feet within the limits

THE CENTRAL VALLEY PROJECT.



of economic pumping depth. Considerable areas of land are now served by pumping from ground water, but underground supplies are not used to as great an extent as in the upper San Joaquin Valley.

The gross irrigable area of the Central Valley Basin is estimated to be more than 9,000,000 acres. To allow for land occupied by roads, canals, farmsteads, etc., this figure has been reduced to a net irrigable area of 8,325,000 acres in Bureau of Reclamation studies. This figure does not include net irrigable areas of 63,000 acres and 120,000 acres on the east and west sides of the upper San Joaquin Valley which lie at an elevation of about 750 ft. Depending upon the elevation to which pumping is found justified, the area of land which will ultimately require irrigation may vary by several thousands of acres. For reasons such as crop rotation and other factors, it has been found that

not all of the irrigable land is irrigated in any one year, and it is estimated that only 6,580,000 acres of land would be irrigated in any year under full development of the Central Valley Basin.

WATER REQUIREMENTS AND FLOW.

Water requirements for the purpose of irrigation have been estimated by the Bureau of Reclamation on the basis of an average net use of $2\frac{1}{2}$ acre-feet per irrigated acre of land on the main valley floor and 2 acre-feet per irrigated acre of mountain, valley and foothill land. Net use is considered to be the sum of consumptive use from artificial supplies plus irrecoverable losses. The estimated ultimate net water requirements for commercial agricultural purposes in the basin total 16,600,000 acre-feet. Local industrial and miscellaneous uses are estimated to total 550,000 acre-feet. In practice, it is necessary, by reason of conveyance and applica-

tion losses, to divert more water from the stream or reservoir than is required for net use. Most of the excess water thus diverted eventually finds its way back to the stream as surface or underground return flow, or percolates to an underground basin where it is available for re-use by pumping. Under the comprehensive plan for the Central Valley the major part of the higher-quality return flow will be utilized.

Increased pumping from some of the ground-water basins will decrease the outflow through alkaline lands, where the water would become impregnated with salts. Intrusion of ocean salinity is another factor. In the Sacramento-San Joaquin Delta, upstream irrigation diversions have increased from an estimated 1,000,000 acre-feet in 1880 to more than 6,000,000 acre-feet recently. Under conditions existing prior to the construction of Shasta Dam, stream flow into the Delta during the summer and autumn season was not sufficient to supply the large quantities of water required in the Delta for irrigation, growth of natural vegetation, and evaporation. This resulted in invasion of the Delta by ocean water. Tidal action also tended to propel the salt water inland along the Delta channels. In a dry year, as much as two-thirds of the irrigated lands in the Delta were within the area affected by salinity. It has been calculated that, for agricultural use, salinity must be kept down to less than 100 parts of chlorine in 100,000 parts of water. To obtain this result it has been assumed that a discharge of 3,300 cub. ft. per sec. of water from the Delta past Antioch would control salinity to this figure. Releases of water from Central Valley reservoirs of 2,400,000 acre-feet would be required for this purpose. Other requirements include 450,000 acre-feet for export to the San Francisco Bay area for local supply, and navigation releases for the Sacramento River. The grand total of future water requirements are therefore some 20,000,000 acre-feet.

The effect of the comprehensive plan is shown in Figs. 7 and 8, on this page. These indicate the stream flow conditions for the past and the future. Under earlier conditions, shown in Fig. 7, the large outflow to the ocean came principally from the surplus of water carried by the Sacramento River and its tributaries. Under future conditions, the Sacramento River will continue to carry large flows, but instead of wasting to the ocean, the surplus water will be regulated in reservoirs to meet local requirements and to supply water through various canals to the upper San Joaquin Valley for supplementary and new irrigation demands. Similarly, the streams of the American River and lower San Joaquin Valley areas will be regulated and surplus water will be supplied through canals to other areas deficient in supply.

Much of the information for the preparation of this article has been obtained from a report sponsored by the Bureau of Reclamation, entitled "The Central Valley Basin," published as a United States Senate Document.

THE OLD CENTRALIANS.—The next monthly luncheon of the Old Centralians—former students of the City and Guilds Engineering College—will be held on Monday, July 14, at the restaurant "Chez Auguste," 47, Frith-street, London, W.1. Following the luncheon, an address will be given on "World Oil Reserves" by Dr. G. M. Lees, M.C., D.F.C., F.R.S., chief geologist of the Anglo-Iranian Oil Company and President of the Geological Society. The luncheon secretary of the Old Centralians is Mr. A. C. Vivian, Beaufort House, Gravel-lane, London, E.1.

VARIABLE SPEED DRIVE.—The manufacturers of the Druce-Elliott variable-speed drive, Industrial Drives, Ltd., 44, Uxbridge-road, London, W.5, have introduced an improved unit. The Druce-Elliott unit, it may be recalled, was described on page 109 of our 171st volume (1951). The improved unit is available with motors ranging from $\frac{1}{2}$ h.p. to 75 h.p. Belt-tension adjustment and belt replacement have been simplified, and a multiple-groove pulley can be supplied. The makers have also introduced a variable-speed countershaft, comprising two manually-controlled Druce-Elliott pulleys mounted on a common shaft on an adjustable base which allows the pulleys to be opened or closed in opposition, giving a range of speed variation of 20 to 1.

STRESSES IN DRUMHEADS FOR CYLINDRICAL VESSELS.

By NICOL GROSS, Ph.D., M.I.Mech.E., P. H. R. LANE, B.Sc. (Eng.), and A. A. WELLS, Ph.D.

ON page 71 of British Standard Specification 1500:1949, a curve is given from which values of K_1 can be obtained for various ratios of the depth of the drumhead (h_0) to the diameter of the equivalent cylinder (D_0). It was thought interesting to compare this curve with recent experimental results which had become available. The results of Siebel, Höhn and other earlier experimenters have been omitted because, with the means available to them, they were only able to infer interior stresses from exterior measurements. It was also thought useful to add two curves—one for ellipsoidal drumheads, derived by Coates's analysis,* and one obtained for torispherical drumheads by the analogue developed by one of the present authors.† The following notation is used.

NOTATION.

- h_0 = Outside depth of curved portion of drumhead, in.
 D_0 = Outside diameter of cylindrical portion of drumhead, in.
 t_e = Thickness of drumhead, in.
 K_1 = Stress concentration factor in heel of drumhead, i.e., the ratio: (maximum meridional stress in heel of drumhead) to (hoop stress in an equivalent cylinder — S_h).
 S_h = Hoop stress in a thin cylinder under internal pressure = $\frac{PD}{2t}$.
 P = Internal pressure.
 t = Thickness of cylinder.
 D = Mean diameter of cylinder.

It is now generally accepted that Coates's method of calculation of stresses may be applied with reasonable accuracy to drumheads of ellipsoidal form, provided that the drumhead has an $\frac{h_0}{D_0}$ relation greater than about 0.2, and the ratio $\frac{t_e}{D_0}$

is between approximately $\frac{1}{100}$ and $\frac{5}{100}$. Thickness limitations arise at the lower end by virtue of elastic change of shape of the neutral surface after application of pressure, and at the upper end, due to non-linear distributions of stress through the plate thickness when thicknesses become comparable with radii of curvature. The reason for the suitability of Coates's method in this case is that the ellipsoidal drumhead has only one discontinuity between the ellipsoid and the equivalent cylinder. The computation of local bending stresses is, therefore, not much in error if theory applicable to cylinders is used. With the torispherical drumhead, the Coates's analysis is made difficult, because there is a second discontinuity between the spherical and toroidal portions of the drumhead. At this discontinuity it is not acceptable to calculate local bending stresses on the basis of theory applicable to cylinders. For this reason, a mechanical analogue was devised in which the elastic behaviour of the torispherical drumhead can be closely simulated, and the differential equation of bending solved by a finite difference method.

The theoretical curves have been calculated for drumheads with a ratio of thickness to diameter of $\frac{2}{100}$, and are shown in the accompanying figure for comparison with experiments and the curve of B.S. 1500. The differences between these calculated curves and others calculated on the same bases for different thicknesses is not significant. Also, the torispherical cases have been calculated for heads with heel and crown radii as follows:—

$$\text{Middle thickness values} \begin{cases} \text{Heel radius} = \frac{h}{4} \left(1 + \frac{6h}{D} \right) \\ \text{Crown radius} = \frac{D^2}{6h} \left(1 + \frac{h}{D} \right) \end{cases}$$

* "The State of Stress in Full Heads of Pressure Vessels," by W. M. Coates, *Trans. A.S.M.E.*, vol. 52 (1930).

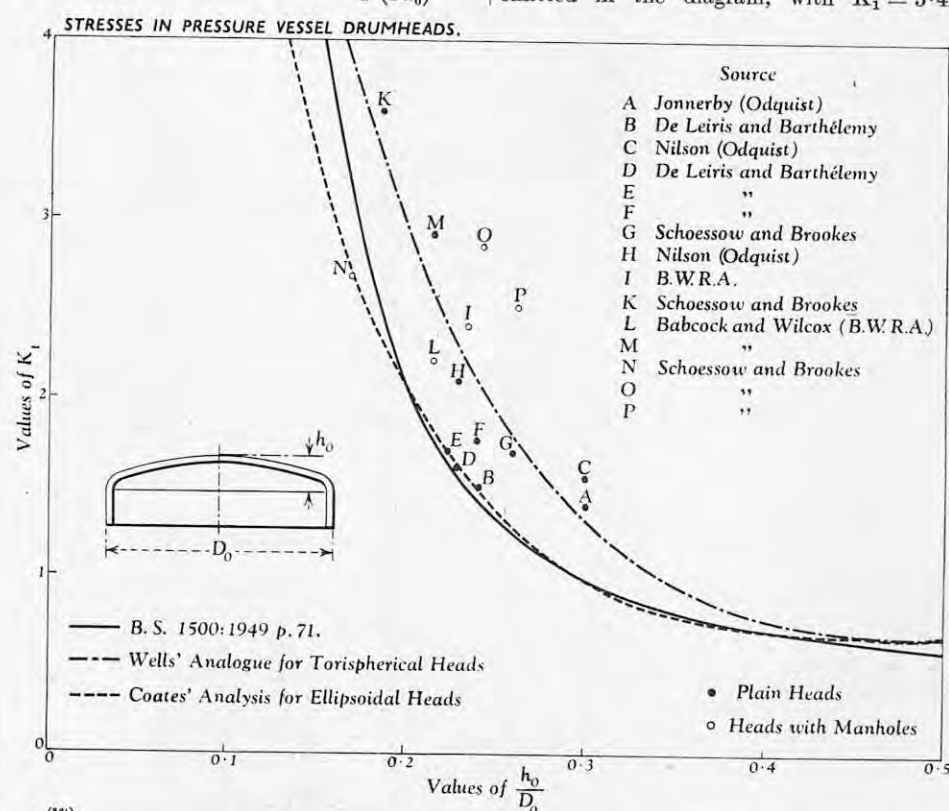
† "On the Solution of Beam-on-Elastic Foundation Problems by Means of a Mechanical Analogue," by A. A. Wells, *Proc. I.Mech.E.*, vol. 163, W.E.P. No. 62 (1950).

These values have been found by calculation to give slightly lower stress-concentration factors than for the cases where the ratios of heel-to-crown radii are maxima. It may also be shown that heads with the radii given above are at least as close in shape to true ellipsoids as those in which the heel-to-crown radii ratios are maxima. Calculations also show that the stress concentration factor for a given $\frac{h_0}{D_0}$ ratio is not sensitive to the heel and crown radii ratio, provided that, as specified on page 69 of B.S. 1500:1949, the heel radius is larger, and the crown radius is smaller, than their respective extreme values for the equivalent ellipsoid.

The theoretical curves presented in this note relating stress concentration factor in the drumhead with the depth ratio, may be expressed fairly accurately over the whole range by the following two simple formulae:—

$$\text{For the torispherical head} \dots K_1 = \frac{1}{2} \left(\frac{D_0}{2h_0} \right)^2$$

$$\text{For the ellipsoidal head} \dots K_1 = \frac{1}{2} \left(\frac{D_0}{2h_0} \right)^{\frac{3}{2}}$$



Other methods of analysing the stresses in torispherical drumheads have been and are being developed, but sufficient numerical results from them are not yet available to permit inclusion in this very practical comparison. Attention is drawn to papers by Salet and Barthélemy in France,* the work of the Pressure Vessels Committee in the United States,† and to the work by Moir,‡ and Fergusson and Kudar§ in this country.

In considering the experimental results indicated on the diagram below and summarised in Table I, opposite, it is necessary to differentiate between them as follows:

(a) The four experimental points obtained from

the work by de Leiris and Barthélemy|| originate from model tests on specimens with ellipsoidal heads, machined from the solid. In spite of the scale relation, these experiments are thought to be as significant as full-scale tests, since the base length of the extensometer used (2 mm.) bore approximately the same relation to the base length of a strain gauge normally used for such investigations ($\frac{7}{8}$ in.) as the models did to a full-size specimen.

(b) The tests communicated by Professor F. K. G. Odqvist and referred to in the diagram under the names of Jonnerby and of Nilson, are stated only with a tolerance of ± 15 per cent. Also, although not explicitly stated to be torispherical or ellipsoidal, the evidence in Professor Odqvist's communication would suggest that the heads were, in fact, torispherical.

(c) The points attributed to Schoessow and Brooks¶ are derived from experiments by Kooistra and Blaser.** Two of the three drumheads without openings, discussed in Schoessow's paper, are of torispherical shape, namely, K and a second point, omitted in the diagram, with $K_1 = 5.42$ and

$\frac{h_0}{D_0} = 0.126$. Points N and O refer to torispherical drumheads with a central manhole opening having pressed reinforcement. Points G and P represent ellipsoidal drumheads, one with no opening (G) and one with an inserted rim reinforcement round a circular opening (P).

(d) Of the Babcock and Wilcox (B.W.R.A.) and the B.W.R.A. results, points L and J were obtained from torispherical drumheads with a central manhole opening, and M with a plain torispherical head.

For all experimental points relating to drumheads with openings (open circles in the diagram), the maximum stresses indicated refer only to the inside

* "Les Contraintes dans les Fonds de Récipients sous Pression," by G. Salet, *Bulletin de la Société Française des Mécaniciens*: 1re Année, No. 1. June, 1951. "Méthode de Calcul des Tensions dans une Enveloppe Flexible de Révolution Soumise à une Pression Normale Uniforme: Application aux Fonds de Réservoirs Cylindriques," by G. Salet and J. Barthélemy, *Assoc. Tech. Maritime et Aeronautique*. Paper 820 (1946).

† "The Basic Elastic Theory of Vessel Heads under Internal Pressure," by G. W. Watts and W. R. Burrows, *Jl. of App. Mechanics*, vol. 16, page 55 (1949). "Stresses in 'Head-to-Shell' Junction of Pressure Vessels," by R. G. Sturm, H. L. O'Brien, E. Wetterstrom and J. Evans, *Welding Journal*, Supp., vol. 15, page 285 (June, 1950).

‡ "Direct and Bending Stresses in Hemispherical Dished Ends," by C. M. Moir, *Jl. of the Royal Tech. Coll.*, Glasgow, vol. 3, part IV (1936); and "Axial Bending

Stresses in Thin Cylindrical Shells with Flat and Spherical Ends," *ibid.*, vol. 4, part I (January, 1937).

§ Kudar, J. See discussion to paper by A. A. Wells: "On the Solution of Beam-on-Elastic Foundation Problems by Means of a Mechanical Analogue," *Proc. I. Mech.E.*, vol. 163 (1950).

|| "Détermination Expérimentale des Tensions dans les Fonds de Réservoirs," by H. De Leiris and J. Barthélemy, *Assoc. Tech. Maritime et Aeronautique*, Paper 886 (1948).

¶ "Analysis of Experimental Data Regarding Certain Design Features of Pressure Vessels," by G. J. Schoessow and E. A. Brooks, *Trans. A.S.M.E.*, page 567 (July, 1950).

** "Experimental Technique in Pressure Vessel Testing," by L. F. Kooistra and R. U. Blaser, *Trans. A.S.M.E.*, page 579 (July, 1950).

of the heel, and not to the larger concentrated stresses at the opening itself.

In most cases, the measured stresses in plain drumheads (full points in the diagram) lie near the theoretical curves for the ellipsoidal and torispherical cases. The experiments do not show any systematic variation of maximum stress with thickness to diameter ratio. Although the experimental points are, with one exception, above the British Standards Institution's curve to varying degrees, it should be borne in mind that the measurements refer partly to extreme fibre bending stresses.

It is a feature of many precise determinations of stresses in engineering structures in common use that the existence is revealed of concentrated stresses greater than those allowed for in design. The useful conception of factors of safety takes these concentrated stresses into account. With special reference to pressure-vessel drumheads in this respect, it appears that a curve such as that of B.S. 1500, when applied to design, gives adequate safety, even when measured maximum stresses give a curve above it, following more closely the analogue solution curve. A method should be devised, therefore, to use stress measurements and calcu-

APPENDIX: EFFECT OF THICKNESS ON DRUMHEAD STRESS-CONCENTRATION FACTOR.

Although it is stated above that the effect of thickness on the maximum stress in a drumhead is not practically significant, it is of interest to examine such evidence as there is on the subject. Experimental evidence is given by Salet* for six ellipsoidal model drumheads of thicknesses varying from $\frac{t_e}{D_0} = 0.01$ to 0.15. For these drumheads, the ratio $\frac{h_0}{D_0}$ was equal to 0.5. Over this large range of thicknesses, the maximum stress at the heel varied almost uniformly with thickness from 1.3 times the circumferential stress in the equivalent cylinder at the smallest thickness to 1.9 at the largest.

Calculations of drumhead stresses usually show the opposite result. Even the precise calculations presented in Salet's paper show this tendency, as do those for the Coates's analysis of ellipsoidal drumheads and the mechanical analogue results for torispherical drumheads. There are at least two reasons for this. All methods of drumhead stress calculation so far developed are obliged to assume, firstly, that the application of pressure causes no

Schoessow and Brooks.* The non-dimensional parameters for thrusts and bending moments given by them for each point in a drumhead are such that, at the point of greatest stress, the stress concentration factor is given by:—

$$K_1 = \left(\frac{T}{P R} \right) + \frac{6 R}{t} \left(\frac{M}{P R^2} \right).$$

In this equation, T and M are the thrust and bending moment per unit width, respectively; P is the internal pressure; R is the internal radius of the equivalent cylinder; and t is the thickness. The non-dimensional parameters plotted by them are $\left(\frac{T}{P R} \right)$ and $\left(\frac{M}{P R^2} \right)$. It is obvious that the second term in this equation is inversely proportional to thickness, so suggesting the existence of infinite bending stresses for the thinnest vessels. This is certainly not true, and it should be recognised that results presented by this means cannot be applied, therefore, to vessels of any other thickness than that of the original experiments.

THE ROYAL AGRICULTURAL SHOW AT NEWTON ABBOT.

(Continued from page 12.)

THE Royal Show, which was held this year at Newton Abbot, closed on Friday, July 4, after having been open since the previous Tuesday. The attendance figures, unfortunately, were lower than for last year, but owing to the complete lack of cloven-hoof livestock, normally one of the principal features of the Show, this was only to be expected. Despite this limitation, however, the general feeling is that the Show proved successful, the amount of business done, particularly in the implement yard, exceeding expectations. We continue below our account of new, or improved, implements.

TRACTOR-MOUNTED GANG MOWER.

Messrs. Ransomes, Sims and Jefferies, Limited, Ipswich, have been associated for a number of years now with the Ford Motor Company, Limited, Dagenham, in the development of implements for use with the latter company's Fordson tractors, and several of their ploughs were being shown on the Ford Company's stand. The exhibits also included a gang mower, which has been developed by Messrs. Ransomes, Sims and Jefferies, Limited, for use in conjunction with the Fordson hydraulically-operated rear implement linkage, the design being such that all mowers can be lifted clear of the ground when required. This arrangement should prove most advantageous when cutting road verges, parks, etc., where it is frequently necessary to negotiate high curbs and footpaths. The mower is illustrated in Fig. 6, on page 42, from which it will be seen that there are three cutting units, each fitted with pneumatic tyres. The cutting units are of the manufacturer's "Sportutter" type and have been designed so that they can withstand continuous hard usage, the width of cut being 7 ft. 2 in. The main frame is constructed from steel tubes and when lowered the complete unit is free to trail from the single-point universal hitch, thus permitting easy manoeuvring round trees and similar obstacles. Accessible thumb-nuts fitted to each cutting unit give rapid but accurate setting of the cutting cylinder in relation to the bottom blade and the units are coupled to the main frame in such a way that, although under directional control, they are free to follow ground undulations.

TRACTOR-MOUNTED HAMMER-MILL.

The exhibits on the stand of Scottish Mechanical Light Industries, Limited, Ayr, Scotland, included the hammer-mill illustrated in Fig. 7, on page 42. This machine has been designed specially for use with the Nuffield "Universal" tractor and is now an approved implement. As will be seen from the illustration, the mill is coupled directly to the hydraulic lift at the rear of the Universal tractor and can, as a consequence, be transported to the

TABLE I.—SUMMARY OF EXPERIMENTAL DATA.

Ref.	Source.	$\frac{h_0}{D_0}$	K_1	$\frac{t_e}{D_0}$	Shape of Head.	Plain Head or with Manhole.
A	Jonnerby (Odqvist)	0.3	1.4	$\frac{3.3}{100}$	Torispherical ..	Plain.
B	de Leiris and Barthélemy	0.24	1.5	$\frac{3.0}{100}$	Ellipsoidal ..	"
C	Nilson (Odqvist)	0.3	1.55	$\frac{1.89}{100}$	Torispherical ..	"
D	de Leiris and Barthélemy	0.23	1.62	$\frac{7.3}{100}$	Ellipsoidal ..	"
E	"	0.225	1.7	$\frac{9.7}{100}$	Ellipsoidal ..	"
F	"	0.24	1.77	$\frac{5.7}{100}$	Ellipsoidal ..	"
G	Schoessow and Brooks	0.264	1.71	$\frac{1.57}{100}$	Ellipsoidal ..	"
H	Nilson (Odqvist)	0.23	2.1	$\frac{0.5}{100}$	Torispherical ..	"
J	British Welding Research Association ..	0.235	2.4	$\frac{4.2}{100}$	Torispherical ..	Manhole
K	Schoessow and Brooks	0.186	3.6	$\frac{1.57}{100}$	Torispherical ..	Plain
L	Babcock and Wilcox (B.W.R.A.) ..	0.22	2.23	$\frac{2.5}{100}$	Torispherical ..	Manhole
M	"	0.22	2.9	$\frac{2.3}{100}$	Torispherical ..	Plain
N	Schoessow and Brooks	0.17	2.7	$\frac{2.2}{100}$	Torispherical ..	Manhole
O	"	0.245	2.8	$\frac{3.5}{100}$	Torispherical ..	Manhole
P	"	0.26	2.5	$\frac{2.3}{100}$	Ellipsoidal ..	Manhole
—	"	0.126	5.42	$\frac{2.3}{100}$	Torispherical ..	Plain

lations in a rational approach to a curve to be used in design.

One such rational approach is to divide the measured or calculated stresses into "heart of plate" and concentrated or bending stresses. For the heart of plate stress, the calculated crown stress in an ellipsoidal drumhead of equal $\frac{h_0}{D_0}$ ratio might be taken. The concentrated stress would then be the difference between this and the value calculated by the analogue and represented by the upper curve in the diagram. Adopting a given factor of safety for the heart of plate stress, and half its value for the concentrated stress, is equivalent to utilising a line on the diagram, midway between the analogue line and the heart of plate line, and approximating fairly to the line of B.S.1500, except for values of $\frac{h_0}{D_0}$ smaller than 0.2. A rational combination of measurement and calculation, on the one hand, and experience, on the other, might then be adopted more generally for pressure vessel design.

Permission to publish this note has been given by Dr. H. G. Taylor, Director of Research, British Welding Research Association, to whom the authors' thanks are due, and by the F.E.12 Committee of the B.W.R.A. on Stresses in Welded Pressure Vessels; but the responsibility for any expressions of opinion or statements of fact rests entirely with the authors.

change of shape, and secondly, that stress distributions through the thickness of the drumhead are linear, even when the material is formed to a radius of curvature comparable with the thickness. The first effect makes measured stresses on thin drumheads smaller than those calculated, since internal pressure produces a more favourable shape, while the non-linear stress distributions due to the second reason raise stresses in thick drumheads above those calculated. In comparison with the magnitudes of these effects, variations of stress concentration factor due to change of thickness, as can be calculated by the methods of Coates, Barthélemy and Salet, and the analogue, will not be significant. The conclusion must be drawn, therefore, that, until more evidence is available, the effect of thickness on the stress concentration factor for design of drumheads cannot be taken into account.

In view of the experimental results due to Salet, mentioned above, it is important to give a warning with reference to the non-dimensional method of presentation of experimental results given by

* "Les Contraintes dans les Fonds de Récipients sous Pression," by G. Salet, *Bulletin de la Société Française des Mécaniciens*: 1re Année. No. 1. June, 1951. "Méthode de Calcul des Tensions dans une Enveloppe Flexible de Révolution Soumise à une Pression Normale Uniforme: Application aux Fonds de Réservoirs Cylindriques," by G. Salet and J. Barthélemy, *Assoc. Tech. Maritime et Aéronautique*, Paper 820 (1946).

* "Analysis of Experimental Data Regarding Certain Design Features of Pressure Vessels," by G. J. Schoessow and E. A. Brooks, *Trans. A.S.M.E.*, page 567 (July, 1950).

required working place without dismantling, and, therefore, losing the alignment. The design is similar in most respects to previous units produced by the firm, which have been described from time to time in *ENGINEERING*. It is driven from the tractor rear power take-off through a flat belt, the geared rear pulley unit supplied with the mill taking approximately ten minutes to fit to the tractor. The supporting frame is coupled to the three-point linkage and it is claimed that correct alignment can be obtained in a few minutes. A wide range of screens is available and grain, sheaves, dried grass or chemicals can be ground to any fineness by selecting the appropriate mesh.

TWIN FRONT WHEEL FOR NUFFIELD "UNIVERSAL" TRACTOR.

Twelve of their Universal tractors fitted with a selection of the latest approved equipment were being shown by the Nuffield Organization, Cowley, Oxford. Two of the tractors were equipped with the new V-twin front wheel; this assembly, which is illustrated in Fig. 8, on page 43, is virtually a single wheel unit and is readily interchangeable with the standard front axle. It should prove most useful, therefore, for row-crop and similar work, where accuracy of steering and quick turning are essential. The unit consists of a pair of 5.50-in. by 16-in. pneumatic tyres fitted to 4.00-in. by 16-in. steel disc wheels having offset naves which permit alternative track widths of 8 in. and 10½ in. to be obtained. As will be seen from the illustration, the tyres each have a deep central rib to give steering stability when riding ridges, etc. The hubs are supported on a crosshead, the vertical shaft of which is carried by taper-roller bearings fitted in a cast housing, the housing, in turn, being bolted to a special "nose" pad attached to the front end of the frame. Steering movement is obtained by means of a horizontal steering shaft which transmits the motion to the vertical shaft through a pair of bevel gears. The outer end of the horizontal shaft carries the drop arm, which is joined to the normal drag link.

DIESEL-ENGINED TRACTOR.

The exhibits on the stand of David Brown Tractors, Limited, Meltham, Yorkshire, included their improved Cropmaster Diesel wheeled tractor, which is equipped with the latest version of the David Brown four-cylinder engine. This machine is illustrated in Fig. 10, opposite, from which it will be seen that it is similar in most respects to its predecessor. The design of the engine follows the makers usual practice, incorporating wet replaceable liners, a monobloc cylinder head fitted with overhead inlet and exhaust valves, shell-type main and big-end bearings, thermostatically-controlled cooling and a vacuum-operated all-speed governor. It has, however, an increased bore, the bore and stroke now being 3½ in. and 4 in., respectively, whereas the bore of the previous model was 3½ in. The maximum brake horse-power, as a result, is now 34 at 1,800 r.p.m., as against 31 for the previous model. The maximum belt horse-power and drawbar horse-power have also been increased, the belt horse-power being 29.5 at 1,800 r.p.m. and the drawbar horse-power 23.5, whereas the previous figures were 27.5 and 19.25 respectively. The design of the tractor remains much as before, the transmission incorporating a twin-range three-speed gearbox designed to give land speeds ranging from 1.73 miles an hour in bottom low gear to 15.6 miles an hour in top high gear, with an engine speed of 1,800 r.p.m., the maximum governed speed. Pneumatic tyres are fitted to all four land-wheels and the track is adjustable from 48 in. to 67½ in. at the rear and from 49½ in. to 62½ in. at the front.

TRACTOR-MOUNTED LOADER.

In common with several other tractor manufacturers, David Brown Tractors, Limited, encourage implement manufacturers to design equipment for use with their machines which, if satisfactory, are officially approved by them. The exhibits on their stand, therefore, included several such implements, a good example being furnished by the loader illustrated in Fig. 9, opposite, which has been developed by Steel Fabricators (Cardiff), Limited, Pengam-road, Roath-sidings, Cardiff, and is known

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

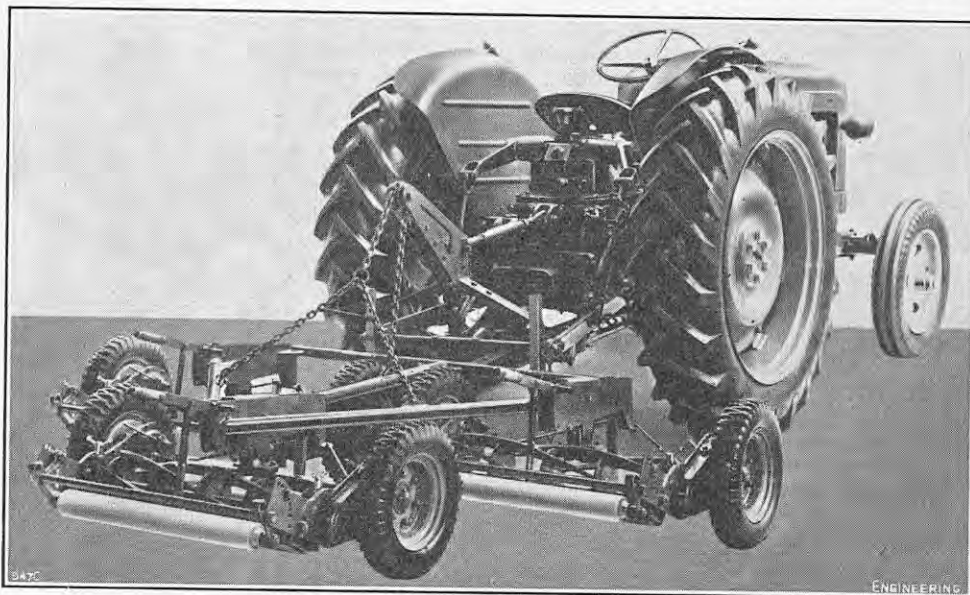


FIG. 6. RANSOMES' MOUNTED GANG MOWER; FORD MOTOR CO., LTD.



FIG. 7. TRACTOR-MOUNTED HAMMER-MILL; SCOTTISH MECHANICAL LIGHT INDUSTRIES, LTD.

as the Horn-draulic loader. Actually, the loader shown at this year's show is an improved version of that described on page 43 of our 170th volume in connection with the 1950 Royal Show. The new loader incorporates several refinements; the distance between the radius arms, for example, has been increased and the arms are now bolted to the rear hubs and to a redesigned front mounting frame now fitted as standard to all tractors in the Cropmaster series. In addition to distributing the load more evenly between the rear axle and the sub-frame, the improved implement is easier to fit and gives the driver more room. Maximum lift has been increased from 8 ft. 6 in. to 11 ft. and the boom has been redesigned so that the apex can be lowered below ground level, thus enabling it to be used in connection with a bulldozing blade. As in the previous model, the boom is raised by two hydraulic cylinder and piston assemblies connected to the hydraulic system of the tractor.

MOUNTED ONE-WAY PLOUGH.

Other approved implements on the stand of David Brown Tractors, Limited, included a one-way plough and a folding harrow. The plough, which is illustrated in Fig. 11, on page 48, has been developed by the Plough and Agricultural Machinery Company, Limited, Bescar-lane, Searisbrick, near Ormskirk, Lancashire. It consists of two separate plough bodies located at the extremities of an arm arranged

across the rear of the tractor. The bodies are opposite handed and are brought into use on alternate furrows by means of a simple mechanism operated from the tractor driving seat. On operating the reversing handle, a gravity pawl engages with a ratchet wheel which, through its spindle, rotates a crank. This actuates an adjustable connecting rod which, by acting through steel quadrant gears, rocks the beam on which the ploughs are mounted about its centre. A simple latch then engages with the ratchet wheel to ensure that the mouldboards are locked in their working positions. A single pressed-steel depth-control wheel suffices for both bodies, the depth being controlled by a handle within easy reach of the driver. This adjustment can be made while the tractor is moving. The depth of working then remains constant irrespective of ground conditions. Three types of body, which are interchangeable, are available, namely, 12-in. semi-digger, 14-in. Continental, and 16-in. deep digger.

FOLDING HARROW.

The harrow is illustrated in Fig. 13, on page 48. This implement has been developed by Teasdale Brothers, Limited, Bank Top Ironworks, Darlington, and, like the majority of implements used in conjunction with David-Brown Cropmaster tractors, has been designed for attachment to the rear implement linkage. It has a working width of 12 ft., but

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, NEWTON ABBOT.

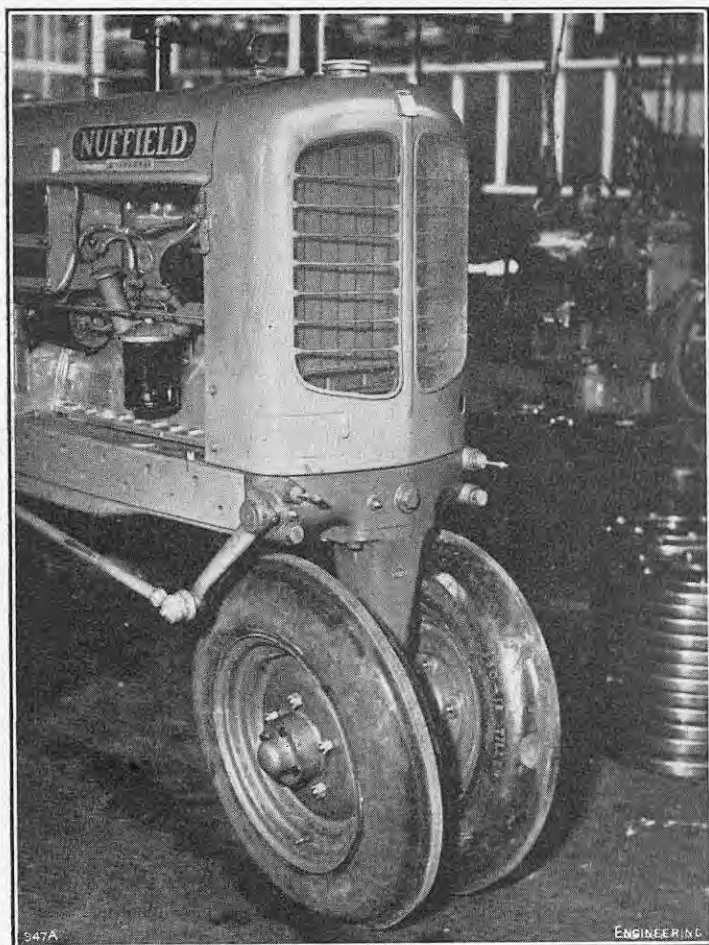


FIG. 8. TWIN FRONT WHEEL FOR "UNIVERSAL" TRACTOR; THE NUFFIELD ORGANIZATION.



FIG. 9. "HORN-DRAULIC" LOADER FOR "CROPMASTER" TRACTOR; DAVID BROWN TRACTORS, LIMITED.

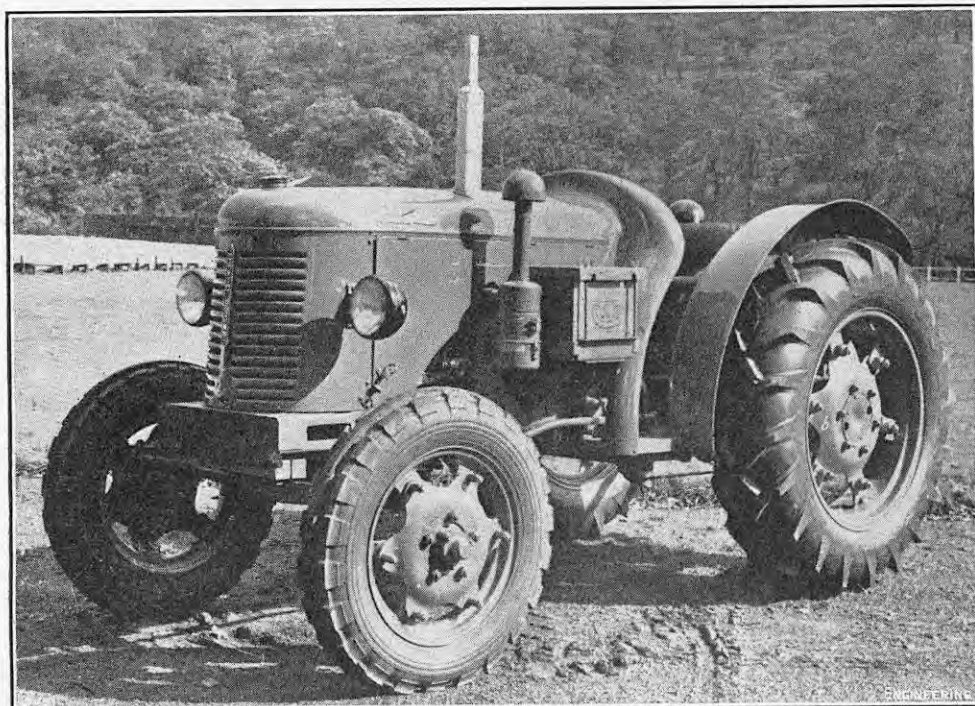


FIG. 10. "CROPMASTER" DIESEL TRACTOR; DAVID BROWN TRACTORS, LIMITED.

can be folded to 7 ft. 9 in. for transport purposes. To enable this to be accomplished, the main tubular whippetree and angle-iron tripod coupling are both provided with hinged joints which enable the two outside sections to be folded towards the centre. To strengthen the joints in the main framework, sliding tubes are provided which slide 6 in. inside the whippetree. When the harrow is being folded, the tubes are withdrawn to clear the joints and, after folding is completed, are allowed to engage in

the end sections thereby locking the implement in the folded position.

NARROW-TRACK TRACTOR.

David Brown Tractors, Limited, were also showing the narrow-track Cropmaster tractor illustrated in Fig. 12, on page 48. This machine has been designed for use in orchards, vineyards, plantations, etc., where working space is restricted. In general, the specification is similar to that of the standard

Cropmaster tractor, but several modifications are incorporated to prevent fouling of plants and low branches. Reduction of the rear track width has been obtained by fitting special housings to the rear axle; these housings have no protruding locknuts, thereby presenting smooth surfaces to any crops with which they may come into contact. Two sizes of rim and tyre are available for the rear wheels, the minimum track width of $43\frac{3}{4}$ in. being obtained when 9.00×28 pneumatic tyres are fitted; this gives an overall tractor width of $53\frac{1}{2}$ in. The front track has been reduced by replacing the standard axle with a fabricated-steel component of a new type which also has the effect of increasing the ground clearance. Other modifications include the replacement of the usual vertical exhaust stack by a down-swept pipe which gives a smooth bonnet.

ROTARY CULTIVATORS.

Most of the exhibits on the stand of Rotary Hoes, Limited, East Horndon, Essex, have been described in connection with previous Royal Shows. They were, however, showing two new models, namely, the Howard Rotovator "Gem" Series IV machine fitted with a 30-in. cultivating rotor and twin land-wheels, and a 36-in. machine for use with Ferguson and Ford 8N tractors. The "Gem" series IV machine is shown in its new form in Fig. 14, on page 48. Basically, it is similar to the 24-in. model shown for the first time at the 1951 Smithfield Show and, as will be seen from the illustration, is hand-controlled by an operator walking behind. It is driven by a two-cylinder in-line air-cooled petrol engine developing almost 10 h.p. at 2,000 r.p.m., the design being such that a lower-compression cylinder head can be installed and the machine operated with tractor vaporising oil. The transmission consists of a clutch and longitudinal shaft arranged to drive a cross-shaft through a spiral-bevel crown wheel and pinion assembly, the cross-shaft, in turn, driving the cultivating rotor through a roller chain and the land-wheels through spur gears.

(To be continued.)

SURFACE GRINDING MACHINE.

ARTHUR SCRIVENER, LIMITED, BIRMINGHAM, 24.

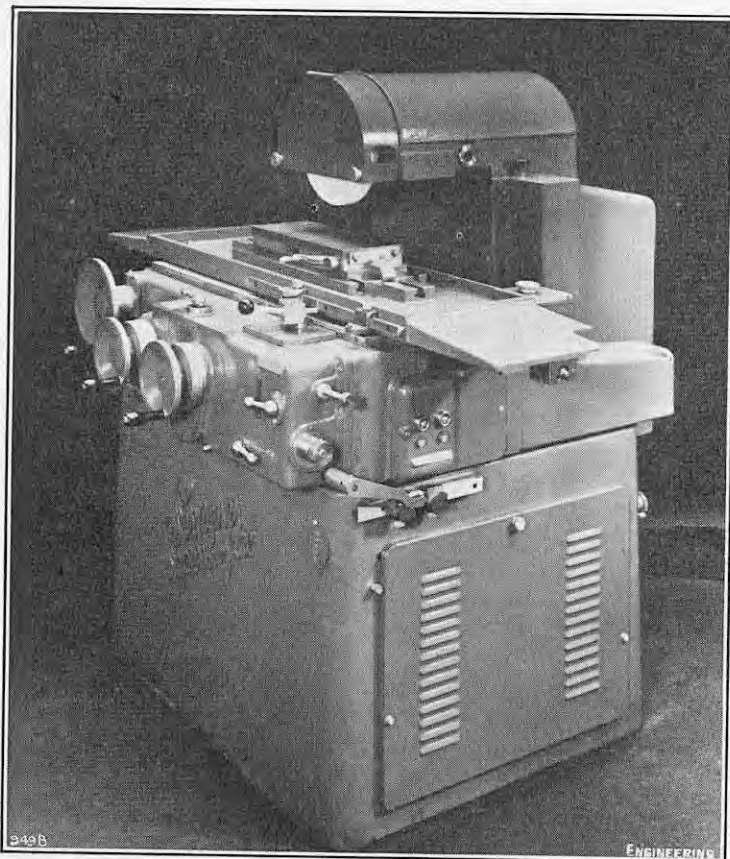


FIG. 1. GENERAL VIEW OF MACHINE.

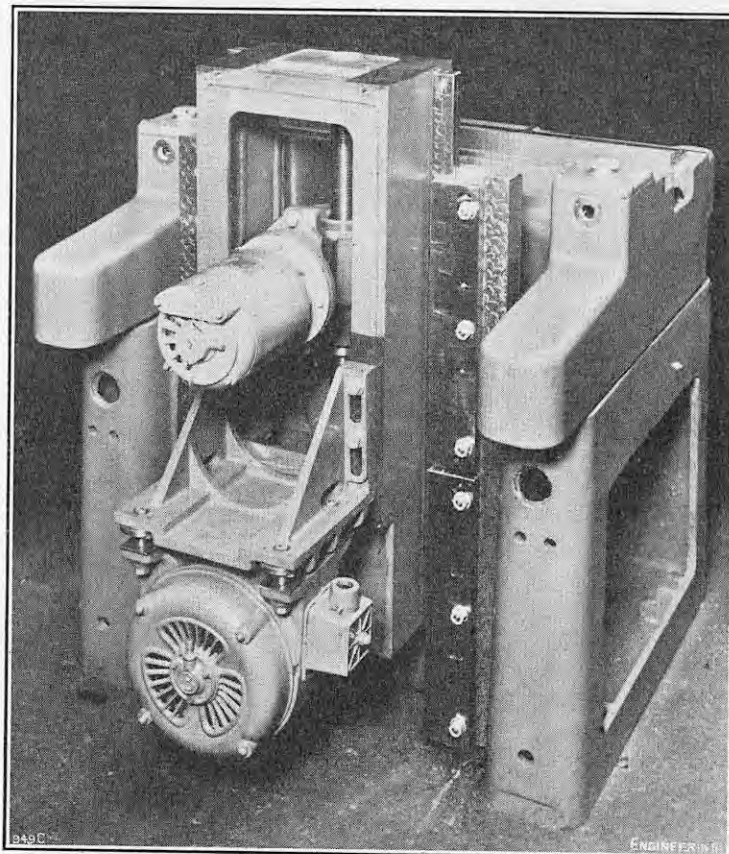


FIG. 2. REAR VIEW WITH WHEEL HEAD AND TABLE REMOVED.

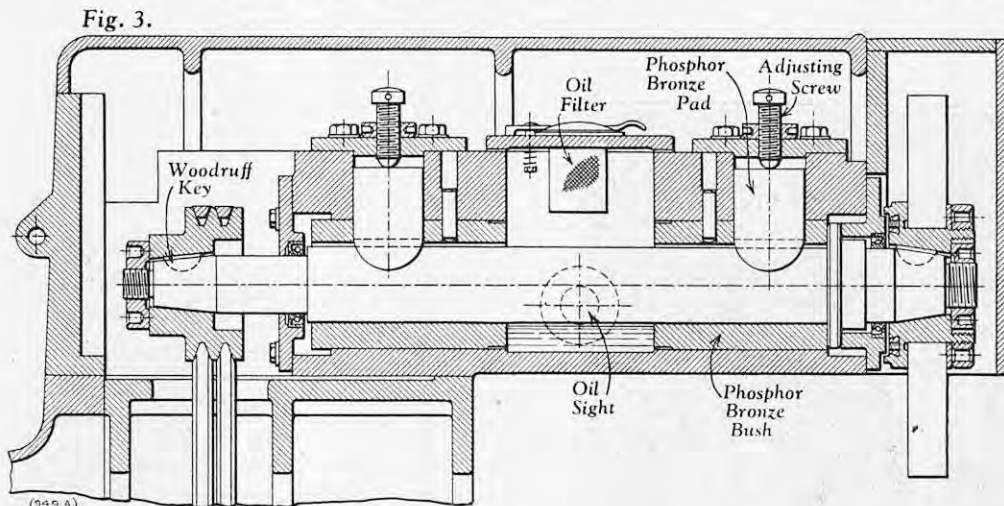


Fig. 3.

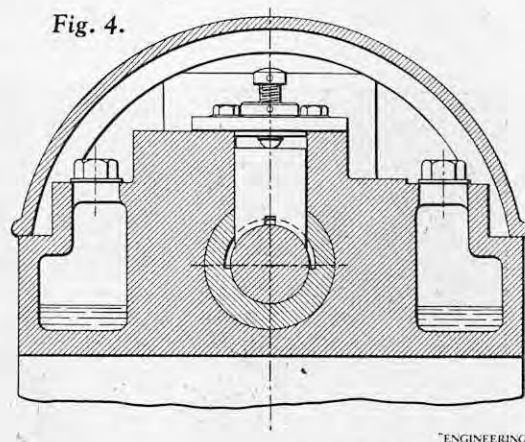


Fig. 4.

SURFACE GRINDING MACHINE.

In Figs. 1 to 4, above, and Figs. 5 to 8, on the opposite page, we illustrate a surface grinder recently produced by Messrs. Arthur Scrivener, Limited, Tyburn-road, Birmingham. The manufacture of surface grinders represents a relatively new departure for the firm, who entered this branch of machine-tool production only this year. The present machine is the largest of the designed range and is being put on the market as the "Super" surface grinder; it has a grinding wheel 10 in. in diameter and 1 in. thick, mounted on a spindle 2 in. in diameter and 22 in. long, which is driven at 1,740 revolutions per minute. Fig. 1 shows the general appearance of the machine and Fig. 2 the method of mounting the motors; in Fig. 2, it will be observed, the table and the wheel head have been removed. Sectional arrangement drawings of the wheel head are reproduced in Figs. 3 and 4. Figs. 5 and 6, opposite, respectively show the saddle with its slides for the worktable, and the base of the machine, with the slides for the saddle; the

narrow central slide in Fig. 6, is the guide for the cross travel. The slides remain covered throughout the full travel of the table and saddle. Fig. 7 is a view of the wheel head, with the cover raised, and Fig. 8 shows the lead screw and nut for the vertical-feed drive.

The work-table measures 8 in. by 18 in. and can be traversed either hydraulically or by hand. The valve gear in the hydraulic circuit is designed to ensure smooth reversal at table speeds up to 40 ft. a minute. The longitudinal travel of the table is 19 in., and the cross travel of the saddle which carries the table is 9½ in. Hand operation of the table traverse is by the left-hand wheel of the three on the front of the machine, to be seen in Fig. 1, and the middle handwheel operates the cross feed. Normally, however, the cross feed is automatic, in increments up to 0.050 in.; it is actuated by trip dogs, which can be set for automatic disengagement at any desired point, and is controlled by the central lever on top of the saddle (Fig. 1). The lever to the operator's right, with the black knob, is the table reversing trip. The wheel for hand operation of the cross feed is graduated in

divisions of 0.01 in., for use in its normal position; pulling this handwheel forward engages a fine-feed gear, with readings to 0.001 in.

The wheel-head has a power-operated vertical movement for rapid setting, driven by a separate motor, and has a maximum travel of 12 in., which gives a clearance of 10 in. between the top of the table and the periphery of a new wheel. The power vertical feed is controlled by the upper of the two small levers on the front of the machine, to the right of the handwheels. This enables the wheel-head to be moved rapidly to or from the work, at a maximum rate of 7½ in. a minute, or "inched" as the grinding wheel approaches the work. The final movement of the head is by means of a fine-feed handwheel (the right-hand wheel of the three on the front) which is graduated in divisions of 0.0001 in. An interlock prevents simultaneous engagement of the hand and power motions.

The grinding-wheel spindle is supported in two solid phosphor-bronze bearings, flood-lubricated, the adjustment of the running clearance being by two phosphor-bronze pads, to be seen in Figs. 3 and 4, which bear on the upper surface of the

SURFACE GRINDING MACHINE.

ARTHUR SCRIVENER, LIMITED, BIRMINGHAM, 24.

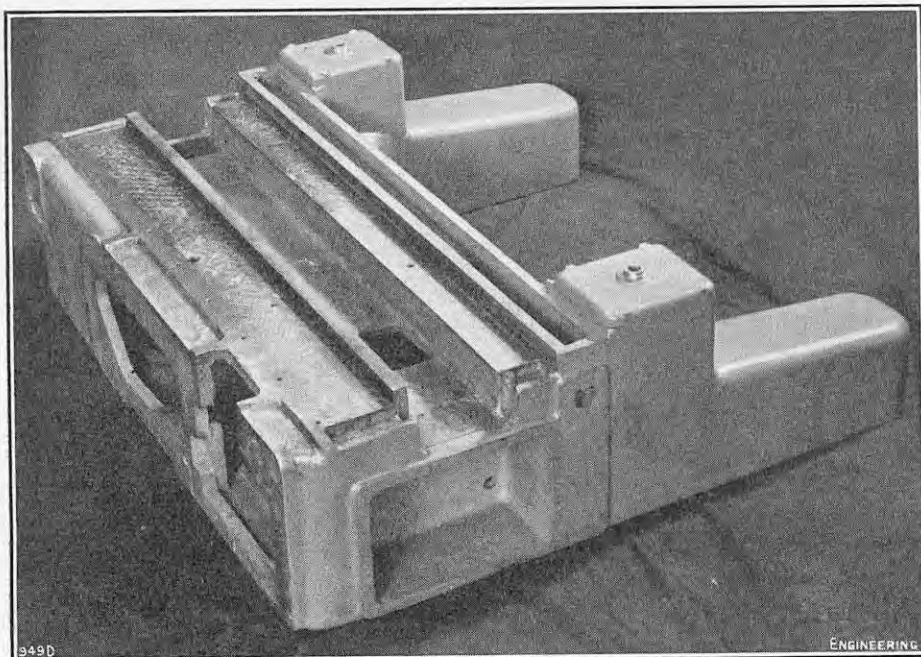


FIG. 5. SADDLE, SHOWING SLIDES FOR TABLE.

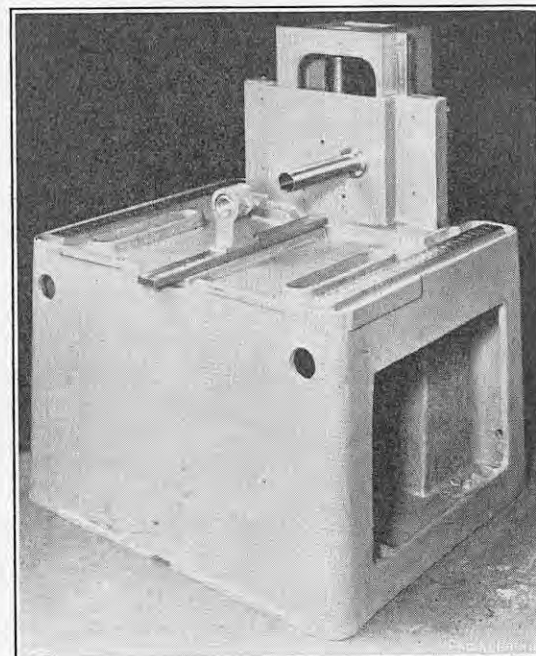


FIG. 6. BASE, SHOWING SLIDES FOR SADDLE.

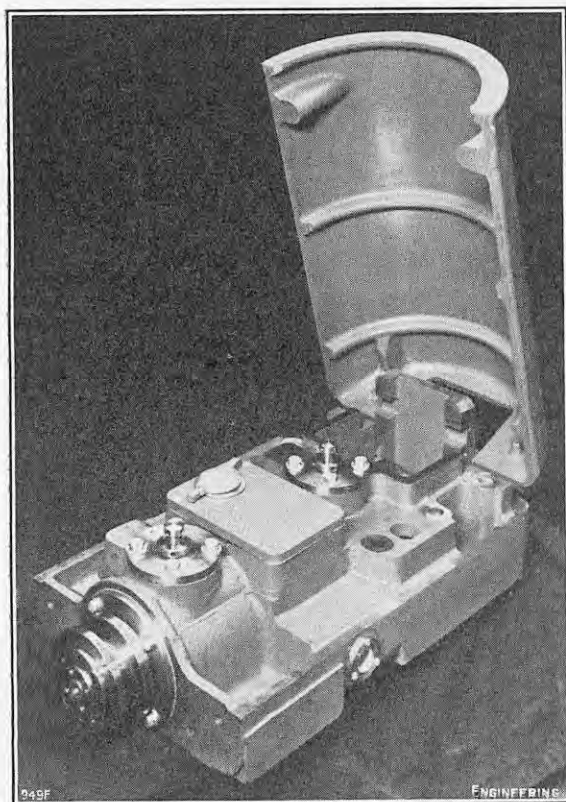


FIG. 7. WHEEL HEAD.

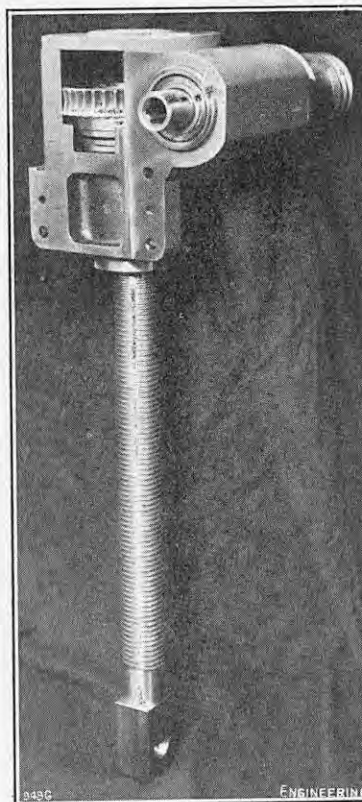


FIG. 8. DRIVE FOR VERTICAL FEED.

spindle and are held down by fine-thread adjusting screws, with locknuts, passing through cap plates bolted to the main head casting. An oil strainer is provided under the filler cap. The drive to the spindle is by twin V-belts. A diamond truing cutter is mounted on the wheel head.

The hydraulic pump, driven by a 1-h.p. motor, is housed in the base of the machine, over an oil reservoir with a capacity of 9½ gallons. It supplies power for all movements of the table and saddle, and can be cut out by the lower of the two levers on the front of the saddle. On the right-hand side of the saddle are the "start" and "stop" push-buttons, a cut-out for the power cross-feed, the cross-feed speed control and the table-traverse speed control. The machine occupies a floor space of 6 ft. 9 in. by 5 ft., and weighs 35 cwt.

FRANCO-BRITISH JOINT TELEVISION PROGRAMMES.

ONE of the problems that had to be solved in connection with the Franco-British joint television programmes, which began last Tuesday, and of which we gave some details on page 31, *ante*, was the conversion of the signals from the French 819-line system to the British standard of 405 lines. The conversion of one television signal to another is impossible unless the picture information is recorded in some way, however temporary, and re-scanned at the appropriate speed. The most convenient form in which to record the information is that of an actual picture and in the converter installed at Cassel the screen of a cathode-ray tube is used for this purpose.

The basic idea of the conversion process is very simple. It consists in displaying the picture with the original number of lines on the screen of a cathode-ray tube which is re-scanned by a television camera operating on the number of lines normally used at the receiving end of the circuit. In developing this converter a considerable amount of experimental work was carried out. This showed that it was necessary to display the picture to be converted on a tube having a phosphor, the delay time of which was comparable with that needed to scan a single frame of the television image. By this means the camera views an image which is virtually continuous during one frame. The use of a phosphor with long persistence has the further advantage that the exposure time is increased, with the result that a greater signal output is obtained from the camera. The phosphor in the cathode-ray tube, which is being used at Cassel, is zinc beryllium silicate. This has an exponential decay characteristic such that the brightness of any particular point in the image falls to about 28 per cent. of its original value during one frame scan. The camera that is being employed to re-scan the picture at the British 405-line standard is a Marconi Image-Orthicon.

In addition to the main transmitting equipment, a 20-watt very high-frequency modulated transmitter/receiver has been installed by Mullard Limited, Shaftesbury-avenue, London, W.C.2, at Cassel, Alembon, Swingate, Wrotham and London to enable continuous radio-telephone contact to be maintained for programme cueing and engineering purposes. Each combined set is capable of providing spot frequencies in the 65 to 100 and 154 to 187 megacycle bands, with a high order of frequency stability. In place of the normal mobile control unit, such as is provided when these sets are used for police or fire purposes, control is effected from a console containing additional amplifier stages, over-modulation indication, telephoto/facsimile input connections, and a loud speaker. The aerials consist of broad-band ground-plane unipole systems with three vertical quarter-wave radiators arranged in cone formation. The 49-mile link from Swingate to Wrotham, which is the longest covered in a regular service, is provided by equipment supplied by Electric and Musical Industries, Limited, Hayes. Apparatus of a similar type is being used on the 40-mile cross-channel link between Alembon and Swingate. The first public transmission, on Tuesday, July 8, was for a time unfavourably affected by a thunderstorm, but the results on the following days were good.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

NEW BLAST FURNACE AT CLYDE IRON WORKS.—As part of a 12,000,000/- development plan for the Scottish iron and steel industry, a new blast furnace is to be built at the Clyde Iron Works of Colvilles Ltd., Tollcross, Glasgow. It will have a hearth diameter of 25 ft. 6 in., and will incorporate the top-pressure system. The furnace will have an output of 365,000 tons of pig iron a year and is expected to be ready for operation in 1955. A programme of coke-oven erection at the same works is due to be completed in September next; this will double the present capacity. The provision to new wharfage facilities at the general terminus quay is also planned, so that 12,000-ton ore carriers will be able to discharge ore there for transport by rail to the Clyde Iron Works. The self-trimming ore ships employed will be capable of discharging at a rate of 1,000 tons an hour.

THE COAL INDUSTRY.—On account of the operation of an 11-day fortnight as against a five-day week, coupled with an increase in the personnel of almost 3,000, bringing the total up to 85,000, the weekly coal production in the Scottish Division is running at about 20,000 tons higher than a year ago. Exports are expanding slowly, but inland consumers are consolidating stocks for next winter. Power stations and iron and steel works, for example, have some 50 per cent. more in reserve than in 1951. Large screened coal is easier than it has been for some time, and good progress is being made with the building of merchants' stocks.

CLYDE COAL EXPORTS.—A cargo of 7,500 tons of coal (washed smalls) is loading in the vessel *Enrica Mazzerella* at Rothesay Dock this week for Italian ports. This is the first shipment of coal from the Clyde to that country for a number of years, and exporters hope that it will indicate an expansion of shipments from the Clyde. Cargoes and bunker coal dispatched from Glasgow totalled 319,797 tons during the year to May 31, 1952, against 1,708,761 tons in the 12 months to June 30, 1939. Coal exports from Scottish ports during May last aggregated 89,114 tons, compared with 86,017 tons in May, 1951. Consignments in April amounted to 66,788 tons.

SURVEY OF COAL CONSUMPTION IN HOSPITALS.—The Scottish Fuel Efficiency Committee decided, at a meeting on June 27, to request the Department of Health for Scotland to consider the advisability of conducting a survey of hospitals with a view to saving coal in these institutions. More than 60 industrial plants have already been surveyed, and a saving of about 25 per cent. has been effected in their use of fuel. The Ministry of Fuel and Power's mobile unit is fully booked until November.

STEEL PRODUCTION AND EXPORTS.—With a slight seasonal improvement in scrap supplies, steelmakers in the district find it less difficult to maintain the recent scale of production. Scrap imports are disappointingly low, but collections from home sources are rather higher. The pressure upon makers and re-rollers for the delivery of steel remains very strong. Supplies are slightly improved as a result of unresponsive export markets; only the Commonwealth countries are showing any great interest in Scottish steel. A fair tonnage is being shipped, however, to Sweden, Finland, and Holland under bilateral trade agreements.

HARVESTING SEAWEED.—Experiments with the two principal methods of harvesting deep-growing seaweed will be carried out off Dunbar next month by the Institute of Seaweed Research, Musselburgh. Two vessels carrying the latest equipment will make the tests.

ROLLS-ROYCE AERO-ENGINE WORKS, EAST KILBRIDE.—Work has begun on the test-bed supplementary contract for the factory of Rolls-Royce Ltd. at East Kilbride. The working of the test-bed plant, which is being erected a mile from the boundary of the new town, is expected to be almost noiseless, equipment having been designed to suppress the noise commonly associated with aero-engine testing.

SOCIETY OF CHEMICAL INDUSTRY.—The annual meeting of the Society of Chemical Industry is being held in Aberdeen from July 7 to 12, for the first time in that city. The Messel Medal address was given by Sir Henry Tizard and the Lister memorial lecture by Professor Alexander Haddow. The President of the Society is Mr. John Rogers, chairman of Imperial Chemical Industries Ltd. The next President will be Mr. Francis Curtis, a director of the Monsanto Chemical Company, New York.

CLEVELAND AND THE NORTHERN COUNTIES.

TELESCOPE MIRROR FOR AUSTRALIA.—Sir Howard Grubb, Parsons & Co., Ltd., Walkergate, Newcastle-on-Tyne, have completed a mirror, 74 in. in diameter, for a telescope for Mount Stromlo Observatory, Canberra, Australia. The mirror, 11½ in. thick and weighing 1½ tons, has taken about 14 months to make. The telescope in which the mirror will be mounted was also made by Sir Howard Grubb, Parsons & Co. and was exhibited at the Festival of Britain Exhibition last year. It was subsequently shipped to Australia. The mirror has passed its tests and will be sent to Australia in the near future.

CONSETT No. 2 BLAST FURNACE.—After being relined, heightened, and provided with a hearth 20 ft. in diameter in place of the former 19-ft. hearth, the No. 2 blast furnace of the Consett Iron Co., Ltd., has been blown in again and is now expected to produce 5,000 tons of pig iron a week. The furnace was built in 1943 and was in continuous service until September, 1950, when it was taken out of operation for alterations as part of the development scheme described in our 171st volume, on page 13. Before the reconstruction it had produced 1,270,685 tons of iron at a rate of over 3,200 tons a week.

WORK ON JET ENGINES FOR JARROW.—The former joiners' shop of Palmers Shipbuilding and Iron Co., Ltd., Jarrow-on-Tyne, has been taken over by Sir W. G. Armstrong Whitworth & Co., Ltd., Gateshead, for the production of components for Rolls-Royce jet engines. The premises cover 40,000 sq. ft. on three floors. About 70 men and women are working there at present, but when all the machines have been installed about 200 persons will be employed.

WEAR IMPORT-EXPORT STATISTICS.—Figures issued by the River Wear Commissioners show that, in May, 292,567 tons of coal and coke were shipped from the Wear, an increase of 11,624 tons on May, 1951, but 81,855 tons less than in May, 1938. For the five months of the year, shipments totalled 1,371,405 tons, or 62,563 tons more than the corresponding period of last year, but 489,145 tons less than in the pre-war period. So far this year, 323,079 tons have been sent to foreign ports, compared with 191,270 tons in 1951 and 880,207 tons in 1938. Imports of general merchandise, during January to May, 1952, amounted to 200,026 tons, compared with 183,888 tons in January to May, 1951. The main imports comprised 65,147 tons of iron ore, 19,989 tons of cement, and 81,461 tons of petroleum. Exports of general merchandise during January to May, 1952, amounted to 43,878 tons, the chief item being 34,961 tons of petroleum products. Exports of engines for new ships totalled 2,581 tons.

EXTENSIONS AT SMITH'S DOCK CO., LTD.—Plans have been approved for an extension of the joiners' shop at Smith's Dock Co.'s shipyard at South Bank-on-Tees. The extension will measure 181 ft. by 68 ft. It is proposed to extend the frame shop also, by taking in an area measuring 199 ft. by 48 ft.

TENDER FOR BRIDGE IN NEW ZEALAND.—A joint tender amounting to 4,236,036/-, submitted by the Cleveland Bridge & Engineering Co., Ltd., Darlington, and Dorman, Long & Co., Ltd., Middlesbrough, is being recommended for acceptance for the construction of a bridge 4,000 ft. long and with five lines of traffic, at Auckland Harbour, New Zealand.

LANCASHIRE AND SOUTH YORKSHIRE.

RAILWAY WORK AND WAGON BUILDING IN SHEFFIELD.—A system of flow-production adopted at the railway carriage and wagon works, Darnall, Sheffield, 9, of Cravens Railway Carriage & Wagon Co., Ltd., will ensure the absence of delivery delays on various contracts which will occupy at least two years. Railway carriages and train sets for the Gold Coast are to be built, and other orders are for Diesel railcars for Australia, luxury coaches for Portugal, and air-conditioned carriages for Iraq. Wagons are also being constructed for Australia, Malaya, Rhodesia, New Zealand and Nigeria.

PURCHASE TAX CONCESSIONS.—At the Forfeit Feast of the Cutlers' Company of Hallamshire, held on July 4, Mr. W. G. Ibberson, President of the Sheffield Chamber of Commerce, welcomed the announcement that Mr. Boyd-Carpenter, Financial Secretary to the Treasury, was willing to meet industrialists on the question of purchase tax. He hoped that the result of the forthcoming negotiations would result in its complete abolition on such essentials as tools and cutlery.

THE LATE MR. J. R. STRUTHERS.—We note with regret the death of Mr. John Russell Struthers, which occurred in Belfast at the beginning of July. Mr. Struthers was well known in Sheffield, where he had been general manager and engineer of the Corporation Electricity Department for 13 years. In 1948, after the nationalisation of the electricity-supply industry, he was made manager of the Sheffield sub-area of the Yorkshire Electricity Board. He retired in 1949 and went back to Belfast, where he had previously served as deputy city electrical engineer and manager. Mr. Struthers was elected an associate member of the Institution of Electrical Engineers in 1919 and was transferred to the class of member in 1928.

THE LABOUR POSITION IN SHEFFIELD.—At a meeting of the Sheffield and District Employment Committee, held on July 1, it was reported that there was a shortage not only of skilled draughtsmen but also of labourers for hot and heavy work in forges, rolling-mill plants and foundries. Attempts had been made to obtain men able and willing to do work of this type, in neighbouring areas, but, so far, these had met with little or no success. On the other hand, the demand for women for unskilled work had fallen off considerably during recent weeks. Short-time working in the cutlery industry was not general, but was confined to certain firms affected by the cancellation of orders from Australia, and elsewhere overseas. Broadly stated, the principal labour problem of Sheffield, at present, was that the skilled men available were too few and the unskilled women wanting work were too numerous.

THE MIDLANDS.

PROPOSED TRUNK ROADS IN WARWICKSHIRE.—Warwickshire County Council have published details of the new high-speed motorways which the Ministry of Transport propose to construct in the county. The first priority will go to a trunk road from Birmingham to South Wales and Bristol, and of almost equal importance will be a similar road between Birmingham and London. To link these two main roads there will be a ring road round the south of Birmingham, which will be known as the Birmingham southern orbital route. It will pass between Solihull and Knowle. A proposed new route from London to Leeds will also cut through a part of Warwickshire.

WALSALL DEVELOPMENT PLAN.—At a public inquiry held at Walsall on the first three days of this month, the Town Clerk of Walsall, Mr. W. S. Brookes, gave an outline of the development plan for the town. The present population of Walsall is over 114,000, and the plan proposes a reduction to 105,000 by means of re-housing projects outside the borough, an arrangement which has been allowed for in the development plan prepared by Staffordshire County Council. Walsall, like most Black Country towns, has large areas of mixed industrial and residential property, and a considerable movement of industry is proposed. Much of the development of the town is planned to take place on land which is at present derelict as a result of former mining operations.

RE-OPENING OF LIMESTONE WORKINGS.—The underground limestone workings at Linley, Daw End, Staffordshire, which have been idle for 12 years, are being prepared for re-opening. The Daw End district was one of the three major limestone-producing areas which supplied stone and lime to the Black Country for centuries. The other two, Dudley Port and Dudley Castle, closed down many years ago, but the Linley quarries only ceased work when they were requisitioned by the Air Ministry at the beginning of the recent war. They were used for storage purposes for a number of years. Some of the workings are flooded, but pumping is in progress, and it is expected that production will start in the near future.

STUDY OF LABOUR TURNOVER.—The Wolverhampton Junior Chamber of Commerce has issued a report on its investigation of the causes and effects of labour turnover in industry, which points out that a certain amount of labour turnover is necessary for flexibility. It is urged that nothing should be done to restrict the freedom of choice of either employers or employees. On the question of causes, the report has much to say, and lists many reasons which have been given by persons seeking to change their employment. Some could only be called frivolous, but were sufficiently numerous to be worthy of record. The greatest single factor, the report says, is poor selection of labour in the first place. It comments on the fact that, during the period of labour shortage, many employers were prepared to accept any labour which presented itself, without inquiring closely into the question of suitability.

PUBLIC TRANSPORT LOSSES.—The Birmingham City Transport Department's annual report, published on

July 3, shows that the Department incurred a loss last year of 390,308*l.* on its public transport services. The city now operates 1,663 buses, which covered a total of 43,115,378 miles during the year. The cost of operating the buses increased by 2.668*l.* per vehicle per mile, the rise being accounted for by the fuel tax in particular, though there had also been wage increases. Increases were also recorded in the prices of all the items which the Department purchases for normal maintenance purposes. As a result, application has been made for permission to raise the fares, and a public inquiry is to be held. It will probably take place on July 16.

THE IRON AND STEEL FEDERATION'S SECOND DEVELOPMENT PLAN.—The British Iron and Steel Federation's declared intention to raise steel output to a total of 20,000,000 tons a year, and the emphasis laid on the use of large integrated plants with a production of 750,000 to 1,000,000 tons a year, has aroused considerable speculation regarding the possible effects in the Midlands. At present, the area has three steelworks, and only one is an integrated plant. Extensions are taking place there which, in the course of three years, will raise the output to over 600,000 tons a year. One of the other works has just been modernised, and, though it is not an integrated plant, it is well situated to take advantage of the large volume of scrap available in Birmingham and district. Both these works will play their part in the plan for increased output, but there is little or no likelihood of any new plant being erected in the area, which, having no coking coal or iron ore, offers no advantages for the building of further iron or steel works.

SOUTH-WEST ENGLAND AND SOUTH WALES.

EMPLOYMENT AT MERTHYR.—In spite of a great deal of redundancy in one factory in the area, the industrial position at Merthyr has not deteriorated to any marked degree, according to Captain H. K. Oram, Wales Controller, Board of Trade; though he admitted that the number of local unemployed was only 100 more than in June, 1951.

THE SOUTH WALES INSTITUTE OF ENGINEERS.—The new President of the South Wales Institute of Engineers is Mr. John Griffiths, who, at the same time, became President of the South-Western Society of Mining Engineers, the two bodies having merged under the title of the former. Mr. Griffiths started work in the pits 63 years ago. In 1938, he retired from active employment with the Ocean Coal Co., Ltd., after completing 50 years with that firm. At the time of his retirement, he was general manager. He then became consulting engineer to the whole Ocean and United National group of collieries. Mr. Griffiths is a member of the National Association of Colliery Managers and has been chairman of the Monmouthshire and South Wales Coalowners' Association.

IMPORTS OF PIG IRON.—Swansea docks were so busy during the first few days of July that four ships with cargoes of pig iron had to be diverted to other South Wales ports; three went to Newport and the fourth to Port Talbot. Sir Lewis Jones, secretary of the South Wales Siemens' Steel Association, said that the diversion of a total of 7,400 tons of pig-iron was a serious matter for Swansea steelworks, for whom the cargoes had been intended, because a number of furnacemen were idle for lack of pig iron. The consignments, he added, would have to be taken back to Swansea at considerable expense and delay. A new blast furnace has been blown in at the Margam works of the Steel Company of Wales, Ltd.; the second to be erected as part of the development plan which has been in progress at the works since 1947. It has a capacity of 1,000 tons a day.

NOTICES OF MEETINGS.

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.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*South-West London Branch:* Wednesday, July 16, 7.15 p.m., Guild House, Worpole road, Wimbledon, S.W.19. "Power Factor Correction," by Mr. J. Fletcher and Mr. T. A. Williams.

ROYAL SANITARY INSTITUTE.—*Leamington Spa Meeting:* Thursday, July 17, 10 a.m., Town Hall, Leamington Spa. Various papers, including "Post-War Housing in Rural Areas," by Mr. B. L. Stephenson.

ASSOCIATION OF BRONZE AND BRASS FOUNDERS.—*London Area:* Thursday, July 17, 12.15 p.m., Clarendon Restaurant, 1, Hammersmith Broadway, Hammersmith, W.6. Luncheon Meeting. "Pressure-Tight Gunmetal Castings," by Mr. E. C. Mantle.

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.

Chart Ranges for Temperature-Recording Instruments.—A new specification, B.S. No. 1794, makes recommendations for the temperature range of charts used in recording instruments of the gas-expansion, mercury-in-steel, platinum/rhodium v. platinum thermocouple, resistance-thermometer and radiation-pyrometer types. As the preferred ranges have been compiled from data supplied by many instrument manufacturers, their calculation has been achieved by grouping and consolidating the ranges favoured by individual users. Although these chart ranges embrace the whole of the useful temperature scale, it is appreciated that not every instrument manufacturer will be in a position to adopt them in their entirety. Moreover, the use of the whole of such a comprehensive selection of ranges is unnecessary when instruments are manufactured for a particular section of industry. [Price 2*s.*, postage included.]

Hand-Operated Circuit-Breakers.—A new specification, B.S. No. G.140, in the series for aircraft components has now been published. This is concerned with hand-operated circuit-breakers for use in the nominal 200-volt, three-phase, 400-cycle, alternating-current systems on aircraft. Clauses relating to general construction, design requirements, and type, routine and production tests are included. [Price 1*s.* 6*d.*, postage included.]

Surface Water and Sub-Soil Damage.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued in final form C.P. No. 303, on surface water and sub-soil drainage. It describes methods of collection and disposal of surface water and of ground or sub-soil water, and its provisions are limited to drains not exceeding 12 in. in diameter, such as would serve housing schemes, schools, factories and individual buildings. The new Code is complementary to, and should be read in conjunction with, Code No. 301, on building drainage, with which it is intended to be incorporated when that Code is revised. Useful reminders are given of the information which should be obtained and of the points on which local and other controlling authorities should be consulted before a system of surface-water or sub-soil drains is designed. Guidance is furnished concerning the design of surface-water drains, and methods of disposal of surface water are described in detail. [Price 2*s.*, postage included.]

Sound Distribution Systems.—Another Code of Practice issued in final form by the Council for Codes of Practice for Buildings, Construction and Engineering Services, C.P. No. 327.300, is concerned with sound distribution systems. It forms part of the series on telecommunication services in the group of Codes on electrical installations in and about buildings. The new Code deals with the installation of sound distribution systems in buildings or in open spaces and seeks to establish criteria for satisfactory sound reproduction. The input to the system may be derived from a microphone, gramophone, radio receiver or other device, or from a wire broadcasting service. Advice is given on the necessary consultation at the planning stage and on the choice of materials, appliances and components. Recommendations follow regarding the design of various types of systems, methods of wiring and power supply, and the provision of the necessary structural accommodation for the equipment and the wiring. Sections on installation, testing and maintenance are included. [Price 6*s.*, postage included.]

Chromium-Steel Wire for Aircraft Bolts.—A further specification in the series for aircraft components has now been issued. It is designated B.S. No. S.115 and relates to 1 per cent. chromium-steel wire for the manufacture of cold-forged bolts of $\frac{1}{2}$ -in. shank diameter and over. The full composition of the steel is given, this, incidentally, being that of En 18, in British Standard Specification No. 970. Other clauses are concerned with the process of manufacture, rough machining, hardening tests, condition of delivery, the mechanical properties of the wire as delivered, inspection and testing procedure, and heat-treatment of the finished bolts. [Price 1*s.*, postage included.]

WENVOE TELEVISION STATION.—The British Broadcasting Corporation hope to start daily test transmissions on medium power from the new television station at Wenvoe in west of England on Tuesday, July 15. The tests will normally take place on weekdays, apart from the Bank Holiday weekend, between 11 a.m. and 12 noon and 3 p.m. and 4 p.m. The station is due to be opened on Friday, August 15.

PERSONAL.

HER MAJESTY QUEEN ELIZABETH II has been graciously pleased to grant her patronage to the Institute of Marine Engineers, 85-88, The Minories, London, E.C.3, in continuation of that granted by King George V and King George VI.

AIR MARSHAL SIR HUGH S. P. WALMSLEY, K.C.B., K.C.I.E., C.B.E., M.C., D.F.C., Air Officer Commanding in Chief, Flying Training Command, R.A.F., is resigning to join the Hawker Siddeley Group, as from August 1, as managing director of Air Service Training, the civil aeronautical training establishment at Hamble, in succession to GROUP CAPTAIN R. J. F. BARTON, O.B.E., who is retiring.

MR. H. CECIL BOOTH, now in his 81st year, has retired from the board of the British Vacuum Cleaner and Engineering Co. Ltd., Goblin Works, Leatherhead, Surrey. He has been chairman for 40 years and was for many years also managing director. The new chairman is MR. J. J. HAMBIDGE, who will continue to act as senior joint managing director.

MR. H. W. BOWEN, O.B.E., M.I.Mech.E., M.I.P.E., who recently relinquished his position of managing director of the factories of Electric & Musical Industries, Ltd., at Hayes, MIDDLESEX, has been appointed managing director of the BRITANNIC ELECTRIC CABLE AND CONSTRUCTION CO. LTD., Iver, Buckinghamshire.

MR. R. M. CLARKSON, O.B.E., B.Sc., A.C.G.I., F.R.Ae.S., assistant chief engineer of the de Havilland Aircraft Co., Ltd., Hatfield, Hertfordshire, and MR. A. S. KENNEDY, secretary of the company, have been elected directors.

MR. J. R. HAMMOND, M.B.E., B.Sc., A.M.I.C.E., has been appointed district engineer, Cardiff, Western Region, British Railways.

MR. H. P. POTTS, M.I.Mech.E., managing director of B.S.A. Tools Ltd., has been appointed a director of the Birmingham Small Arms Co. Ltd.

MR. G. B. PROCTOR has resigned his position as transformer sales manager of Ferranti Ltd., Hollinwood, Lancashire. MR. R. M. HOBILL is to assume responsibility for transformer sales management, and MR. H. G. BINNS has been made transformer contracts manager.

MR. SAM SMILEY, F.C.C.A., MR. J. ORWIG JONES, A.M.I.Mech.E., and MR. R. N. FLETCHER have been elected directors of Edward G. Herbert Ltd., Atlas Works, Levenshulme, Manchester, 19. MR. ALAN KIERNAN, M.I.Mech.E., M.I.P.E., has been appointed assistant managing director and MR. TOM HITCHENS, works manager.

MR. L. G. PACKHAM has been appointed overseas general manager of C. C. Wakefield & Co. Ltd., in succession to MR. W. F. LIST, who is now an assistant managing director.

MR. L. L. EMMETT has been elected national chairman of the Association of Supervising Electrical Engineers, 54, Station-road, New Barnet, Hertfordshire, for the year 1952-53.

MR. I. G. MACKNIGHT has been elected President of the Scottish Motor Trade Association.

MR. A. G. NOTT, of Tenbury Wells, Worcestershire, has been appointed a part-time member of the Midlands Electricity Board.

MR. N. D. MILES has been appointed general supply manager to Remington Rand Ltd., Commonwealth House, 1-19, New Oxford-street, London, W.C.1.

MR. R. W. COTTON, who is a vice-president and director of the Philco International Corporation, Philadelphia, U.S.A., has been appointed director of the Electronics Division and chairman of the Electronics Production Board, Defence Production Administration, National Production Authority, U.S. Department of Commerce.

MR. G. W. TREMLETT has resigned his directorship of Metalock (Britain) Ltd., Grand Buildings, Trafalgar-square, London, W.C.2, owing to ill health. Two new directors, MR. H. A. PAGET and MR. NORMAN TINWELL, have been elected.

MR. K. C. BOWYER, secretary, and MR. CHARLES INSCH, general sales manager, Aga Heat Ltd., Smethwick and Ketley, have been elected directors of the firm.

ACHESON COLLOIDS, LTD., have opened a West of England office at 103, Promenade, Cheltenham. (Telephone: Cheltenham 3847.)

KENNETH HUDSON & SON, Elland, Yorkshire, have become members of the OWEN ORGANISATION, the headquarters of which are at RUBY, OWEN & CO. LTD., Darlaston, South Staffordshire. Messrs. Hudson are removing to a new factory at Darlaston.

The manufacture of the BERGER HANDRAULIC STARTER for Diesel engines, hitherto conducted at the Cardiff works of the HOPKINSON ELECTRIC CO. LTD., is to be transferred to the works at Staines, Middlesex, of BRYCE FUEL INJECTION LTD.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, NEWTON ABBOT.
(For Description, see Page 41.)



FIG. 11. "PAMCOL" ONE-WAY PLOUGH FITTED TO "CROPMASTER" TRACTOR;
DAVID BROWN TRACTORS, LIMITED.



FIG. 12. NARROW-TRACK TRACTOR; DAVID BROWN TRACTORS, LIMITED.

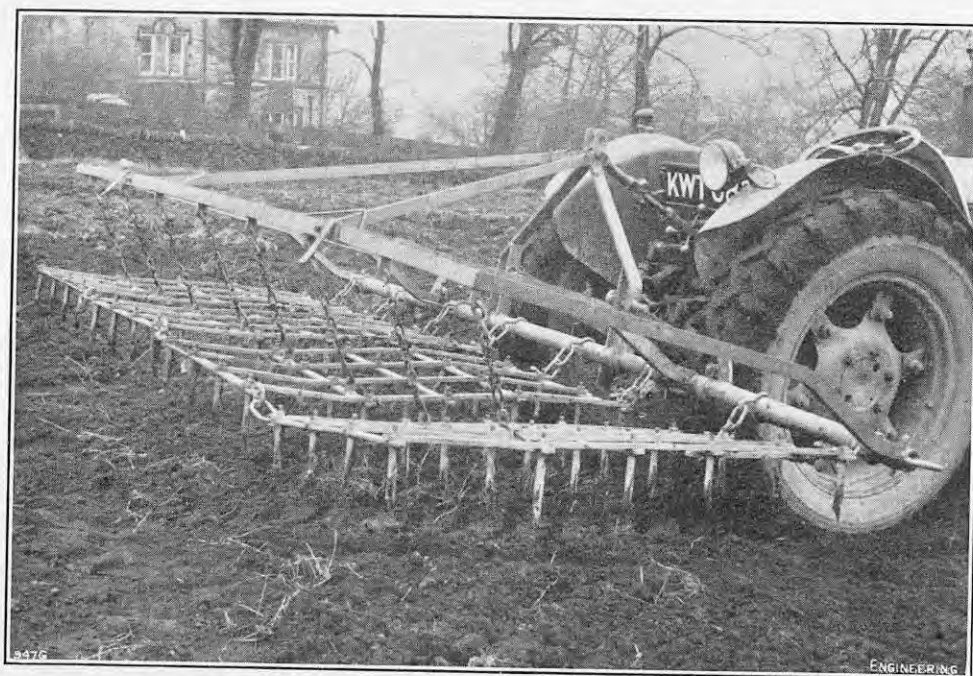


FIG. 13. "TEASDALE" FOLDING HARROW; DAVID BROWN TRACTORS, LIMITED.



FIG. 14. "GEM" ROTARY CULTIVATOR; ROTARY HOES, LIMITED.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND,
LONDON, W.C.2.

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We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30s. per inch. If use is made of a box number the extra charge is 1s. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33½ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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PLATE.

Plate II.—ANTI-CORROSIVE LININGS FOR PROCESS PLANTS.

ENGINEERING

FRIDAY, JULY 11, 1952.

VOL. 174.

No. 4511.

LONDON AND ITS TRAMWAYS.

It was Miss Edith Sitwell, we believe, who apostrophised London's tramway cars as

"Towering castles of steel and wood

"Moving on rails, just as they should";

though, so far as we are aware, neither she nor anyone else ever was moved to poetic fervour by contemplating the power station which the London County Council erected for the purpose of supplying current to run them, and which, for nearly half a century, has spoiled the prospect of historic Greenwich from almost every angle. Not many people, indeed, have written extensively about tramways, whether operated by horses, electricity or in any other way, until their supersession by other forms of street transport began to proceed at a rapidly increasing rate; and since then much of what has been published has been rather too much tinged with unbalanced sentiment to be worth consideration on any technical grounds. The sentimental aspect has its significance, of course, from the point of view of the student of economics—which, after all, is mainly the study of what people do, and why they do it; and, even among the lachrymose scribbles in chalk which adorned the body panels of London's last 100 or so of trams on July 5, when they ceased to run, there were a few comments that were very much to the point. One bore the question, "What are you going to do now

when it's foggy?"; another, "The L.C.C. could give us good tramways"; and another, beside a lament for "The end of cheap travel," bore a comparison of the cost of travelling by tram in London, Leeds and Glasgow which was thought-provoking.

Certainly, the L.C.C. did "give us good tramways"; at their best, they were very good indeed, and cheap withal. The historically-inclined mourner who, on one tram last Saturday, crossed out "London Transport" and substituted the old inscription "L.C.C. Tramways," brought that period vividly to mind by adding, on the bottom edge of the panel, "Aubrey Llewellyn Coventry Fell, General Manager"; for the late Mr. A. L. C. Fell, who was general manager from 1903 to 1924, and had been previously electrical engineer and general manager of the Sheffield Corporation Tramways, did a very great deal to provide Londoners in the mass with quick and cheap street travelling. He must have had many difficulties to overcome in persuading his employers, the L.C.C., to adopt some of his expansionist policies, but his judgment was sound, in the light of that time; though it may be doubted whether, had he lived to the present day, he would have opposed the decision to abolish the London trams entirely, so greatly have the operating conditions changed.

The first electric tram on the L.C.C. system ran on May 15, 1903, from Westminster to Tooting, with the Prince and Princess of Wales as passengers. Our issue of that date contained a leading article on the subject, the opening paragraph of which was more than a little reminiscent of the style of Zerah Colburn, 35 years earlier. "American citizens," we wrote, "have for many years been enjoying the full advantage of electric traction on street railroads; in some English cities the same boon has been the lot of the people for three or four years; but in London, where the dog-in-the-manger policy of the British municipality attains a high degree of pugnacity, we are only this week to witness the inauguration of the first purely London electric tramway."

After this outburst, however, the article proceeded to deal in a more calm and factual spirit with the finances of the change, and especially the effect on costs of adopting the conduit system in the interest of amenity. On the technical side, the London County Council had no cause for uneasiness; their consultant was Dr. (later Sir) Alexander B. W. Kennedy, and their tramway electrical engineer was Mr. J. H. Rider—both still names of weight, though Kennedy died as long ago as 1928 and Mr. Rider is in his 88th year. The cost of the change to electric traction, however, must have been disturbing to many members of the L.C.C. The initial line, 16 track miles, cost 26,835l. per mile, including the cost of the temporary power-station which preceded the permanent one at Greenwich; and, of that total, 13,660l. represented "rails and roadwork." It was estimated that the corresponding figure for the Greenwich and Peckham line, then in process of conversion, would exceed 14,000l. per mile of single track, which was nearly double the cost of a line to be operated on the overhead trolley system. Eventually, of course, both systems were used, the conduit in the central area and the overhead wire on the suburban extension lines; but this conjunction again added to the capital outlay, because nearly all the cars were fitted to use both. Thus the London tramways were saddled from the outset with a financial burden heavier than most such undertakings had to bear.

Considering the amount of labour and material involved in constructing the track on the conduit system, the cost of rather more than 14,000l. per track-mile seems reasonable, and even cheap. The work was fully described in our 74th volume (1902), with drawings, and reproductions of some

excellent action photographs of men at work breaking up (with sledgehammers—there is no sign of a pneumatic hammer) the concrete foundation of the old horse-tram track. By any standards, the conversion was a work of magnitude and of intended permanence; but the substantial nature of the installation made repairs and renewals all the more expensive when they could be put off no longer. For the first 20 years or so, however, the initial outlay paid good dividends; and many of the passengers who rode about South London during "Last Tram Week," in rattling and jolting cars which seldom reached 10 miles an hour, must have been impressed with the falling-away from the standards of 30 years earlier. War-time difficulties of maintenance accelerated the deterioration of the track, which had proceeded so far that many of the older trams suffered structural damage to the bodies. Mr. R. W. Kidner, in his little book on *The London Tramcar, 1861-1951*, which we reviewed recently, comments with reason on "the skill of the engineers who have kept these veterans rolling on permanent way that would have shocked to the core the tramway-men of old."

Glasgow, Sheffield, Blackpool, Sunderland, Leeds (which has a number of ex-London trams in service) still maintain efficient services, though pressure is exerted periodically to have them replaced by 'buses; but Manchester, Tyneside, Southampton, Birkenhead (home of the pioneer British street tramway system, introduced by George Francis Train) and Cardiff, among other centres, have done away with trams, and those of Edinburgh and of Liverpool are not likely to remain in service much longer. In most of such cases, however, the deciding factors are not inherent in the principle of street tramways, but are economic and due largely to external influences; for example, there is the handicap represented by the fact that, while tramway operators are usually held responsible for the repair of the road surface over the width of their track, 'bus operators commonly escape that charge except in its indirect form of the proportion of their taxation that goes to road upkeep generally.

So far as London's trams are concerned, the situation simply is that the traffic conditions which caused the Common Council to refuse consistently to admit trams within the boundaries of the City have now extended over the County. If the conduit system had not been adopted, it is possible (though by no means certain) that the tramways might have survived a little longer; but there is neither room nor need for an efficient tram service and an efficient 'bus service in the same streets. Continental capitals have been often cited as evidence in support of continuing tramways, but the conditions in most of them are completely different; few have parallel 'bus and tram services that are really frequent and adequate, and in most of them neither service is organised to cope with anything like their own modest peak loads.

It is to be expected that the more sentimental Londoners will continue to lament the passing of their trams; to recall the days of "2d. all the way" in mid-week off-peak hours, the switchback dive into the Theobald's-road end of the Kingsway tunnel and, in the days of the 1s. all-day ticket, the absurd competition among enthusiasts to see who could ride farthest for a shilling—we believe that the record is about 227 miles. The older tram-riders may recall with more pleasure the journey out to Uxbridge, before the 1914-18 war; perhaps London's nearest approach to the Continental *vicinaux*. The attitude, however, of those of the public who think as well as feel will probably be that of the old lady, lonely because her family had grown up and left her, who replied to the commiserating visitor, "Yes, I misses 'em and I wants 'em, but," reflectively, "I misses 'em more than I wants 'em."

COAL PRODUCTION.

It has been announced by the Minister of Fuel and Power that coal exports this year are to be increased to a total of 12,500,000 tons, as compared with 7,925,000 tons in 1951. These figures, apparently, do not include ships' bunker coal and coal to stock bunkering depots, as the report of the National Coal Board for 1951 gives 11,588,000 tons as the total shipments in that year. The figure given by the Minister clearly relates only to coal which, when sold abroad, will bring in foreign exchange and help to rectify the dangerous economic position in which the country stands. The decision to increase exports by some 4,500,000 tons is presumably based on the satisfactory rising output, coal production in the first six months of this year being more than 1,500,000 tons greater than in the corresponding period last year.

Coal is, or should be, one of the most important exports of this country, being a commodity which requires no imported material for its production, as do most manufactured articles; but the National Coal Board presumably does not look upon the export market as a primary interest, as motor-car manufacturers, for instance, are compelled to do. The motor trade exports 80 per cent. of its output and last year earned 380£ million of foreign exchange; in the same period the National Coal Board exported something less than 4 per cent. of its output. It is expected that the 12,500,000 tons to be exported this year will earn about 60£ million of foreign exchange. In 1927, when 252,252,000 tons of coal were produced, coal exports earned 45£ million, a larger sum than any manufactured material. At present-day prices, 45£ million may be multiplied by at least three.

Engineering progress is resulting in mineral oil in its various forms taking a position of growing importance in the industrial activity of Great Britain, but, as it is an imported material, financial considerations will probably prevent it from ever becoming the major fuel of the country. Coal is the natural British endowment and on it industrial activity must, in the main, be based. It is certainly the primary business of the National Coal Board to produce sufficient coal for industrial and domestic requirements at home, but it is not only desirable, but essential, that it should also assist in earning the foreign exchange without which the country will not be able to purchase essential raw materials and food from overseas. There is no indication that coal will again become the major foreign-exchange earning export in any foreseeable future, but it is greatly to be hoped that it may at least improve its position relative to manufactured goods.

As home demand is growing, and will continue to grow, the only way in which exports can be substantially increased is by increasing production. The Coal Board report states that, while the results of 1950 were disappointing, those of 1951 in the main were not. This opinion is based on the facts that the output last year increased by 7.8 million tons, that the output per man-year was the second highest for half a century, and that the output per man-shift was the highest ever attained. Satisfaction with these results must be tempered by the facts that three-fifths of the increase in output was obtained from an extension of Saturday working and that the increase per man-shift was only slight. The extension in Saturday working is not to be regarded as undesirable in itself; on the contrary, it is more than doubtful, if in the present financial condition of the country, five-day weeks can be afforded in coal mining or any other industry.

The point of importance is that the expenditure of 20,596,586£ on major capital schemes of re-organisation and equipment up to December 31, 1950, and 10,410,735£ in 1951, have not enabled

production to reach the figure attained in 1927, when there was no opencast mining; in 1951, 10,986,000 tons of the total production was opencast coal. The Board may feel some diffidence, perhaps, in these democratic days in pointing out that the purpose of mechanisation is to obtain increased output from the same amount of man-power; it is not undertaken in order that the personnel can "take it easy" and continue to produce the same amount as before in a more leisurely way. A glance at a table of total outputs over many years will show, however, that mechanisation in the mines has, in broad terms, merely held the position; there has been no sign of the substantial increase in production which might have been expected to follow the lavish provision of new equipment. In 1913, when mechanisation in the modern sense hardly existed, 287,411,869 tons of coal were produced.

This generalisation is subject to attack on various grounds. It may, for instance, be pointed out that, in 1913, 1,104,406 persons were employed in the mines; in 1951, the number was 699,000. On this basis, mechanisation has increased output per man by some 19 per cent., but this is not a striking achievement after 39 years of mechanical progress. Comparisons with conditions 39 years ago are, however, of little value, social and other conditions having greatly changed since that early period. The years between 1922 and 1951 cover a time when mine mechanisation was steadily advancing. (Incidentally, it may be remarked that the application of modern machinery to the winning of coal did not begin with the creation of the National Coal Board, although some speakers and writers assume, or pretend, that it did.) In 1922, the output per man-year was 230 tons; in 1937, it was 299 tons; and in 1951 it was 303 tons. Much machinery and plant has been installed in, and at, the mines since 1937, and an increase of 4 tons per man-year in the 15 years can hardly be called satisfactory. If the man-year output figures from 1922 to 1951 are plotted, a slight rising tendency is shown, but it is far from an encouraging one.

One of the reasons, already quoted, why the Coal Board found the results for 1951 "not disappointing" is that the "output per man-year was the second highest for half a century." The reason why it was not the highest may perhaps be found in a remark in the report of the Productivity Team representing the British coal-mining industry, which visited the United States in 1951. It is there stated that "rather than machines . . . we should like to see injected into the British industry, the sense of adventurous urgency which characterises the American attitude towards development and is found in management and men alike." In view of the capital expenditure to which the National Coal Board has committed itself, and the account of new shaft sinking and the deepening of old ones, together with the information about new plant and equipment which will be found in the report, the Coal Board may reasonably claim that it is not lacking in a "sense of adventurous urgency."

It would be little more than an indication of baseless optimism to make the same claim for organised labour, although there are some signs that prominent labour leaders are coming to realise the facts of the situation of the country. Referring to production in general and not specifically to the coal-mining industry, Mr. Aneurin Bevan, speaking at Manchester on July 6, said that national production had fallen in the past two months, and added, "How do you expect to get higher wages if production goes down?" As Mr. Bevan represents the extreme left-wing of Labour, this remark is encouraging; it is to be hoped it may have some effect. There is little indication that the labour rank and file has even yet any appreciation of the financial state of the country, and major claims for large wage increases are being made on behalf of railway-

men, coal miners, engineers and farm workers. If these were granted the standard of living would fall still farther and the ability of the country to export would be unfavourably affected. It has been stated that a firm market has been obtained for the 12,500,000 tons of coal to be exported this year, but it would be shortsighted for organised labour, or any other body, to assume that Great Britain can export all the coal it can spare and sell it at any price it likes. Competition from Germany is increasing, not only in motor cars, but in coal also; and Poland, too, is becoming increasingly active in the international market.

The Coal Board has to accept labour conditions as they are, and is apparently unable to control the frequent and unjustifiable local strikes and stoppages which are such a prominent feature of labour irresponsibility; the deplorable activity of some districts in connection with Italian labour is another indication of the same thing. The Board is doing all it can to satisfy the claims of the men, and paid holidays and miners' pensions have been introduced. Wages are high, supervisory grades underground now earning 12l. 13s. 0d. a week, an increase of 39s. 5d. over 1947, and other underground workers 10l. 1s. 0d., an increase of 31s. 11d. Pending a better realisation of the facts of the situation by labour generally, the only other thing the Board can do is to press on with the mechanisation schemes.

NOTES.

THE FIRST VOYAGE OF THE "UNITED STATES."

The new American liner *United States*, which left New York on her maiden voyage on July 3, arrived at Le Havre on July 7 at 1.25 p.m. and berthed at Southampton at 6 p.m. on the following day, having broken the eastbound record previously set up by the Cunard White Star liner *Queen Mary* by the remarkable margin of 10 hours 2 minutes. Her time from the Ambrose Channel light-vessel to Bishop Rock—the positions between which records are calculated—was 3 days 10 hours 40 minutes, giving an average speed of 35.59 knots. The record set up by the *Queen Mary*, which had stood since August, 1938, was 3 days 20 hours 42 minutes, an average of 31.69 knots. The highest daily average speed attained by the *United States*, on her third day out, was 36.17 knots. Her master, Captain Harry Manning, who is commodore of the *United States Lines* fleet, admitted that the weather conditions were in his favour during most of the voyage; but it is evident that this advantage had not a great deal to do with the fact that the former record was decisively beaten. That the westbound record time will also be cut considerably is a foregone conclusion; and that both will remain in the possession of the *United States* until a new challenger is built may be taken as equally certain.

THE INTERNATIONAL ORGANISATION OF NUCLEAR RESEARCH.

The European Council for Nuclear Research, which has been set up with the collaboration of Unesco, recently held a three-day meeting in Copenhagen during which a plan of work was adopted. This was based on a survey presented by Professor W. Heisenberg, in which it was pointed out that the centre of interest in atomic physics had moved from the nucleus to the elementary particles and that it was necessary to make investigations with particles of high energy. For this purpose, the high-energy region was most important, as it was only in it that a comparatively large number of mesons could be created. A small synchro-cyclotron with a range of about 600 million electron volts should therefore be built and other forms of joint atomic research considered. The four study groups of the Council were asked to prepare a report on the proposed international nuclear laboratory for the meeting in Amsterdam next October and for subsequent submission to member governments. In the meantime, work on detailed plans for the laboratory, the site for which is not yet decided, are to be initiated and preliminary

studies are to be carried out on the design of the machine mentioned above. Other forms of joint atomic research are also envisaged, including the building of a proton synchrotron, or cosmotron, which will take about seven years. The President of the Council, the headquarters of which are in Geneva, is Professor P. Scherrer, while the vice-presidents are Professors E. Perrin and W. Heisenberg and the secretary is Professor E. Amaldi.

THE COLLEGE OF AERONAUTICS, CRANFIELD.

The vital problem of air defence demands a supply of technologists who are able to visualise the problems of the future and to develop techniques for dealing with them. The present "super-priority" demands on the aircraft industry, however, are having an adverse effect on the flow of young engineers to the College of Aeronautics, Cranfield, the Government-sponsored post-graduate college of air technology. These points were made by Air Marshal Sir Victor Goddard, K.C.B., C.B.E., the Principal of the College, in his speech at the fifth annual presentation of diplomas and prizes held at Cranfield on Friday, July 4. The remedy, he suggested, was to call up young men with the required initiative and ability into the Royal Air Force, and to send them to Cranfield for their period of national service. The diploma presentation ceremony was opened by the chairman of the board of governors of the College, Air Chief Marshal Sir Edgar Ludlow-Hewitt, G.C.B., G.B.E., C.M.G., and the diplomas and prizes were presented by the Minister of Education, the Rt. Hon. Florence Horsbrugh, P.C., C.B.E., M.P. The Governors' Prize, for the best over-all performance during the course, was awarded to Squadron Leader Peter Charles Cleaver; and the Principal's Prize, for the best piece of original work in the second year, to Mr. Harold George Sevier, for a thesis on ground resonance in helicopters. Of 59 students who have completed the normal two-year course, 50 have been awarded diplomas, 15 with distinction.

PRODUCTIVITY REPORT ON STEEL CONSTRUCTION.

The Productivity Team appointed under the auspices of the Anglo-American Council on Productivity to investigate American practice in steel construction—the 53rd exploratory party thus organised—went to the United States on September 26, 1951, and concluded their tour on November 7. They visited 22 works and covered about 3,000 miles in the country. Their conclusions, set out in a report now available (price 3s., including postage) from the office of the Council at 21, Tothill-street, London, S.W.1, resembles most of the others in the comments made, especially on the attitude of American labour towards mechanical handling appliances and other devices for transferring the more arduous tasks from the man to the machine, and on the desire of the American workman to improve both his own efficiency and that of his firm. Generally, it was found that shop layouts were similar to those in Britain, but that they were more often designed to facilitate the regular flow of materials and to expedite handling by the intensive use of lifting and moving devices. It was remarked that the higher and wider loading gauge of American railways, compared with those in Britain, afforded opportunity for considerable economies in assembly costs on site. Important contributions to the higher outputs per man achieved in the United States were made by the extensive use of wide-flanged beams, and the relative absence of trade demarcation rules and restrictive practices in the shops; for example, a "fitter-up" was permitted to practise all the trades—fitting, tack-welding, burning, chipping, etc.—necessary for assembly of the work, so avoiding waste of time in waiting for an operation to be carried out by some other craftsman. Work on details was taken much farther in the drawing office, so simplifying production later in the shops. Erection was speedier, and it was observed that there was no guaranteed week, such as obtained in Britain, for men working on erection sites, nor was there any payment when adverse weather halted the work. The American trade unions showed themselves to be "aware of the need for studying management methods and assisting in the application [of them] at factory level." The

Team remarked also that "the interest of the trade unions in production management and in the implications of maintaining a rising standard of living is an important factor in the vigour and resilience of American industry." The report contains various illustrations of crane layouts, special clamps, etc., which facilitated output.

THE INSTITUTION OF MINING ENGINEERS.

In the course of their recent summer meeting at Stoke-on-Trent, the Institution of Mining Engineers held their dinner in the University College of North Staffordshire, on July 3, the chair being taken by the President, Mr. R. J. Weeks, M.A., J.P. At the opening session of the three-day meeting, on the previous day, the Institution had been welcomed by Professor F. A. Vick, acting Principal of the College. In proposing, at the dinner, the toast of "The City and Industries of Stoke-on-Trent," Mr. Rowland Bennett, F.G.S., traced the growth of Stoke from being, 200 years ago, a town of fewer than 10,000 people to its present position of the tenth largest city in England and Wales, and congratulated the local authorities on their 20-years development plan for the Potteries. The Lord Mayor (Alderman G. L. Barber), who responded, said that, while no iron ore was now worked in the district, there were coal reserves which were rich in quality and quantity; "and coal," he added, "is the key to our economic salvation." Sir Hubert Houldsworth, chairman of the National Coal Board, proposing the toast of "The Institution," referred to development work in the Cannock Chase coalfield, and looked forward to the time when the new pit would increase the output of the field from $3\frac{1}{2}$ to $6\frac{1}{2}$ or $6\frac{3}{4}$ million tons a year; "there need be no misgivings," he said, "about the future of that coalfield." The toast was acknowledged by the President, who reviewed the work of the Institution and referred particularly to the five new honorary members whose certificates were bestowed at the opening session, namely, Mr. Etienne Audibert (France), Mr. C. Augustus Carlow (past President), Dr. Ir. C. T. Groothoff (the Netherlands), Mr. Laurence Holland (past President) and Dr. Lewis E. Young (United States).

THE NORTHERN HEIGHTS MODEL FLYING CLUB.

By courtesy of the directors of Hawker Aircraft, Limited, the Northern Heights Model Flying Club, of which Dr. A. P. Thurston, M.B.E., F.R.Ae.S., is President, were able, on June 29, again to hold their annual gala on the company's airfield at Langley, near Slough. For several years, at this event, which attracts participants from as far as the Midlands, there has been a notable increase in the number, and a steady improvement in the performance, of model aircraft driven by internal-combustion engines. This trend continues, with a strong leaning now towards miniature jet engines, but this year the most noticeable feature, perhaps, was the precision displayed in the competition for radio-controlled flights and landings, the flights being required to be not less than one minute in duration or longer than three; Mr. R. C. Lawyer, the winner of the award—the R.A.F. Review Cup—brought his model to land within 13 yards of the target. The winner of the Queen Elizabeth Cup (formerly known as the Queen's Cup), for power-driven model aircraft not exceeding 5-c.c. engine capacity, was Mr. V. Smeed, who received also a silver medal and a prize of 20l. The runners-up in the second and third places, Mr. J. Lewis and Mr. R. A. Mead, received prizes of 10l. and 5l., respectively. The prize money in all three cases was given by Hawker Aircraft, Limited. The prizes were distributed by the Lady Mayoress of London (Lady Boyce). Model helicopters appeared to be attracting increasing attention, but, technically, they have still a long way to go to attain the efficiency of the "straight" power-driven models, some of which are capable of more than 90 miles an hour. The general impression conveyed by such an event as that of June 29 is that the cult of model flying must be contributing notably towards providing the British aircraft industry, and the Royal Air Force, with a substantial reserve of recruits who are not merely air-minded, but have developed a considerable degree of craftsmanship and a useful familiarity with the elements of aircraft design.

LETTER TO THE EDITOR.

CRITICAL REYNOLDS NUMBERS
FOR STEADY AND PULSATING
FLOW.

TO THE EDITOR OF ENGINEERING.

SIR,—Professor Kastner and Dr. Shih, in their informative paper on the above subject in your issue of September 28, 1951, refer to a paper by Nikuradse, published in the V.D.I. Forschungsheft 356 (1932), of which an analysis by the writer was tabled and discussed at a meeting of the Fluid Motion Panel of the Aeronautical Research Committee in 1933. The method of analysis is here extended to the balancing of the energy account. Schiller's assumptions appear as a fair approximation and give an instructive picture of the field of motion. For brevity and clearness a numerical example is taken from Nikuradse, that of flow in a straight pipe of circular section, radius $a = 0.5$ cm., coefficient of viscosity $\mu = 0.0135$ gram per centimetre per second, gradient of pressure $\text{grad } p = 58.4$ grams per cm^2 per sec.²

The condition for steady laminar flow is

$$2\mu \frac{\partial u}{\partial r} = \text{grad } p r,$$

whence

$$u = u_0 \left(1 - \frac{r^2}{a^2}\right),$$

parabola ANSV in the attached figure

$$u_0 = \text{grad } p \frac{a^2}{4\mu} = 270 \text{ cm. per second,}$$

in the example,

$$\text{curl } u = \frac{\partial u}{\partial r} = \text{grad } p \frac{r}{2\mu} = 2 r \frac{u_0}{a^2},$$

straight line OKL in the figure.

Energy dissipation

$$F = \int_0^a \mu (\text{curl } u)^2 2\pi r dr,$$

per unit axial length.

Rate of work done

$$W = \pi a^2 \text{grad } p \frac{u_0}{2}$$

whence

$$F = W$$

after straightforward integration.

For a hollow coaxial cylindrical volume, inner radius r , outer radius a ,
Dissipation

$$F_r = F \left(1 - \frac{r^4}{a^4}\right)$$

Rate of work

$$W_r = W \left(1 - \frac{r^2}{a^2}\right)^2$$

The smooth curve drawn through Nikuradse's experimental values of the Pitot-mean axial velocity u' , ACDNN₀ in the figure, cuts the parabola of steady laminar flow in N. Points outside the parabola imply a coefficient of radial transfer of momentum less than μ , and are, therefore, rejected and replaced by the intercepted arc of the parabola, AN, from the boundary to the point of intersection at which $u = u' = 45$, $r = 0.456$.

The curve of u' may be differentiated numerically giving corresponding values of $\frac{\partial u'}{\partial r}$, and the condition of equilibrium between end pressure and tangential forces on a coaxial cylindrical volume of fluid of radius r has the same form as for laminar flow

$$2\mu' \frac{\partial u'}{\partial r} = \text{grad } p r,$$

defining an empirical coefficient of radial transfer of momentum, μ' , of the same physical dimensions as μ . This equation may be integrated numerically, merely reversing in identical detail the process of numerical differentiation by which it was obtained without the possibility of leading to a contradiction.

The further assumption is now made that these values of μ' and $\frac{\partial u'}{\partial r}$ may be used in an equation

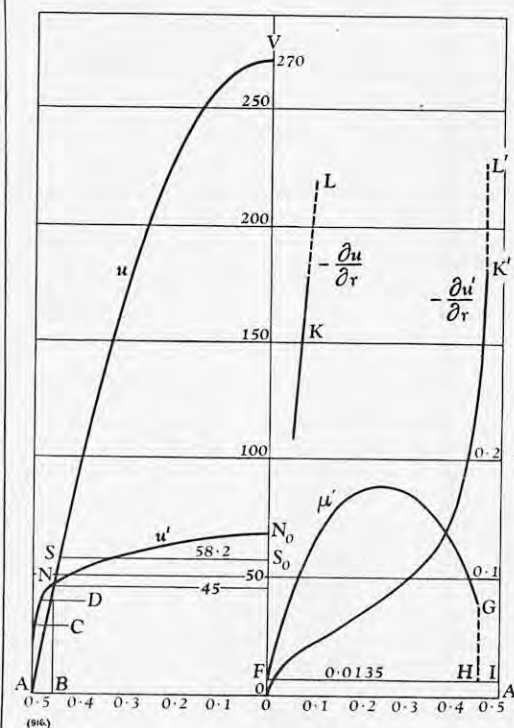
of the same form as for dissipation in laminar flow, namely,

$$F' = \int_0^r \mu' \left(\frac{\partial u'}{\partial r}\right)^2 2\pi r dr.$$

In the present example, the results give a balance of the energy account which is practically exact within slide-rule accuracy. The following extract from Nikuradse's Table 2 (page 12, *loc. cit.*), will enable the results to be checked without reference to the original.

r	u'	$\frac{\partial u'}{\partial r}$	μ'
0.4564	45.0	170	0.075
0.45	47.0	157	0.084
0.40	52.7	90	0.130
0.35	56.6	64	0.160
0.30	59.5	50	0.175
0.25	65.0	41	0.178
0.20	63.5	34	0.172
0.15	65.0	29	0.152
0.10	66.4	22	0.133
0.05	67.4	15	0.097
0.00	68.1	0	0.0135

For values of r between 0.4564 and 0.5, Nikuradse's values are replaced by the values in unchanged laminar flow.



To find the value $r_1 = 0.4564$ we have

$$u'_{r_1} = 45 = 270 \left(1 - \frac{r_1^2}{a^2}\right)$$

The integral for F' is transformed by partial integration into

$$F' = \text{grad } p \pi \left(r_1^2 u' - \int_0^{r_1} u' d(r^2) \right) \\ = \text{grad } p \pi r_1^2 (u' - \bar{u}'_r)$$

where $\bar{u}'_r$ is the mean value of u'_r from $r = 0$ to $r = r_1$ found by numerical integration to be $\bar{u}'_r = 57.4$.

Hence

$$F' = 58.4 \times 3.1416 \times 0.2084 \times (57.4 - 45) \\ \approx 480 \text{ ergs per second.}$$

$$W' = 58.4 \times 3.1416 \times 0.209 \times 57.4 \approx 2200.$$

From $r = r_1$ to $r = a$

$$F = 6190 \times \left(1 - \frac{r_1^4}{a^4}\right) = 1900$$

$$W = 6190 \times \left(1 - \frac{r_1^2}{a^2}\right)^2 = 180.$$

Schiller's assumptions may now be compared with these results.

A horizontal straight line, SS₀, is drawn at $u = 58.2$ cutting the parabola in S, $r_2 = 0.443$. This value is determined either by the condition that the total flow with the profile ASS₀ is equal to

the total flow observed experimentally, or that the total work and dissipation are equal to the experimental values. Both these conditions lead to the equation,

$$F = 6190 \left(1 - \frac{r_2^4}{a^4}\right) = 2380,$$

whence the above values are obtained.

Tabulating the results:—

	Laminar Region.	Turbulent Region.	Total.
Schiller—			
Rate of work done ..	290	2,090	2,380
Energy dissipation ..	2,380	0	2,380
Nikuradse—			
Rate of work done ..	180	2,200	2,380
Energy dissipation ..	1,900	480	2,380

The computations were made by slide-rule, but squares and square roots were taken from Barlow's tables.

The writer is more impressed by the consistent picture given than by the close balance of the energy account in a single case. Schiller's assumptions are equivalent to replacing the turbulent region by a solid core moving with the inner surface of the laminar region. The writer has observed the formation of plugs or wads of turbulent motion in a modification of Reynolds' experiment, with an open end of discharge. Just above the critical velocity, a plug of turbulence about a centimetre long would be formed in a fraction of a second, slowing down the whole motion until it was discharged at the free end; whereupon the flow speed increased until another plug of turbulence was formed.

During the travel from the point of formation to the free exit the convolutions of the originally axial thread of coloured indicating fluid rapidly came to rest. On suddenly stopping the exit, these convolutions already formed remained at rest or in motion too slow to be noticed while the hitherto steady laminar region was filled with violent distortions of the axial thread of indicating fluid, showing that the available energy of the parabolic profile of velocity was transformed impulsively into eddy energy by inertia forces while the previously available energy in the plug had already been transformed into eddy motion and then, and then only, rapidly brought to substantially steady axial motion by the much increased viscous forces internal to the plug and not much affecting the subsequent field of axial velocity.

A further point of fundamental importance was the absence of the smearing effect observed when a thread of coloured indicating fluid penetrates the boundary layer. From this it is inferred that there was, in fact, a layer of laminar flow which was not penetrated by the eddies.

Yours faithfully,

A. R. Low, F.R.Ae.S.

E.T.H. Library,

Zürich.

June 12, 1952.

BRITISH THOMSON-HOUSTON ENGINEERING RESEARCH FELLOWSHIP.—The British Thomson-Houston Company have recently instituted the annual award of engineering research fellowships. These fellowships, of which two have now been granted, are open to honours graduates who are in their last year of apprenticeship with the Company. The holder will engage in engineering research for one to three years, either wholly with the company or partly with the company and partly at a university. He will work under the supervision of a senior engineer of the company and under the guidance of a research fellowship panel which has been set up for the purpose.

ADVICE ON MAKING CONCRETE.—The Ministry of Works have issued Advisory Leaflet No. 26, "Making Concrete," to assist the small builder, clerk of works and foreman to make consistently good concrete. The way to get the best proportions is given in straightforward language, with hints on determining quantities of materials by volume and the amount of water to be added. Tabulated proportions, based on one bag of cement, are given for concrete suitable for various purposes, together with notes on mixing by hand as well as by machine. Copies of the leaflet, price 3d. each, may be obtained, either singly or in bulk at reduced rates from H.M. Stationery Office, Kingsway, London, W.C.2.

"QUANTOMETER" FOR RESEARCH ON CAST IRON.



BRITISH CAST IRON RESEARCH ASSOCIATION.

Two years ago, on July 5, 1950, on the occasion of an open or "members" day held at the headquarters of the British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, we attended the opening of several newly-constructed buildings by Mr. P. H. Wilson, O.B.E., M.I.Mech.E., who was then President of the Association. The new buildings comprised a new machine and instrument shop, a mechanical testing laboratory and also kitchens and a new dining room for the use of the staff, which now numbers 100. Subsequently, the Council of the Association decided upon further extensions, partly to furnish more adequate accommodation for the existing staff, but also to provide for extended work. We were given an opportunity of seeing the progress made with these new extensions at an open day held at Bordesley Hall on July 3. The Association's chemical laboratory and spectrographic laboratory are now housed in a completely new building erected behind the Hall. The chemical laboratory is in an advanced state of completion internally but is not yet equipped. The spectrographic laboratory contains a Quantometer, which has only just been installed, but the remaining spectrographic apparatus has still to be transferred from the premises it has occupied hitherto. The sand-testing and sands-research laboratories have been moved from the old building into new quarters, which also provide additional accommodation for the development department, the operational research team and the foundry-atmospheres team. The heavy stores for pig iron, scrap, sands and refractories, envisaged in 1950, have now been completed and the foundations of a new experimental melting shop are being laid.

The temperature of the new spectrographic laboratory is controlled to within ± 2 deg. F., and efforts have been made to reduce the incidence of dust. The Quantometer, which is of United States manufacture and cost some 15,000l., has been supplied by Applied Research Laboratories, Glendale, California. A general view of the apparatus is seen above. It comprises a high-precision source unit which can reproduce almost any known type of electrical discharge; a spectrometer which measures spectra by means of photo-electric cells; and a console which records, through an electronic system, the photo-electric cell current produced in the spectrometer. In the illustration, the operator is noting the path traversed by the pen on the chart in the recording console of the Quantometer.

Although the instrument forms a complex electronic and photo-electric system, it is stated that it is comparatively simple to operate and that the ordinary elements in a cast iron usually determined spectrographically can be recorded within 60 seconds of the sparking of a sample. Moreover, it appears that 12 elements can be dealt with in all, and it is hoped to be able to carry out determinations of carbon and phosphorus, elements which, normally, are not capable of being determined by spectrographic means. It is of interest to add that the Quantometer was applied for at a time when the United Kingdom was receiving Marshall Aid, and negotiations had reached an advanced stage when the Aid was suspended. The Department of Scientific and Industrial Research, however, made a special grant of 80 per cent. of the first cost of the Quantometer and the arrangements to purchase it were completed.

The new sands laboratories are equipped for routine testing and research work on core and moulding sands, binders, auxiliary materials and foundry refractories. Among other matters under investigation are the stress-strain characteristics of moulding sand at room and elevated temperatures, the expansion and scabbing tendency of moulding sands, the determination of the specific surface of sand samples and the "flowability" of sand. The work of the development department falls broadly into two main groups. The first group covers the actual investigation of a foundry problem on the premises concerned. During the past year it has been the policy to send members of the staff to "on-the-spot" investigations for periods of up to a week, to ensure that a thorough understanding of a particular problem is obtained and to provide time for any suggestions made to be put into practice and the results observed. The second group of activities covers investigations in the laboratories at Alvechurch, generally designed to fill gaps in the knowledge or experience of the Association that have been revealed by a consideration of problems of members or of users of cast iron.

A branch of the development department formed in 1951 is concerned with foundry atmospheres. During the period of 18 months that the foundry atmospheres team has been in operation, surveys of dust concentrations at various points in mechanised, partly mechanised and non-mechanised foundries, have been carried out, particular attention being paid to the knock-out area and the fettling shop. Recent investigations of the conditions under which stand grinding machines are operated in fettling shops have indicated that the conven-

tional system of hood extraction is inadequate to deal with the very fine particles of dust borne in the air stream at the periphery of the wheel. The problem has been attacked by the Association and one solution, which was demonstrated at the recent open day, has been found. This solution, which we understand is largely the work of a member of the team, Mr. W. H. White, involves the use of high-velocity air streams above and on each side of the grinding wheel. A matter of interest is that it appears that the power required to provide this protection is less than that normally employed. A film showing the production and distribution of dust by a stand grinder, with and without the new improvement, has been made with the co-operation of the Factory Department of the Ministry of Labour and National Service and the Air Ministry.

We have referred to the additional accommodation for the operational research team. This team was inaugurated in June, 1950, to advise member-firms on means of increasing production efficiency. The success of the experiment has been shown by the response made by the ironfounding industry. So far, 213 visits have been made to foundries, in all parts of the United Kingdom, at the request of the managements concerned, and evidence has been forthcoming that these visits have contributed to improvements in the quality and output of castings and the correct distribution of man-power. The original team of three has recently been increased to five, thus enabling visits to be made more expeditiously and the general scope of the work to be increased. Teams, consisting of two or three, visit the foundries of member firms, by invitation, to make a general survey and to submit a confidential report to the management. The report suggests a long-term policy of planning which can be carried out over a number of years with a view to increasing production efficiency. The team will also deal with technical details as far as the time available permits, but problems which require closer study are passed on to the development department for further advice or investigation.

The general trend of the building policy and activities of the Association is to remove laboratory and experimental work from the original building, Bordesley Hall, into external buildings specially constructed for the purpose, reserving the Hall itself for offices and the intelligence department and library.

FREQUENCY CONVERSION ON SOUTHERN REGION ELECTRIC LINES.

WHEN the western suburban section of the present Southern Region was converted to electric traction in 1915, the necessary power was obtained from the railway's power station at Wimbledon. It was distributed thence at 11 kV and a frequency of 25 to manually-operated rotary converter substations. The same system was also used later on the central and eastern suburban sections, which drew their power from the Deptford generating station. A total of 46 of these rotary converter substations are now operating on 25 cycles, but the plant needs replacement. After consideration of various alternatives, the Railway Executive have therefore authorised a scheme for the substitution of the existing 11-kV 25-cycle power supply system by 50-cycle equipment, and for the installation of the mercury-arc rectifiers which can be used on this frequency without difficulty.

Power for the new substations will be drawn from the grid and will be transmitted from Deptford and four other supply points through 300 miles of cable to 72 remotely-controlled substations in which over 300 MW of mercury-arc rectifiers will be installed. In addition, there will be three remotely-controlled switching stations and 67 remotely-controlled track-parallel huts. Remote control of this plant will be effected through pilot cables which will be installed with the power cables. Other pilot cables will be used for protection purposes. As a result of this change, the plant capacity of the substations will be considerably increased and it will be possible to extend the length of the trains from eight to ten cars, and to provide an augmented and accelerated service.

RUBBER ANTI-CORROSIVE LININGS FOR PROCESS PLANT.

ALTHOUGH rubber in its various forms has been used in the construction of chemical plant for some considerable time, this material, so far as it can be ascertained, was not adopted as a lining for large fabricated vessels until the first World War, when railway tank wagons lined with ebonite were used for the bulk transport of acids. These wagons proved most successful, quickly showing a marked advantage over the use of carboys, and it was not long before their use became widespread. Development from this stage was comparatively rapid and rubber was soon being used to line reaction vessels, pipe-lines, valves, pumps, etc. As time went by, rubber linings were adopted for an ever widening range of steel vessels used in many industries and it is now common practice to apply such linings to the largest units used in chemical and similar plants.

An important part in the development of rubber-lining techniques was played by the Dunlop Rubber Company, Limited, and the organisation they have built up at their Manchester premises is capable of lining a wide variety of vessels not only with rubber but with Neoprene, polyvinyl chloride and butyl as well. The shops devoted to this work are illustrated in Fig. 1, on Plate II. Though the processes involved in placing the linings in position are quite straightforward, they involve a considerable amount of skill, particularly when the surfaces to be treated are not entirely smooth. A clean surface is absolutely essential if a good bond is to be formed between the rubber and the parent metal. All metal surfaces to be covered, therefore, are first "sweated" in live steam so that all traces of oil, grease, etc., are removed, and this is followed by shot blasting for removal of rust and scale. The steaming process is carried out in an autoclave which is also used for the subsequent vulcanisation.

The next step is the application of the adhesive to the prepared metal surface. This is carried out as soon as possible after the cleaning operations so that the surfaces have little chance to deteriorate, the number of coats applied depending on various factors such as the thickness and specification of the lining. Application of the adhesive has to be carried out with considerable care as the success of the whole process is largely dependent on correct procedure at this stage. The lining is applied to the surface in the form of unvulcanised sheets, which are usually built up from several layers of calendered rubber, thus ensuring a good texture. They are cut to the required shapes and sizes by hand and, when the adhesive is quite dry, are placed in position and rolled down by means of small hand rollers. This operation also has to be carried out with great care as it is important that a perfect bond is made between the rubber and the metal and that any air trapped behind the rubber is removed by the rolling action.

After the surface has been covered, the lining is inspected for pinholes and similar defects. This is carried out by subjecting the surface to a dry spark test in which a low-current discharge of approximately 20,000 volts is applied to the surface by means of a long flexible wire probe, any defects being indicated by the formation of sparks. The surface is explored thoroughly by the probe and it will be appreciated that the discovery of any defects before vulcanisation renders subsequent rectification a much simpler matter. When it has passed the spark test, the rubber lining is subjected to the vulcanising process. Wherever possible, vulcanisation is carried out by steam under a slight pressure, for which purpose a large steam autoclave, 20 ft. long and 15 ft. in diameter, has been installed. This is illustrated in Fig. 2, on Plate II, which shows a large rubber-lined vessel being removed after vulcanisation. Frequently the units are too large to be treated in the autoclave, but in such cases it is often possible to vulcanise them by fitting temporary covers over all apertures, lagging them externally and admitting live steam to the inside. This method can only be adopted, however, when the structure is strong enough to withstand the

pressure of the steam. As an alternative, the vessel can be well lagged and filled with water, which is then boiled by the admission of live steam. These last two methods are particularly useful when the lining has to be installed on site. After vulcanisation, the lining is again tested by the spark process and any weak spots repaired. A typical rubber-lined component is illustrated in Fig. 4, on Plate II, which shows part of a continuous pickling unit for use in Belgium.

Pipes are lined in much the same manner, but in the case of those of small diameter which do not permit easy access to the interior, the rubber lining is first wrapped round a mandrel and formed into a tube, the outside diameter of which corresponds to the internal diameter of the pipe. After the abutting edges have been joined to each other by an adhesive, the tube is removed from the mandrel and inserted in the pipe, which meanwhile has been coated with adhesive. In the case of very small pipes, the tube is made slightly longer than the pipe so that the ends can be sealed and the tube inflated to give the necessary pressure to bond it to the interior of the pipe. The same method is used when lining medium-sized pipes but in this case bonding pressure is applied by inserting a canvas bag inside the tube and inflating it. Large pipes, of course, can be treated in much the same way as ordinary vessels, the rubber lining being "rolled" into position by hand. As in the case of all rubber-lined articles, the pipe linings have to be vulcanised and this is carried out in a series of smaller autoclaves.

Although the foregoing notes apply mainly to articles made from steel, so long as there is a good surface there are few limitations to the metals which can be covered with rubber. The surfaces, however, should be smooth and for this reason it is desirable to avoid riveted joints; if rivets have to be used, they should be countersunk so that they are flush with the surface of the metal. Welding is preferable as the welds can be ground level with the adjacent surface. Sharp bends and awkward corners also should be avoided as they are liable to cause air to be trapped behind the lining or lead to undue stretching of the lining material as it is worked into position. Although welded-steel vessels are easier to line with rubber, cast-iron and cast-steel vessels can be treated, provided the metal has a close grain and the castings are designed so that sharp corners, etc., are avoided and easy access provided for the operators. Even concrete storage and process tanks can be lined and there appears to be no practical limit to the size of vessel that can be so treated. The Dunlop Rubber Company, for example, have recently been requested to investigate the possibility of lining an underground reservoir 750 ft. long, 300 ft. wide and 18 ft. deep, with a normal capacity of approximately 20,000,000 gallons. Major subsidences have occurred in the area of the reservoir and, though these are now considered to have eased, fine cracks are still appearing in the concrete fabric. Normal methods of repair have been ineffective and, despite repeated efforts, water losses are still severe. It was considered that a lining of rubber would, possibly, absorb the slight movements involved and overcome the trouble. Accordingly, an experimental lining was fitted to a section of the reservoir and this has shown that the idea is a practical and economic proposition. Preparations are being put in hand, therefore, to line the mixing chamber, which is 42 ft. long, 34 ft. wide and 18 ft. deep and contains all those features which will be met in the main reservoir. If this portion is also successful, then the complete reservoir will be lined, a project, it has been estimated, which will require 200 tons of rubber.

As previously mentioned, vessels can be lined with butyl, polyvinyl-chloride or Neoprene. Butyl has a greater chemical resistance than natural rubber in the temperature range for which the latter is generally used and has an increased resistance to ageing and oxidising agents, it being possible to operate tanks so lined at a temperature of 100 deg. C. for long periods. The use of polyvinyl-chloride has now become well established and has considerably extended the application of plastic materials for the protective lining of tanks, pipes

and other components of chemical plants. Lining with polyvinyl-chloride can be carried out at normal temperatures and, as there is no need to vulcanise, the operation can be completed at site. Its outstanding property is its superior resistance at temperatures up to 60 deg. C. to acids such as nitric, chromic and hydrofluoric at concentrations which have a severe deleterious effect on comparable materials such as rubber. Although originally produced as an acid-resisting material, polyvinyl-chloride can be modified to withstand prolonged contact with plant liquors such as sodium hydroxide and hydrogen peroxide. Wooden vessels and concrete tanks can be lined with equal facility. Fig. 3, on Plate II, shows a concrete tank used in connection with a sulphonation process being lined with polyvinyl-chloride at site. Neoprene is superior to natural rubber in its resistance to oil, and is resistant to the effects of heat, oxygen and sunlight. Animal, vegetable and petroleum-base products cause slight swelling but have little effect on the physical properties of the lining. In general, Neoprene is used in contact with organic chemicals and many organic compounds, the more highly saturated having least effect on the lining.

FOURTH INDUSTRIAL PHYSICS CONFERENCE, GLASGOW.

(Continued from page 22.)

THE second lecture on June 23, the opening day of the conference, was delivered by Sir Robert Watson-Watt, who chose as his subject "Meteorology in Industry." After reviewing the many ways in which the weather influenced industry and industrial processes, and had to be taken into account in the siting of industries, the design of buildings, and the transport of goods by land, sea and air, Sir Robert emphasised the importance of reliable weather-forecasting; in particular, long-range forecasting. At present, he said, a good forecast of the weather at any particular time over the whole country could be given a day ahead, and a moderately good forecast three days ahead. Forecasting over longer periods, however, five days, for example, was unreliable. It would be a great boon and saving to many industries if dependable forecasts for still longer periods such as five weeks or five months, could be given. The possibilities of reliable weather-forecasting had been greatly enhanced by advances in telecommunications and methods of telemetering, and, indeed, more information could be collected by such means than could be analysed in the time available. With the advent of electronic computers, however, new developments in weather forecasting could be envisaged. Hydrodynamic data relating to a whole layer of the troposphere might be fed into such equipment and rapidly analysed. A major effort on the lines suggested seemed well worthwhile.

Turning to the specific matter of meteorology in industry, Sir Robert said that he believed there was a place for highly skilled meteorologists in industry as well as in the public service, and that industry ought to employ such persons. Already, there were industrial meteorologists in the United States of America, and their number was growing rapidly. It had been widely held that the needs of industry could be met by the public weather service, but such a view was incorrect. The State meteorological service performed an essential task on a national and regional scale, but there was a real need for specialists who could interpret and apply publicly-provided synoptic material to the needs of individual industries. One of the principal functions of the State meteorological service was to act as custodian of records of the weather. If such information were stored in punched-card form and were available to industrial meteorologists, it would be of great value.

In the course of a discussion which followed, Sir Nelson Johnson, director of the Meteorological Office, London, expressed himself as being only partly in agreement with Sir Robert. The directions in which meteorology had made its most significant progress during the past decade were three, namely, towards a better understanding of

ANTI-CORROSIVE LININGS FOR PROCESS PLANT.

(For Description, see Page 54.)

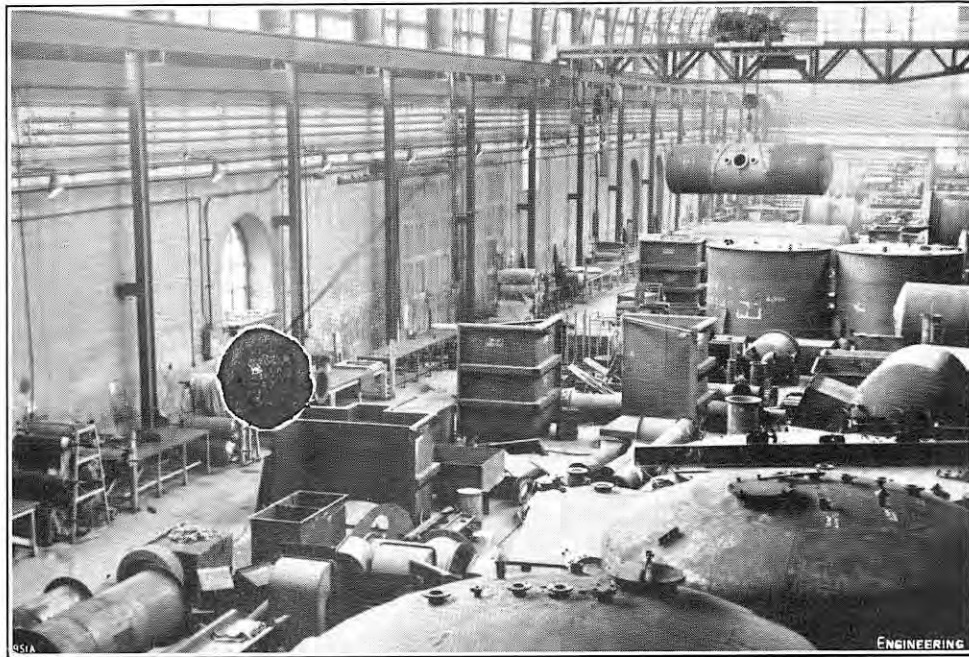


FIG. 1. GENERAL VIEW OF LINING SHOP.



FIG. 2. LARGE VULCANISER.



FIG. 3. CONCRETE TANK LINED WITH P.V.C.

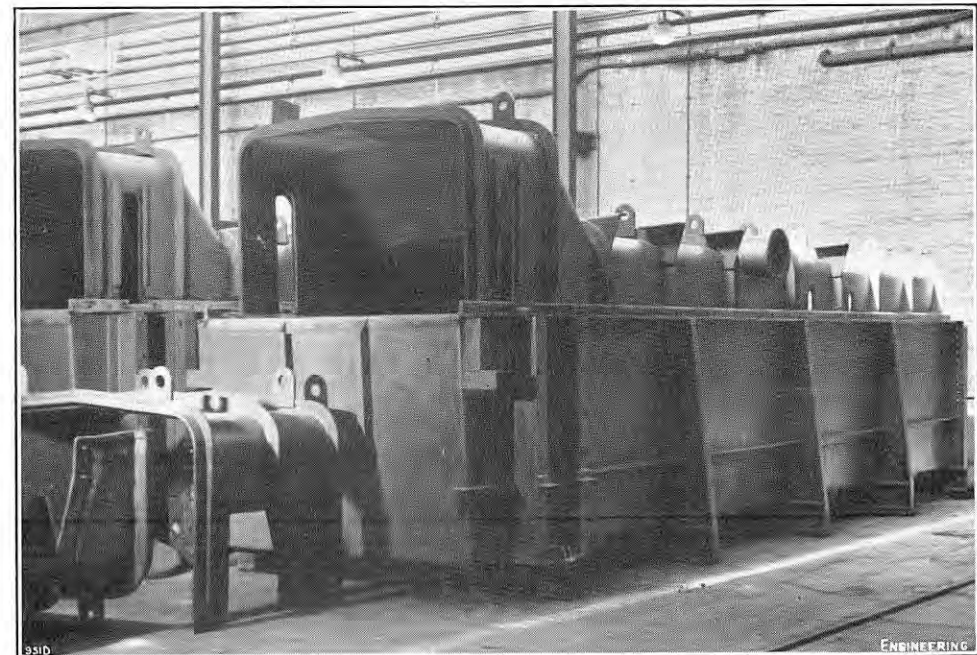


FIG. 4. RUBBER-LINED COMPONENT FOR PICKLING PLANT.

the physical processes of the weather, in the field of statistics as applied to atmospheric data, and towards improved observational techniques. In the last instance, the increased amount of data made available had not led to the advances expected. It was true that a three-dimensional picture of the atmosphere could now be obtained but it was one of appalling complexity. He felt it necessary to issue a warning against the facile assumption that reliable long-range forecasting was just round the corner. The difficulty about computing the weather electronically was that the equations to be solved must first be determined. Drastic assumptions and simplifications would certainly be necessary before they could be reduced to a manageable form, and would render the answer of extremely doubtful value. Hollerith cards had been used for many years at the Meteorological Office but not for conditions over land, and the best method of arranging the information was by no means clear.

As regards industrial meteorologists, Sir Nelson agreed that it would be essential to have persons with high qualifications, but he asked where they could be found. Meteorology, itself, was a subject with highly specialised branches. A specialist in the appropriate field would be desirable, and such specialists were not likely to be found outside the State meteorological service. Furthermore, he thought that many of the meteorological problems of industry were of a short term nature, so that it would be a luxury for a firm to employ a meteorologist full time. Equally, a good meteorologist would demand a reasonably good career. A private forecasting service might supply a want, but he doubted if its cost could be justified.

Mr. R. A. Watson, of the Meteorological Office, Edinburgh, agreed with Sir Nelson. He said that the office frequently received inquiries from manufacturers and industrialists seeking advice about such matters as the deterioration of their products owing to climatic conditions in various parts of the world, but often they failed to supply all the relevant facts, and asked for information which was not really that most suited to their problem. Given full information, he thought that the Meteorological Office could be more useful to industrialists than any private information service. A State meteorologist had at his disposal a large amount of unpublished material, some of which was available only in the minds of his colleagues. Mr. M. G. Bennett, of British Railways, London, supported the suggestion that there was a need for meteorological specialists in industry, but thought that more research on meteorology was necessary as a preliminary. This, he thought, should be undertaken outside and independently of the Meteorological Office, and he would like to see more university research departments devoted to meteorology. Sir Robert Watson-Watt, in his reply, said he had not intended to imply that accurate long-range weather forecasting was just round the corner, but he thought it would be wrong for meteorologists to neglect the possibilities of its development.

TRAINING OF PHYSICISTS.

On the resumption of the conference in the afternoon, there was a discussion on "The Education and Training of Industrial Physicists in Scotland," but most of the remarks were apposite to such education and training anywhere in Britain. The first speaker was Dr. J. Taylor, of Imperial Chemical Industries, Limited, who said that, speaking from his own experience, industry required physicists for four kinds of work, namely, for research and development, to translate these into successful manufacture, to operate plants efficiently and improve industrial processes, and as technical managers and leaders. Scientific and technical personnel could be placed in three categories, namely, scientists, technologists and technicians, the first being university-trained, the second trained in technology, or science with particular reference to its practical applications, and the third being persons of largely *ad hoc* training who were mechanically apt and skilled in particular technical processes.

Physicists, continued Dr. Taylor, were at a disadvantage compared with chemists and engineers in that there was no "physical" industry. Physics graduates seeking employment in industry must,

therefore, be versatile and adaptable, and capable of absorbing knowledge in other fields. In his own experience, a basic training in mathematics and physics was an excellent foundation for a subsequent career in industry. It was to scientists, well trained in fundamental principles, that the nation looked for new discoveries, but some men in this category eventually found their proper sphere to be development work. Thanks largely to the excellence of her universities, Britain had always taken a leading place in the field of new discoveries but, in the provision of opportunities for higher technological training, she was probably behind such countries as the United States of America, and Switzerland. More opportunities for such training at post-graduate level were necessary.

Technicians, said Dr. Taylor, were required by industry in large numbers. Scottish education had been good in the past, and it was to be hoped that the introduction of the new School Certificate would not result in a fall in educational standards. As regards the National Certificate, the difficulty of obtaining suitable teachers and adequate equipment was considerable in many instances. Finally, industry had a real need for technical managers and leaders, but a large proportion of the recruits to industry from the universities and technical colleges showed a lack of general education and the initiative and other qualities necessary for leadership. He did not think this was wholly attributable to over-specialisation. The absence of suitable training in the home and at school, and the meagre opportunities for communal living at most of the universities and for social intercourse with students in other faculties were probably also to blame.

The second speaker was Professor P. I. Dee, of Glasgow University, who said that he would confine his remarks to the training of research physicists at Glasgow. The universities were sometimes charged with devoting too much attention to what might be termed the more glamorous branches of the subject, such as nuclear physics, but this was not so. The training at Glasgow was mainly on classical lines up to the end of the third year of the honours course, and only in the fourth year did students study post-1900 physics in any detail. There was, however, a three-years' post-graduate course, which was mainly on nuclear physics, partly owing to lack of funds and accommodation, but also because it was essential to have a lot of persons working on one subject if good results were to be achieved. He thought that the subject used for training purposes mattered little. The object was to train the student's mind, to inculcate the proper attitude towards research, and to develop the mental faculties and processes rather than build up a store of knowledge. He contended, therefore, that the training given in universities was suitable for subsequent research in any field, including industry.

As an example of the truth of his contention, Professor Dee cited the development of radar during the recent war. When this work started, there had been a great influx of university-trained physicists into Government departments and industry, who had had no previous experience of radar. Yet it was largely such persons who had worked out the basic theory of radar and had shown how centimetric waves could be used. It was often found that fundamental scientists were more successful in this work than those who had long experience in the radio field, because their minds were untrammelled by experience of standard techniques and modes of thought which were unsuited to the new developments. What had been required was a straightforward attack on the problem, and it was physicists who had a sound knowledge of fundamental principles but no knowledge of the existing technology who had achieved the complete solution.

He saw a main function of university physics-research departments, therefore, as one of training students to approach new problems from first principles, of producing men who would be adaptable to any work and uninhibited by a knowledge of established techniques. Finally, he thought that one of the best ways of training students in university research departments was to let them evolve their own apparatus. To do so developed initiative and originality.

(To be continued.)

CONCRETE SHELL ROOF CONSTRUCTION.

A SYMPOSIUM on concrete shell roof construction, organised by the Cement and Concrete Association, was held in London on July 2, 3 and 4. The first day's papers dealt with the architectural aspects of shell roofs and were discussed at the Royal Institute of British Architects. On the second and third days, the papers were presented at the Institution of Civil Engineers and were devoted to design and research, and construction, respectively.

A complete list of the papers and authors is as follows. July 2: "Domes, Vaults and the Development of Shell Roofing," by Leo. M. De Syllas, A.R.I.B.A.; "Various Forms of Shell Roofing and their Application," by Edward D. Mills, F.R.I.B.A.; and "Architectural Problems of Shell Roofing," by E. Leslie Gale, M.C., F.R.I.B.A. July 3: "Existing Methods for the Analysis of Concrete Shell Roofs," by J. J. McNamee, Ph.D.; "Flexibility Coefficient Methods and their Application to Shell Designs," by A. Goldstein, B.Sc. (Eng.), A.M.I.C.E., A.M.I.Struct.E.; "Research on Shells," by P. B. Morice, B.Sc., Ph.D.; "New Forms of Shells," by R. S. Jenkins, B.Sc., A.M.I.C.E.; and "The Combination of Shells and Prestressing," by C. V. Blumfield, B.Sc. (Eng.), M.I.C.E., A.M.I.Struct.E. July 4: "Design and Construction from the Economic Aspect," by H. G. Cousins, B.Sc., M.I.C.E., M.I.Struct.E.; "Construction of Skelton Grange Power Station at Leeds and a Factory at King's Lynn," by H. E. Manning, B.Sc., M.I.C.E., M.I.Struct.E.; "Formwork used on a Factory at Greenford," by H. F. Rosevear, M.I.Struct.E.; and "Travelling Formwork as used on Sheds at Antwerp," by A. Paduart. Over 60 members contributed to the discussions.

The meeting was opened by Sir Francis Meynell, R.D.L., director of the Cement and Concrete Association. He welcomed the 550 members, who included representatives from some 12 overseas countries, and pointed out that the conference was the first in this country, and possibly the first in the world, on the subject of shell roofs. Sir Francis said that, since the first barrel-vault roof was constructed in this country in the early 1930's, about 500 had been built, principally since the war.

ARCHITECTURAL ASPECT OF CONCRETE SHELL ROOFS.

The three papers presented in this section developed the architectural aspect in three distinct stages. In the first paper, Mr. De Syllas briefly reviewed the classical epochs of architecture and early attempts to construct roofs over large areas. He was followed by Mr. Mills, who surveyed the different forms of barrel roof that have been tried so far; and by Mr. Gale, who considered, in the third paper, those problems which belong particularly to the architect in the design of such roofs.

Mr. De Syllas pointed out that, structurally, the history of architecture was simply the story of man's efforts to enclose space, as a protection against the weather, and to admit light in the most effective manner. With the development of the arch, it was the Romans who first embarked upon the roofing of large and complex buildings on a monumental scale, to be followed through the centuries by the construction of the world's great churches. The history of Roman, Byzantine and mediaeval architecture could be traced in the solution of the problem of opposing the thrust of the arch, whether in its simplest form or in its more complex developments of the vault and the dome. In an analysis of the Cathedral of St. Sophia, Istanbul—the building which, he said, still had the greatest clear floor space in the world—Mr. De Syllas showed how four major problems of this type of construction were solved. The problems were, firstly, to distribute the thrust of the dome through ribs, as with the

vault, so as to substitute the simple abutment for the massive walling; secondly, to keep the weight of the dome down at the apex so as to reduce the thrust; thirdly, to extend the dome over a planned form other than a circle; and, lastly, to admit light into the space below the dome. He contrasted the achievement of lightness at the apex of the dome in all Byzantine structures with the later problem of the Baroque builders, who created an illogical difficulty by crowning their domes with a massive cupola. Thus, on St. Paul's Cathedral, London, the dome was surmounted by 800 tons of Portland stone which had to be carried by a brick cone hidden between the outer and inner domes.

The discussion of Mr. De Syllas's paper centred round the growth of knowledge since the classical days of architecture, when works often collapsed through lack of good design, whereas it was claimed that, to-day, no one feared the precipitant failure of a structure designed with present knowledge. To Robert Maillart, a Swiss pioneer in reinforced-concrete design, was attributed the concept of removing from a building or any other structure all that was non-functional, so that everything which remained served a positive structural purpose. Shell roofs—highly stressed membranes providing protection from the weather—were the modern fulfilment of that concept.

Mr. Mills introduced his paper with a number of slides illustrating the various forms of shell roof that have been constructed so far both in Britain and abroad. The examples ranged from the simple but attractive canteen of Messrs. May and Baker, Limited, at Dagenham, to the remarkable square domes used at the new rubber factory at Brynmawr, South Wales, which was described in our issue of April 4, 1952. Mr. Mills began the summary of his paper by stressing that shell roofs were no universal solution to all problems of roofing and that their indiscriminate use would lead—as it had done already—to some most unsatisfactory buildings. His second point concerned the essential need for co-operation, at an early stage, between the architect and the engineer. Thirdly, he observed that "shells" had a character of their own and appealed to all concerned not to hide that character behind false ceilings and high parapets. It may have been out of consideration for the feelings of the contracting members present, that subsequent speakers omitted to suggest that false ceilings were not incorporated to hide the shell form of construction, but to hide the shortcomings of the concrete, such as bad shutter marks, iron stains and slurry runs.

In opening the discussion, Mr. E. Seel referred to the problems of acoustics and illumination. In particular, he made the point that a great number of interior treatments tended to be reflective rather than absorptive, and that the path of the architect was often made more difficult by clients who changed the purpose of buildings from that initially prescribed. Mr. O. N. Arup commented that the square domes of Brynmawr were only the beginning, and that shells would soon develop into much more difficult—and interesting—shapes. The only limitations were going to be the reduction of the engineering mathematics contained in the design (although the later paper of Mr. Jenkins indicated that this limit would not, for long, be particularly restrictive) and of the cost and convenience of construction, which difficulties could be overcome by sufficiently wealthy clients. A number of speakers, of whom the first was Mr. E. Loewy, mentioned the possibilities of making economies by standardisation. In general, support for standardisation was received from engineers, whereas the architects expressed their fears of limited development if too rigorous standardisation was introduced. In closing the discussion on his paper, Mr. Mills, however, declared himself untroubled by such fears.

(To be continued.)

LABOUR NOTES.

COMMENTS on the existing production situation, made by Mr. Aneurin Bevan, M.P., in the course of an address to a labour rally at Belle Vue, Manchester, on Sunday last, included a suggestion that trade unionists should face up to the fact, grim though it was, that higher standards of living would be impossible if production declined. After deriding appeals by the Government for harder work, Mr. Bevan said that certainly his hearers and their fellows would work harder if it became necessary for them to do so, but, under modern industrial conditions, it was not only muscle power that was needed: high-quality brain power was required also. Increased electric horse-power and machine tools of improved efficiency should be placed in the hands of workpeople, if the country wanted more productivity. The present position, however, was that production had recently begun to decline, as he had prophesied a year ago that it would, and, for this, the re-armament programme was partly to blame.

His trade-union friends who were pressing for higher wages should be warned, Mr. Bevan stated, that they could not have higher wages without higher production. If people tried to obtain more wages without working harder, all that would happen would be inflation of the worst possible kind. At the same time, it had to be realised that higher production in Britain was unobtainable with the present re-armament programme. If it were decided that the country could have, and should have, more tanks, and a re-armament programme on that scale was agreed to, then the facts must be faced and everyone must realise that no amount of transferring wealth from rich to poor in Great Britain would make up for the result. It was just impossible to obtain increased social services, increased wages, more arms and a higher standard of living from lower production. Anyone who said differently, Mr. Bevan declared, was not speaking the truth.

References to the dangers of inflation and the need for a national wage policy were made by Mr. H. W. Franklin, the President of the National Union of Railwaymen, in his address at the opening of the union's annual conference at Scarborough on Monday last. He considered that wage increases, by themselves, should not be regarded with any great joy. It would, in fact, be folly not to recognise that the inflationary spiral would continue, to the eventual detriment of everybody, if wages were allowed to continue chasing prices. Last year, he had referred to his concern at the calamity which would occur if the chasm between wages and the daily alterations in prices went beyond human control. The great needs at the present time were to stabilise prices and give the pound greater purchasing power. There could be no doubt as to the wisdom of such a policy, for while the majority of railwaymen now had more pound notes to spend, their purchasing power was less than formerly.

On the subject of wage negotiations, Mr. Franklin stated that his union greatly valued, and would wish to retain always, its complete prerogative to have the unfettered right to negotiate freely with transport employers on wage questions, but it might be deemed desirable, under a Labour Party Government, to give up this right for a period and permit some agreed national trade-union organisation to be given complete power to negotiate with such a Government, in order that that part of the national income allocated for wage purposes might be shared out fairly. That might seem a revolutionary project, but, if the existing economic difficulties continued to worsen, and the danger of uncontrolled inflation drew still nearer, it would pay all trade unions to give up their individual sovereignty, if, by that sacrifice, they were able to assist in saving the nation from a financial catastrophe.

Earlier on Monday, Mr. J. B. Figgins, the union's general secretary, presented his annual report, in which he said that, after six years of work for all, the dread spectre of unemployment again darkened

the horizon. He asked all members of the union to consider seriously and dispassionately whether the interests of the community, and of railway employees in particular, would really be served by unregulated competition. This permitted other operators to select the cream of the traffic, while the railways, as common carriers, were compelled to accept the residue. Although there was an acute shortage of staff in some branches of the railway service, especially in the permanent-way department, highly-trained personnel in a number of railway workshops had been transferred from their work of useful social production in an attempt to satisfy the export market and the needs of the re-armament programme.

During a discussion on the economic position of British coal mines, at the annual conference of the National Union of Mineworkers, which also opened on Monday last at Scarborough, Mr. Arthur Horner, the union's general secretary, suggested that an attitude of complacency had been adopted by the National Coal Board regarding the present state of production and man-power in the coal-mining industry. He said that Britain's coalmines would probably produce some 25 million tons more coal this year than they had done during the twelve months immediately before nationalisation, in spite of the fact that there were now twelve thousand fewer miners. Still more coal was needed, however, and many more men were wanted to dig it.

There was no need whatever, Mr. Horner considered, for anyone to fear that a superabundance of coal was likely to arise. Even if countries covered by the Schuman plan pooled their coal resources, they would still require 12 million tons a year between them, and there was likely to be acute competition between Britain, Poland and the United States to supply this. There were also many markets in the rest of the world. If, however, a superfluity of coal should begin to appear, the miners could deal with the situation very easily. Open-cast mining and the working of Saturday shifts could be stopped and miners could begin to take their full fortnight's holiday. It should be recognised by all that increased coal production was essential for the balancing of Britain's overseas payments. More coal must be obtained more quickly, using British labour, and, therefore, thousands more miners were needed and they required a living wage. There must be no complacency.

Among the resolutions which were approved during early stages of the miners' annual conference was one asking the National Coal Board to provide payment for the loss of wages due to illness for a period of up to six weeks during any one year. This resolution was carried unanimously. Another successful resolution, from the union's South Wales area, called upon the Board to subsidise miners' fares in cases where the cost of travelling to and from the mines exceeded 5s. a week.

Attempts were made early this week, by some of the men concerned in the dispute, to break the strike which has been in progress at the Dagenham works of the Ford Motor Company, Limited, but, on Monday last, a meeting of the 95 shop stewards voted in favour of the stoppage being continued. The trouble began at the Ford Company's associated organisation, Briggs Motor Bodies, Limited, also of Dagenham, where employees put forward a claim for an increase of 9d. an hour. A stoppage of work to enforce the claim resulted in the holding up of the supply of motor bodies for the Ford Company, and this, in turn, led to some 900 employees at Ford's works being stood off for reasons of redundancy. Thereupon, the remainder of Ford's employees joined in the strike. Some idea of the complicated nature of this dispute may be inferred from the fact that no fewer than 17 unions are involved. The opinion is held in some quarters that what began as an industrial dispute has been unnecessarily prolonged by the men's leaders for political reasons. The strike at Ford's ended on Wednesday, after a mass meeting of the company's employees had decided to resume work.

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 37.

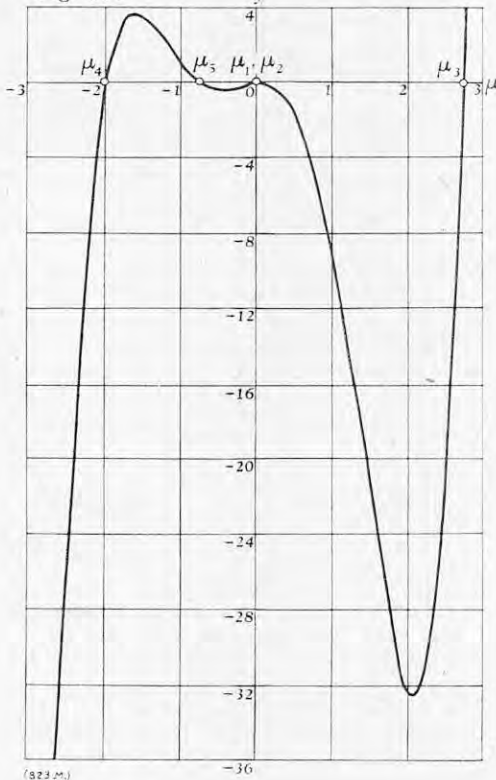
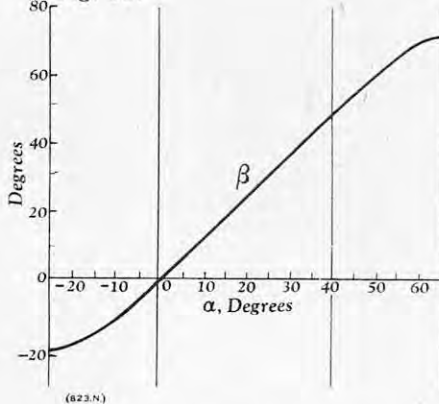


Fig. 38.



MECHANISMS FOR INTERMITTENT MOTION.

By O. LICHTWITZ, M.I.Mech.E.

(Continued from vol. 173, page 743.)

THE kinematics of star-wheel mechanisms will now be considered. Fig. 32, on page 743, of the previous volume, shows the same star-wheel mechanism as Fig. 31, in a general position during the acceleration period. CD is part of the epicycloid which forms the centre line of the slot. As in Fig. 31, A' is the centre of the circle, the rolling of which generates the epicycloid CD, when the circle is in the position which corresponds to the generation of point D. The angle $\alpha = \angle C'AD$ is the angle through which the driving roller must rotate up to the central position. The triangles C'AD and EA'D are congruent, and as the arcs CE and DE each equal $r_1\alpha$, the angle CBE is $\frac{r_1\alpha}{r_2} = \frac{\alpha}{\mu}$. The angle $\beta = \angle C'BC$ is the angle through which the driven gear must rotate up to the central position. The angle $\angle C'BE = \beta + \frac{\alpha}{\mu}$, and the angle $\angle C'BD$ is, therefore, $\frac{1}{2}(\beta + \frac{\alpha}{\mu})$. Since $ID = r_1 \sin \alpha$, and $IB = r_2 + r_1 - r_1 \cos \alpha$, $\tan \frac{1}{2}(\beta + \frac{\alpha}{\mu}) = \frac{r_1 \sin \alpha}{r_2 + r_1 - r_1 \cos \alpha} = \frac{\sin \alpha}{\mu + 1 - \cos \alpha}$, so that the relation between β and α is

$$\beta = 2 \tan^{-1} \frac{\sin \alpha}{\mu + 1 - \cos \alpha} - \frac{\alpha}{\mu} \quad (41)$$

Fig. 39.

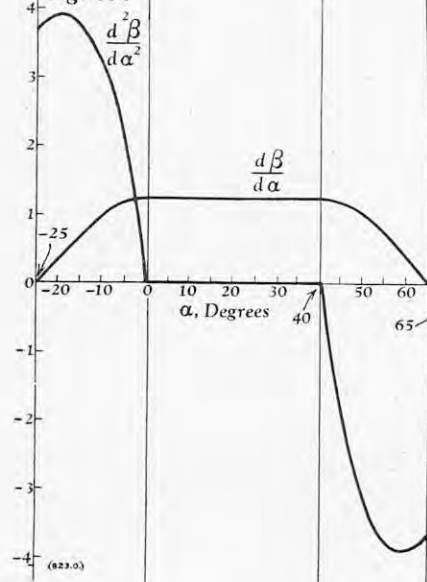
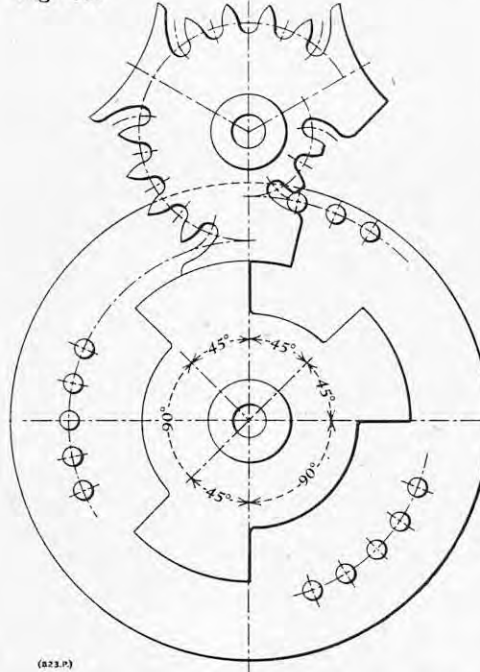


Fig. 40.



If the angular velocity of the driving gear is $\omega = 1$, the angular velocity of the driven gear is obtained by differentiating β with regard to α .

$$\frac{d\beta}{d\alpha} = 2 \frac{(\mu + 1) \cos \alpha - 1}{(\mu + 1)^2 + 1 - 2(\mu + 1) \cos \alpha} - \frac{1}{\mu} \quad (42)$$

The maximum angular velocity is reached when $\alpha = 0$, as can easily be gathered from Fig. 32. In this case,

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{1}{\mu} \quad (43)$$

That result is not surprising, because the gears behave in the central position like ordinary spur gears of gear ratio $\frac{r_2}{r_1} = \mu$. By differentiating (42) with regard to α the angular acceleration of the driven gear is obtained as

$$\frac{d^2\beta}{d\alpha^2} = -2\mu(\mu + 1)(\mu + 2) \times \frac{\sin \alpha}{[(\mu + 1)^2 + 1 - 2(\mu + 1) \cos \alpha]^2} \quad (44)$$

As in the case of Geneva mechanisms, the minus sign indicates here also that the driven gear is accelerated before the central position. The angular acceleration at the start of motion is obtained by substituting $-\alpha_0$ for α in (44). Since $\sin \frac{\alpha_0}{2} = \frac{\mu}{2(1 + \mu)}$, it follows that

$$\sin(-\alpha_0) = -\frac{\mu \sqrt{(\mu + 2)(3\mu + 2)}}{2(\mu + 1)^2}$$

$$\text{and } \cos(-\alpha_0) = \frac{\mu^2 + 4\mu + 2}{2(\mu + 1)^2},$$

and, by (44),

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0} = \frac{\mu + 1}{\mu^2} \sqrt{\frac{3\mu + 2}{\mu + 2}} \quad (45)$$

The third differential coefficient is

$$\frac{d^3\beta}{d\alpha^3} = -2\mu(\mu + 1)(\mu + 2) \times \frac{2(\mu + 1) \cos^2 \alpha + (2 + 2\mu + \mu^2) \cos \alpha - 4(\mu + 1)}{[(\mu + 1)^2 + 1 - 2(\mu + 1) \cos \alpha]^3} \quad (46)$$

and the maximum of $\frac{d^2\beta}{d\alpha^2}$ occurs at the position

where $\frac{d^3\beta}{d\alpha^3} = 0$, or where

$$2(\mu + 1)(\cos^2 \alpha + (2 + 2\mu + \mu^2) \cos \alpha - 4(\mu + 1)) = 0.$$

The solution is

$$\cos \alpha = -\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)} \pm \sqrt{\left[\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)}\right]^2 + 2}.$$

The value under the square root is larger than 1, and only the plus sign is admissible. Thus,

$$\alpha_{\max.} = \cos^{-1} \left\{ -\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)} + \sqrt{\left[\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)}\right]^2 + 2} \right\} \quad (47)$$

The maximum angular acceleration is obtained by substituting $\alpha = \alpha_{\max.}$ in (44).

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{\max.} = -2\mu(\mu + 1)(\mu + 2) \times \frac{\sin \alpha_{\max.}}{[(\mu + 1)^2 + 1 - 2(\mu + 1) \cos \alpha_{\max.}]^2} \quad (48)$$

The angle α in all previous formulae is not limited, from the mathematical point of view, to the period of motion. The existence of a maximum value of $\frac{d^2\beta}{d\alpha^2}$, therefore, does not necessarily mean that the maximum occurs at an actual position during the period of acceleration. The maximum is of interest only if $\alpha_{\max.} < \alpha$, that is, if $\cos \alpha_{\max.} > \cos \alpha_0$. By using (47), and the relation $\cos \alpha_0 = \frac{\mu^2 + 4\mu + 2}{2(\mu + 1)^2}$, it follows that this implies that

$$-\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)} + \sqrt{\left[\frac{\mu^2 + 2(\mu + 1)}{4(\mu + 1)}\right]^2 + 2} > \frac{\mu^2 + 4\mu + 2}{2(\mu + 1)^2}.$$

By isolating the square root on one side, and squaring both sides of the inequality above, a more convenient form is obtained in $\mu^2(\mu^3 - 6\mu - 4) < 0$.

The curve $y = \mu^2(\mu^3 - 6\mu - 4)$ is plotted in Fig. 37, herewith. The factor μ^2 indicates that two of the five solutions of the equation $\mu^2(\mu^3 - 6\mu - 4) = 0$ are zero.

The origin is a double point of the curve, and the μ -axis is the tangent to the curve at that point. The other three solutions are the roots of the cubic equation $\mu^3 - 6\mu - 4 = 0$, that is

$$(\mu + 2)(\mu^2 - 2\mu - 2) = 0.$$

They are, therefore, -2 , $1 + \sqrt{3} = 2.732$, and $1 - \sqrt{3} = -0.732$.

If only positive values of μ are contemplated, the condition $\alpha_{\max.} < \alpha_0$ is satisfied if $\mu < 2.732$. The acceleration then reaches a true maximum within the actual period of acceleration. For $\mu > 2.732$, the theoretical maximum acceleration occurs at an angle prior to motion, and the largest value, therefore, is that at the commencement of motion. The value of $\frac{d^2\beta}{d\alpha^2}$ for $\alpha = 0$ is $-\frac{2(\mu + 1)(\mu + 2)}{\mu^3}$;

it measures the rate at which the angular acceleration diminishes. It is of less interest, however, than in the case of Geneva mechanisms, because the occurrence of uniform motion between the periods of acceleration and retardation does not cause the driving roller to change contact from one flank of the slot to the other.

Figs. 38 and 39, herewith, are diagrams of the value β , $\frac{d\beta}{d\alpha}$, and $\frac{d^2\beta}{d\alpha^2}$ for the mechanism shown in Fig. 26, which has been considered in a previous example. The angular acceleration starts at $\alpha_0 = -25 \text{ deg. } 16 \text{ min.}$ with a definite non-zero value, rises to a maximum at $\alpha_{\max.} = -19 \text{ deg. } 1 \text{ min.}$, and decreases to zero at $\alpha = 0$. The motion is

uniform during the subsequent period of 39 deg. 28 min. The angular retardation which follows lasts for 25 deg. 16 min., and is analogous to the angular acceleration in the first period.

In addition to the values already discussed, Table VI, page 742, of the previous volume,

contains the values of $\left(\frac{d\beta}{d\alpha}\right)_0$, $\left(\frac{d^2\beta}{d\alpha^2}\right)_0$, $\alpha_{\max.}$, and $\left(\frac{d^2\beta}{d\alpha^2}\right)_{\max.}$, the last two only for $\mu < 2.732$. As

an example, we may investigate the kinematic properties of the mechanism shown in Fig. 26. Its geometrical relations have already been considered in the previous example, where μ was assumed to be $\frac{2}{3}$. Let $N = 50$ r.p.m., that is, assume the speed to be the same in the first example of an equivalent Geneva mechanism. The maximum

angular velocity, for $\omega = 1$, is by (43), $\frac{1}{\mu} = \frac{3}{2} = 1.226$ radians per sec. For $N = 50$ r.p.m., it is $5.2360 \times 1.226 = 6.732$ radians per sec. The initial angular acceleration, for $\omega = 1$, is by (45), 3.670 radians per sec.², or, for $N = 50$ r.p.m., $27.416 \times 3.670 = 100.617$ radians per sec.² The maximum angular acceleration occurs at $\alpha_{\max.} = -19$ deg. 1 min., by (47), and is 3.921 radians per sec.², by (48). For $N = 50$ r.p.m., it is $27.416 \times 3.921 = 107.497$ radians per sec.²

A comparison between the results of this and the first example shows that a star-wheel mechanism, with $n = 4$ and $\epsilon = 1$, has better kinematic properties than an equivalent Geneva mechanism. The same is true to a still higher degree for $n = 3$, and to a lesser extent for $n = 5$. For $n \geq 6$ however, the maximum accelerations of Geneva mechanisms are lower than those of equivalent star-wheel mechanisms. This is due to the fact that Geneva mechanisms have longer periods of acceleration, so that the average acceleration is smaller than in the case of star-wheel mechanisms. Only the unfavourable course of the motion of Geneva mechanisms having a small number of stations is responsible for the high peaks in the acceleration of such gears.

Modifications similar to those described earlier for external Geneva mechanisms can also be made to external star-wheel mechanisms. The relation between the number m of equally distributed groups of driving rollers and the ratio ν is, as in the case of modified Geneva mechanisms $m\nu \leq 1$, or $m \leq \frac{1}{\nu}$.

From the relation $\nu = \frac{\epsilon}{n}$ obtained in (35), it follows that $m \leq \frac{n}{\epsilon}$.

The maximum of m thus corresponds to the minimum of ϵ .

$$m_{\max.} = \frac{n}{\epsilon_{\min.}} \quad (49)$$

The nearest whole number smaller than the right-hand side of (49) is to be found from Table IV, page 742, of the previous volume, as $m_{\max.}$. These values are higher, or at least as high, as the analogous values for Geneva mechanisms. Two groups of driving rollers can be arranged for any number of stations. In particular, if $\epsilon_{\min.} = \frac{3n\alpha_0 \min.}{2\pi}$ (from formula (32) is used, together with (49), it follows that

$$m_{\max.} = \frac{2\pi}{3\alpha_0 \min.} \quad (50)$$

α_0 is for a finite number of stations less than 60 deg. $= \frac{\pi}{3}$ radians, so that $m_{\max.} = \frac{2\pi}{3\pi} = 2$.

The driving rollers can be arranged in equally or unequally spaced groups. Fig. 25, on page 741, of the previous volume, for instance, shows in dotted lines two additional groups of driving rollers which would ensure that the driven gear made half a revolution during every third of a revolution of the driving gear. If only one of the additional groups were provided, the unequally spaced groups of driving rollers would come into action alternately after one-third and two-thirds of a revolution of the driving gear. Fig. 40, page 57, shows a mechanism for imparting intermittent motion with varying periods of motion, and Fig. 41 shows the corresponding displacement diagram

MECHANISMS FOR INTERMITTENT MOTION.

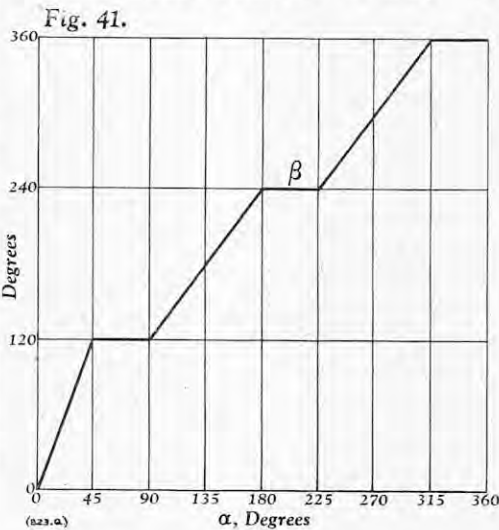
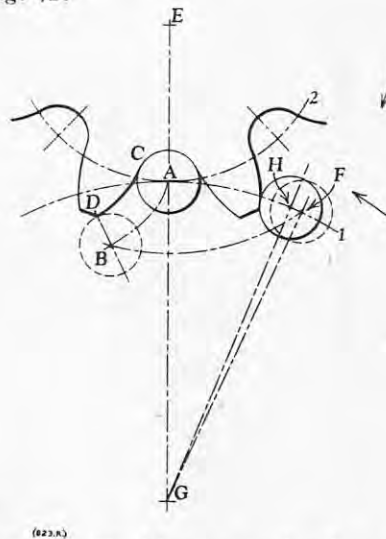


Fig. 42.



schematically. The driven gear makes three partial rotations, each of 120 deg., which are separated by three standstills lasting for 45 deg. rotation of the driving gear. One partial movement lasts for 45 deg., and the other two for 90 deg. rotation of the driving gear. For the partial movement which lasts 45 deg., $\epsilon = \frac{45}{120} = 0.375$, and Table V, on page 742, of the previous volume, indicates that, for $n = 3$, $\mu = 0.2869$. For the partial movements lasting 90 deg., $\epsilon = \frac{90}{120} = 0.75$, and $\mu = 0.6047$. The pitch radii and all other relevant dimensions vary with varying values of μ . Mechanisms can be designed in a similar way, not only for differing periods of motion and standstill, but also for differing partial movements.

Design and Machining.—In the earlier part of this discussion reference was made to the elements for imparting the non-uniform motion. In designing such mechanisms, the angles β_0 and ρ_0 , and the distance ρ_0 determine the shape of the slot in the driven gear, and a knowledge of the tangents at both ends of the slot enables the centre line of the slot to be drawn almost without constructing the epicycloid. The angle between the accelerating and retarding rollers (i.e., the first and last roller of each group) is $\mu \left(\frac{2\pi}{n} - 2\beta_0 \right)$, and the angle over which the locking drum extends is γ defined by (39). The elements for imparting uniform motion must be laid out according to the rules of ordinary gearing. Pin gearing has been chosen in most of the illustrations mainly because it makes them self-explanatory. In practice also pin gearing has the advantage (probably its only one) of simplicity, because the rollers for accelerating, imparting uniform motion, and retarding, are uniform and arranged on a common disc, and the slots for non-uniform motion, and the teeth for uniform motion are in the same plane. Such details of pin gearing

Fig. 43.

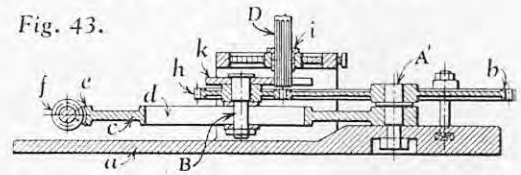
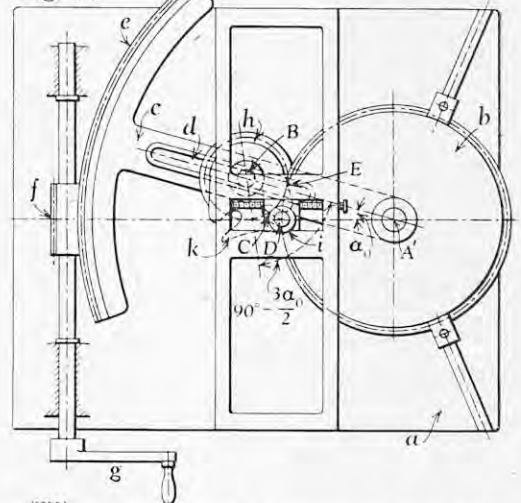


Fig. 44.



as are required for design purposes are given below.

The path along which the centre of a driving roller travels relative to the driven gear is an epicycloid congruent with that used for designing the slots for non-uniform motion. The distance between the accelerating roller and its neighbour can be determined as follows. The acceleration occupies the angle α_0 of the driving gear, and the accelerating roller leaves its slot after a rotation through a further angle α_0 . Between the start of the motion and the position where uniform motion begins, therefore, the driving gear must rotate through an angle which lies between α_0 and $2\alpha_0$. Within limits, the pitch of the intermediate rollers can be chosen arbitrarily. There is a lower limit, since with decreasing pitch the teeth become weaker, and also an upper limit imposed by the requirement that at any time at least two of the rollers must be in action.

The angle during which a roller is active can be found graphically, as shown in Fig. 42, herewith. A B is part of the epicycloid generated by the rolling of the pitch circle of the driving gear on the pitch circle of the driven gear. The flank C D is a equidistant curve at the distance of the radius of the roller. Near the root, the flank does not exactly represent the shape intended by the epicycloidal centre line, because the radius of curvature there is smaller than the radius of the roller. With the direction of rotation indicated, the roller is in the central position A at the end of its engagement with the flank C D. The height of the tooth determines the extremity D of the flank, and that point corresponds to the point B on the epicycloid. If a circle with centre E is drawn through B, its intersection F with the pitch circle of the driving wheel determines the commencement of engagement.

If the second roller is required to come into action at a certain angle (for instance α_0) after the accelerating roller, the angle A G F is made equal to that angle, and the height of the teeth is determined by reversing the construction. If the height of the teeth for transmitting uniform motion is chosen equal to the height of the first and last teeth, the pitch of the intermediate teeth must be smaller than the arc A F, in order to have two rollers simultaneously in action (the pitch A H in Fig. 42 is shown smaller than the arc A F). If the rollers are pitched uniformly, the height of the intermediate teeth must exceed that of the first and last tooth.

As an example, consider the design of the uniform-motion parts of a star-wheel mechanism, for which $n = 1$, and $\mu = 0.375$ (Fig. 24, page 741, of the previous volume). The distance between centres is 5.5 in., and the diameter of the rollers may be chosen as 0.5 in. For $\mu = 0.375$, $\alpha_0 = 15$ deg. 40 min. 30 sec., $\beta_0 = 24$ deg. 41 min.,

the pitch radii are $r_1 = 4$ in. and $r_2 = 1.5$ in., respectively. The uniform motion occupies 360 deg. $- 2\beta_0 = 310$ deg. 38 min. of rotation of the driven gear, or 0.375×310 deg. 38 min. = 116 deg. 29 min. of the driving gear. The angle 16 deg. 38½ min. lies between α_0 and $2\alpha_0$, and is, therefore, suitable also as the angle between the extreme rollers and their neighbours. On adopting this angle and proceeding as shown in Fig. 42, the height of the teeth will be found to be $\frac{5}{16}$ in. If, as in Fig. 24, eight equally-spaced pins or rollers are chosen, the angle between two consecutive pins is $\frac{1}{8} \times (116 \text{ deg. } 29 \text{ min.}) = 16 \text{ deg. } 38\frac{1}{2} \text{ min.}$ The central teeth must be higher than the two adjacent to the accelerating and retarding slots.

It has already been mentioned that the uniform motion can be obtained by common involute gears, and Figs. 29 and 30, page 741, of the previous volume, show the mechanism of Fig. 24 carried out in that way. The locking drum a is secured to the uniform-motion part b of the driving gear, and the locking shoe and slots c are secured to the uniform-motion part d of the driving gear. The driving unit also incorporates the carriers e for the rollers f . The angle of approach δ for involute gears, that is, the angle between the position of the driving gear where a tooth first meets a mating tooth and the position where the contact takes place in the central position, can be computed from the overall radius e_2 of the driven gear, the pitch radius r_1 of the driving gear, the pressure angle ψ , and the ratio $\mu = \frac{r_2}{r_1}$ of the pitch radii. It may be proved that the angle of approach in radians is

$$\delta = \sqrt{\left(\frac{e_2}{r_1 \cos \psi}\right)^2 - \mu^2} - \mu \tan \psi. \quad (51)$$

The angle between the centre of the accelerating roller and the tip of the first involute tooth must be at least as great as δ , defined by (51). The number of teeth in the involute gear segment can be calculated if the duration of the uniform motion, and the angle δ are known. The number can also be found graphically. As an example, consider the design of the uniform-motion parts of a star-wheel mechanism, for which $n = 1$, and $\mu = 0.375$, as shown in Figs. 29 and 30. The distance between centres is $5\frac{1}{2}$ in.

An equivalent mechanism has been considered in the previous example, where the pitch radii were taken to be $r_1 = 4$ in., and $r_2 = 1\frac{1}{2}$ in., respectively. If the diametral pitch of the involute gears is chosen as $P = 9$, the complete gears would have 72 and 27 teeth respectively. If the height of the teeth above the pitch line has its customary value $\frac{1}{P}$, the overall radius e_2 of the driven gear is

$\frac{29}{18} = 1.611$ in. The pressure angle ψ depends on the available milling cutter or hob and may be assumed to be $14\frac{1}{2}$ deg. Since $\mu = 0.375$, (51) gives

$$\delta = \sqrt{\left(\frac{1.611}{4 \cos 14\frac{1}{2} \text{ deg.}}\right)^2 - 0.375^2} - 0.375 \tan 14\frac{1}{2} \text{ deg.} = 0.08319 \text{ radian, or } 4 \text{ deg. } 46 \text{ min.}$$

In the previous example, the uniform motion was found to occupy 116 deg. 29 min. of the driving gear, so that the angle during which the involute gears are effective should be less than 116 deg. 29 min. $-(2 \times 4 \text{ deg. } 46 \text{ min.}) = 106 \text{ deg. } 57 \text{ min.}$ The pitch angle is $\frac{360}{72} = 5 \text{ deg.}$, so that 106 deg. 57 min. correspond to 21.39 pitches. The arc covered by 22 teeth, measured along the pitch circle between the respective external flanks, is $21\frac{1}{2}$ pitches, and the distance between the external tips of the two extreme teeth corresponds to a somewhat smaller angle. Twenty-two teeth would be possible, but to be on the safe side, 21 teeth have been chosen in Figs. 29 and 30. As the number of teeth is odd, the driving gear has a tooth, and the driven gear a gap in the central position. Only 21 gaps need be machined in the driven gear, corresponding to the same number of teeth in the driving gear. There is no objection, however, to cutting all the teeth of the driven gear if the teeth are cut by hobbing.

The previous example makes it obvious that the pitch diameters of the driving and driven gears, which are the same for uniform and non-uniform

motion, must be chosen to suit the requirements of involute gearing. The design, therefore, is best started from a suitable value of μ . If involute gears are used to impart the uniform motion, the only parts which involve some difficulty in machining are the accelerating and retarding slots. The slots can be marked off, and drilled and filed to shape. Where star wheels are required in considerable quantity, an attachment like that shown in Figs. 43 and 44, opposite, simplifies the work. The base a is equipped with a stud A' , on which a gear b is rigidly mounted. The gear must have the same pitch diameter as the driving gear, and the driving gear which imparts the uniform motion can be used to advantage. A lever c , pivoting round stud A' has a slot d , and terminates in a segment of a wormwheel e which meshes with a worm f , operated by the crank g . A stud B is adjusted in the slot d so that the distance $A'B$ is equal to the distance between centres of the star-wheel mechanism to be machined. A gear h , of the same pitch diameter as the driven gear, pivots round stud B , and meshes with gear b . Here also, the uniform-motion part of the driven gear can be used as gear h .

A milling cutter D , of the same diameter as the driving roller, is guided in the adjustable bush i , and the milling attachment is mounted in such a way that the distance between stud A' and milling cutter D is equal to the pitch radius of the driving gear. The angle $D A'B$ is made equal to α_0 , and the blank in which the slot is to be machined is connected to gear h in such a way that the centre line and the centre line of the lever c include the angle $90 \text{ deg.} - \frac{3\alpha_0}{2}$. It will be found that the points A' , B , D , and E are identical with the analogous points in Fig. 31, and on turning the crank g the milling cutter D produces the required slot along the centre line $D C$. Pointers (not shown) may simplify the setting of the two angles required.

The manufacture of gears like those shown in Figs. 28 and 36 is simplified by the absence of special elements for imparting uniform motion. In these cases, the accelerating and retarding rollers include the angle α_0 . The retarding roller enters its slot when the accelerating roller reaches the central position, and both rollers impart uniform motion during an angle α_0 of the driving gear. Elements for imparting uniform motion can also be dispensed with if the angle between the accelerating and retarding roller is increased up to $2\alpha_0$, in which case the retarding roller enters in the moment when the accelerating roller leaves its slot. As the duration of uniform motion is $\mu \left(\frac{2\pi}{n} - 2\beta\right)$, special elements for imparting uniform motion are unnecessary if $\mu \left(\frac{2\pi}{n} - 2\beta_0\right) < 2\alpha_0$.

This condition can be transformed, by (23), into $\alpha_0 < \frac{\pi}{3} \frac{n-2}{n}$, and again, by (20), into

$$\mu < \frac{2 \sin \left(\frac{\pi}{6} \frac{n-2}{n}\right)}{1 - 2 \sin \left(\frac{\pi}{6} \frac{n-2}{n}\right)}. \quad (52)$$

For $n = 1$, we find $\mu < -0.5$, and for $n = 2$, $\mu < 0$. As μ must be positive for external star-wheel mechanisms, uniform-motion parts must be provided whenever $n = 1$ or 2.

For $n \geq 3$, (52) leads to positive values of μ ; elements for imparting uniform motion can be dispensed with between $\mu_{\min}$ and the values determined by (52). For values of n between 3 and 10, the ranges of μ are as follows:

$n = 3$	...	...	0.02411 to 0.5321
$n = 4$	...	...	0.3943 .. 1.0731
$n = 5$	...	...	0.7696 .. 1.6180
$n = 6$	...	...	1.1483 .. 2.1650
$n = 7$	...	...	1.5280 .. 2.7133
$n = 8$	...	...	1.9092 .. 3.2619
$n = 9$	...	...	2.2911 .. 3.8114
$n = 10$	...	...	2.6731 .. 4.3612

These comprise only a small part of the full ranges of μ ; and as the commonly occurring cases $n = 1$ and 2 are excluded, designs in which accelerating and retarding rollers serve also to produce uniform motion can be employed only infrequently. (To be continued.)

BRITISH ELECTRICAL POWER CONVENTION.

(Concluded from page 31.)

STEAM GENERATION.

Of the three remaining papers on research, one on "Researches into Some Problems Associated with Steam Generation" was read by Mr. W. F. Simonson. After an historical survey of the development of steam-raising plant, the author pointed out that changes in turbine design had presented the boilermaker with increasingly exacting conditions and had provided a constant stimulus to research. Recent work had been much affected by the adoption of higher steam pressures and temperatures, which had revealed anomalies in the existing steam tables. Data were also lacking on the flow of water when undergoing change of phase and on the chemistry of water treatment. The characteristics of suitable steels, the methods of construction, and the physics and chemistry of combustion were other matters that required further investigation. As far as the fuel itself was concerned, the effects of trace elements in the coal which might be volatilised from the ashbed were becoming of major importance.

The boilermaker would be the first to acknowledge his indebtedness to his colleagues in the purely electrical research laboratory in providing him with the means of driving and controlling his auxiliary machinery and in particular in giving him the instruments which were continually being placed at his disposal. The electronic valve was to be found incorporated in the boiler-control panel of to-day and the television camera offered itself as a means of observing drum water level or internal furnace conditions. The close control of operation by automatic means, which enabled the modern boiler to deliver its product within the close limits of temperature and pressure that present-day conditions demanded, owed much to the development of electrical devices. The boilermaker might equally claim that his contribution to the electrical industry derived from continued research into the fundamental scientific concepts underlying his own art.

CABLE MAKING.

"Some Aspects of Research in the Cable-Making Industry" were dealt with in a paper by Mr. E. L. Davey. After giving a résumé of the history and present position, the author defined the factors governing the allocation of the work between the individual makers and the co-operation between those makers, the users and the various research organisations. The amount of research that had taken place in the cable industry had been well justified by the economies effected and by the savings accruing from the avoidance of troubles in service. In future, research would be necessary to ensure that not only were technically sound and economic cables available in this country for the purpose of supplying industry and thereby reducing the power energy costs to a minimum, but also to ensure that cables were available for competing in foreign markets.

THE ELECTRIC-LAMP INDUSTRY.

The final paper was by Dr. J. N. Aldington, on "The Influence of Research on the Electric-Lamp Industry." Attention was called to the intimate association which had existed between the electric-lamp industry and the supply industries since the earliest days. For this reason the paper was divided into two parts: the first dealing with the interplay of research and development in the growth of the electric-lamp industry and the second with some aspects of the present relationship between that industry and the research laboratories which, during the last two decades, had produced many light sources and major contributions to production methods, manufacturing techniques and lamp and lighting production. So intimately had the electric-lamp industry been associated with developments in lighting techniques that much of the fundamental work on the measurement of light output and the colour of light had been carried out in the laboratories of the principal lamp manufacturers. Thus, in parallel with the

basic work on lamps and on the materials with which they were made had grown up related fields of research work to do with the application of light. Among matters which received continuous study were investigations into the promotion of optimum seeing conditions.

DISCUSSION.

The joint discussion on the seven papers on research was opened by Dr. P. Dunsheath, who said that that meeting of the Convention must be unique in the history of research exposition in view of the vast amount of information of great value to the industry which had been crowded into it. Having regard to the operations of the Monopolies Commission, he wondered whether the individuals who had produced the remarkable results described by Dr. Aldington had been given full credit before the profits of the industry had been calculated for the purposes of criticism. The most expensive research was cheaper than learning by experience; research was one of the nation's soundest investments.

Mr. E. B. Wedmore emphasised the need for adopting means to secure that the discoveries of research were quickly applied in production. One of the advantages of the co-operative research committee lay in the opportunities which it gave to make contact between investigators and those who wished to use the results.

Mr. D. P. Sayers stressed how much had still to be done in the field of research and what innumerable opportunities there were for economic and technical improvements in present engineering techniques. Circuit-breakers for normal load currents of 800 to 1,000 amperes had to be designed to deal with the stresses arising in rupturing fault current of 10,000 amperes or more. What was needed was some mechanism which would prevent the building up of such currents, so that the energy that had to be dealt with at the instant of rupture would be quite small. Chemical and metallurgical research should be able to produce a more durable material than the galvanised-steel towers on the grid, which needed regular painting. He would like to see more appreciation, particularly in applied research, of the need for co-operation between manufacturers and users.

Mr. J. A. Vice pointed out that if the deleterious constituents in combustible ash were only 0.001 per cent. of the 45 tons of coal per hour burned in a 100-MW unit boiler, the amount during 11 months steaming on a base-load plant would be about 30 tons. If only 1 per cent. of this stuck somewhere, the station engineer would have to deal with 6 cwt. of deleterious material.

ANNUAL DINNER.

In the evening the annual dinner was held, with the President in the chair. Proposing the toast of "The Electrical Industry," the Chancellor of the Duchy of Lancaster and Minister of Materials (the Rt. Hon. Viscount Swinton) said there was a good deal more scarcity than many people realised, in some cases because the materials themselves were scarce, and in others because of the need to husband resources to preserve the balance of payments. While it was natural that the electricity supply industry should want its buildings to combine efficiency with agreeable architecture, he wondered whether it was necessary to disguise a power station as a cathedral. He also wondered whether it was necessary for the architects of cathedrals to make them look like power stations. His policy with regard to materials was to have a free market wherever possible, and, where it was not free, to work with and through the trade. The balance of trade, however, made it impossible to take even slight risks, for nothing could be worse than to return, say, lead or copper to a free market and then have to reimpose control because the exchange position suddenly became worse.

On the morning of June 18, a meeting was held in the Pavilion at which an "electrical forum" took place. The President acted as question-master and the panel consisted of Sir John Dalton, Sir Vincent de Ferranti, Sir John Hacking and Messrs. J. R. Beard, C. T. Melling and S. F. Steward. A number of questions were put, including the desirability of competition between the Area Boards, the prospects of exchanging electrical energy with the Continent, and whether the standard sizes of

the larger generating units in power stations should be fixed at 60 MW and 100 MW. In addition, it was questioned whether transmission lines operating at 400-kV alternating or direct current should not be erected to enable the necessary operating experience at this voltage to be obtained. The prospects of the use of nuclear energy in the electricity supply industry were also canvassed.

The annual general meeting followed, at which it was suggested that the desirability of reverting to a normal period (instead of limiting it to three days) should be considered. Sir John Hacking was elected President and Mr. J. R. Beard vice-president for the ensuing year; and it was decided that the 1953 convention should be held at Torquay during the week beginning Monday, June 8.

CONFERENCE ON BRASS FOUNDRY PRODUCTIVITY.

THE brassfounding industry held a conference on productivity in Harrogate, from June 23 to 26, under the auspices of the Association of Bronze and Brass Founders and the National Brassfounding Association. It was attended by some 220 representatives of brassfounding companies. The main purpose of the conference was to discuss and follow up the report of the productivity team on brassfounding which visited the United States in 1950, and which published its report in August, 1951. During the conference, a suggestion was made that regional groups should be formed in the industry to consider the problem of increasing efficiency in brassfoundries and to give assistance to brass-founders. Various managerial and technical matters were raised during the conference which could profitably be followed up by such regional groups. The full proceedings of the conference are to be published and copies will be obtainable in due course from the Association of Bronze and Brass Founders at the price of 7s. 6d.

The work of the conference was divided into three sections, concerning technical aspects of non-ferrous founding, and concerning the machining side of the industry, and problems of human relations and incentives. Among the papers on non-ferrous founding, the most significant were that on the use of aluminium alloy match-plates, by Mr. E. C. Mantle and Mr. D. H. Potts, and one on the use of flexible cutting-off wheels, by Mr. C. A. J. Timms. All three authors had been members of the Brassfoundry Productivity Team. Mr. Mantle and Mr. Potts, in discussing the potentialities of aluminium match plates, were able not only to refer to American practice—and this was the only novel foundry technique seen in America by the Team—but also to report that there was no technical reason why these match-plates should not be produced in this country. The process of making them, they stated, was simple, and sufficient work had been done already in this country on the methods of production to enable them to be made on a commercial scale as soon as there was sufficient demand. Match-plates were also being tried out in the ironfounding industry. Their great advantage was the simpler production which they made possible. Developments in Britain were ahead of those elsewhere.

While the use of match-plates would increase the efficiency of the moulder in the industry, the use of a flexible unbreakable cutting-off wheel, Mr. Timms claimed, would do more than anything else to increase the efficiency of brassfounding dressing shops. A flexible wheel was on the market which was unbreakable in normal conditions; the drawback was that there was no suitable machine to hold it. There was room, he submitted, for greater co-ordination between manufacturers of the flexible wheel and manufacturers of a holding machine. At present, the flexible wheels available were expensive compared with standard wheels; but it was likely that, as soon as a demand developed and the wheels were put into production on a larger scale, they would become cheap enough for the average brassfounder.

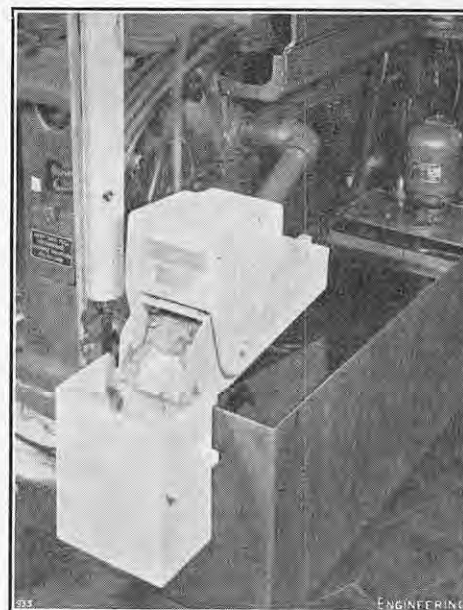
Among the papers on the machining side of the industry, Mr. C. H. Wilson gave a detailed account of methods of factory transport and storage. Mr. F. E. Ratlidge discussed general machining, assembly, testing and inspection, and compared British with American methods. He referred

particularly to the development in the design of production equipment in the United States of the use of standardised parts such as heavy-feed drill heads, which could be assembled in various ways to produce a composite machine. The Americans, he said, had available numerous valuable devices for using old equipment to obtain speedier production.

Representatives of the ironfounding and steelfounding industries, who spoke at the opening dinner, pointed out that the amount of research being undertaken for both of these industries was far greater than was being carried out for the brassfounding industry, the main reason being that the British Non-Ferrous Metals Research Association had comparatively few members from the brassfounding industry and, therefore, had insufficient resources available. Mr. W. R. Marsland, President of the Association of Bronze and Brass Founders, expressed the opinion that there should be a levy on bronze and brass ingot production, similar to the pig-iron levy, to finance research.

MACHINE-TOOL COOLANT SEPARATOR.

THE accompanying illustration shows a compact magnetic separator, for removing, continuously and automatically, particles of ferrous material from machine-tool coolants. It has been developed by the Sundstrand Machine Tool Company, Rockford, Illinois, U.S.A., whose British agents are the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2. The separ-



ator, which can be fitted on most types of grinding and honing machines, is 28 in. long, 23 in. high, and 10½ in. wide, and is designed to be mounted on the coolant reservoir supplied with the machine; in most cases, therefore, no additional floor space will be required. It consists of a permanently-magnetised drum, driven by a ½-h.p. motor and rotating against the flow of the coolant, which passes below the drum. The separated material is removed from the drum by a stainless-steel scraper, which discharges it by a chute into a waste bin that can be easily removed for emptying. Interchangeable drive sprockets are available, giving two rotational speeds of the drum. The separator will deal with a coolant flow of 30 gallons per minute, and, in some cases, up to 40 gallons per minute. It is claimed that the use of this separator gives a longer wheel life and better finishes, besides saving coolant by eliminating periodical sump-cleaning.

CERTIFICATES IN GAS TURBINE TECHNOLOGY.—The School of Gas Turbine Technology special course for Ministry of Supply apprentices has now been recognised as a qualification by the Ministry of Education and the Institution of Mechanical Engineers. In consequence, all the apprentices on the course who hold Higher National Certificates have now had them endorsed in Gas Turbine Technology.

MECHANISATION IN BRITISH COLLIERIES.*

By E. H. BROWNE.

STATISTICAL increases in the amount of machinery installed in the collieries do not reflect fully the changes which the industry is undergoing, and, in any case, the information available is limited to a few particular classes of equipment and takes no account of much intricate plant which is being installed. For instance, the number of electric motors at collieries has increased from 54,800 in 1938 to about 94,000 in 1951; coal cutters from 7,700 to about 12,000; and conveyors from 7,800 to about 24,000. There is no comparable pre-war figure, but the length of conveyor belting in use underground has grown from 2,030 miles in 1947 to 3,630 miles in 1951. Underground locomotives have increased from 80 in the first year of nationalisation to 450. It is underground, particularly, that the growth of machinery has taken place.

At the coal face, new machinery and new techniques are being tried; however these turn out, there is a strong likelihood that more and more complicated machinery will be used and that there will be a greater degree of concentration, requiring standards of performance and maintenance of equipment to be higher. The reconstruction of the collieries means on the surface much more mechanical equipment for handling and cleaning; more equipment at the shaft top and pit bottom; new underground roads with modern transport systems; and mechanical equipment in many parts of the mine where human labour has been extensively employed in the past. These developments will make new demands on colliery mechanical and electrical engineers.

SERVICE DEPARTMENTS AND SPECIALISTS.

I believe that mining needs a stronger and more modern technical control to meet the complicated needs of the present day and of the future; that this stronger technical control should be provided not vertically, but by fortifying the lateral branches; and by these I mean the planning organisation, service departments and specialists. Of the service departments, engineering stands out in importance. Service departments and specialists are not the same thing. Service departments such as engineering have a "staff" organisation within the technical management; their tasks and functions may involve direct control of labour; maintenance staff at a pit come under the colliery engineer through whom the general "line" control of the manager is exercised, and central shops and erection gangs are under the direct control of Area engineers. There are, moreover, different kinds and degrees of specialisation and there is also specialisation within a service department. But the problems involved in the relationship with the direct line of management differ only in degree between major service branches and the most newly appointed individual specialist devoted to a particular mining subject.

ENGINEERING.

Let us now turn to engineering: first of all, to specialisation within the service department. There are important fields for this in colliery engineering. For instance, the specialisation of engineers on plant efficiency has been advocated, especially where steam and compressed air are used at collieries. There is a slow acceptance of the need for these and other specialists; but the plain fact is that in engineering, as in the direct line of command, men with "geographical" territory cannot carry out their routine duties and simultaneously be omniscient of all the technical facets of their work. There is a need for specialists with "functional" duties within the service branch—experts in ropes, in winding equipment, in traction, in combustion, in mechanical handling, and in other aspects of an ever-widening field. The appropriate place for the specialist engineer depends on the volume of work in his particular subject. It may be the pit or the

Area. It may even be Headquarters, where we do to-day have specialist engineers in such things as underground locomotives, winding equipment, central shops, and layout.

There are different kinds and degrees of specialisation. There is specialisation in an aspect, rather than a subject: an example of this is the Safety Branch. Safety is a thread which runs through everything and the safety engineer has an interest in all operations. There is, at the other extreme, the specialist who has one single subject, and who operates in a very narrow field—for instance, a rope engineer. Between these limits there are all variations of degree and combination. Places to watch in the development of specialist services are the overlaps. The specialist may pick up a great deal of knowledge and experience about aspects of his subject which really belong to another branch, but he must be careful not to take on the job of that branch. The Coal Preparation Branch, which I regard as an important one, though it can be relatively small in numbers of staff, needs to be built up to exercise technical control over cleaning plant and to be responsible for the quality of the finished products. An important function of this branch is to plan future plant and extensions; but in so doing the mechanical and electrical engineers must also participate, certainly so far as the details of the design and specification of the equipment are concerned.

If organisation is becoming more complicated by the development of "line" and "staff" systems and specialisation, the Engineering Branch has a further complication of its own; this is the integration of mechanical and electrical engineering. In times gone by, it was possible to make a fairly close delineation of duties; to-day, the overlapping and lack of distinction between mechanical and electrical engineering is increasingly difficult. Working arrangements are established between electrical and mechanical staff easily enough, but the changing situation does seem to demand that new entrants should have a good grounding in both electrical and mechanical engineering, whichever branch they decide to follow. Though specialisation in particular branches or aspects of mechanical or electrical engineering will extend, there may come a time when a man with "geographical" responsibility—for instance, an Area Engineer—will have to take command of both sides. Whether it is the mechanical or electrical man should depend wholly on the ability of the individual.

I believe that engineers must be strengthened in our industry. In coal-mining in this country at present, the situation is made somewhat equivocal owing to the obsolete provisions of the Coal Mines Act regarding responsibility. Engineers should welcome the implementation of the Royal Commission's* recommendations on this subject; they should accept gladly the vesting of the appropriate responsibilities in them. It is for the engineers so to equip themselves as to be able to carry the higher responsibility and justify this fuller recognition. There is much to be done in raising engineering standards in the industry and in establishing first-class techniques everywhere. There may even have been too much concentration on spectacular repair work. Concentration on celerity and readiness to perform feats of physical endurance in dealing with breakdowns is really secondary in importance to preventing them.

PLANNED MAINTENANCE.

There is room at too many collieries for a system of planned maintenance as a means of ensuring continuity of efficient working. For instance, washeries—particularly the new comprehensive plants—need a carefully worked-out system of preventative maintenance. Cleaning plants have often been neglected, with consequent grave losses of efficiency in washing. It may help to allocate a special maintenance staff solely to a plant of this kind. Underground plant is an even greater problem, particularly face machinery; however the work is arranged, the maintenance of all underground machinery must be firmly placed within the responsibility of the Engineering Branch.

This takes me on to the importance of mechanical

and electrical engineers making regular visits underground, particularly to the coal face. The surface operations are all ancillary to the process of getting the coal. In the past, because face work was largely manual, the colliery engineer seldom took much interest in it; but the coal face is becoming the place with the greatest concentration of complicated machinery for which good design and maintenance are all-important. Prejudice against the use of electricity underground on safety grounds is fast fading, and with good reason. Its introduction may actually increase the safety margin, because electricity demands higher ventilation standards and their close supervision, and mechanisation and the development of new techniques at the coal face are virtually dependent on the use of electricity. Standards of organisation and technique should be in advance of the extended use of electricity.

STANDARDISATION.

There are dangers in too rigid adoption of standards, in striving after perfection in uniformity. The mining industry, however, is at the other extreme. First of all, there are certain fundamental physical factors, common to the whole industry, to be dealt with. Examples of these are the voltage and frequency of electrical supplies, and the track gauge for underground transport systems. It should not be difficult to decide upon standardisation for these and some progress has already been made. I am far from happy, however, about the continued ordering of non-standard voltage equipment. Secondly, there is the need to reduce the multiplicity of equipment which is already covered by British Standard specifications. These specifications are necessarily broad in scope, with many varieties, to meet the requirements of all industries. For one industry, and for the specialised circumstances of coalmining, we can reduce very greatly the numbers of standards. For example, we can decide on certain preferred sizes of cables and cut down substantially the number of different diameters of winding and haulage ropes. There is no doubt that there should be an immense reduction in the varieties of equipment and materials used.

After preferred sizes of British Standard specifications comes the standardisation of component parts—for instance, drill rods, drilling bits, conveyor rollers, pulley wheels, tub wheels and axles. Then there is the standardisation of complete articles, such as mine cars, gate end boxes, ventilation doors, points and crossings, etc. Where these are made by outside firms, we need not necessarily standardise complete design—to do so would be to stultify development; but we can go far enough to make interchangeability possible and also to reduce the enormous number of spare parts held in the country. There are at present well over a thousand different two-piece steel arches in use, let alone all the special sections and types of arches. In this and in many other fields, we can look to benefits in the reduction in the cost of manufacture, reduction in the variety and quantity of stocks held and greater flexibility in their usage and general savings in handling stores.

(To be continued.)

TANK INSULATION.—Details have been published by the Gas Council of a patented system of pre-cast insulating blocks made by the Reymor Brick Co., Ltd., Church-lane, Wolverhampton. The incorporation of asbestos-compound boiler lagging in Reymor bricks has been discontinued mainly because of the Factory Regulations, which, in an endeavour to minimise the danger of asbestosis, place restrictions on the use of asbestos in confined premises. The bricks are now made of a mixture of *ciment fondu* and exfoliated vermiculite. The result is a brick of improved appearance and slightly reduced weight, which is much harder than the original brick, but slightly more brittle; it cannot be easily sawn, but it can be cut quite simply with a bricklayer's trowel. A fuel consumption test, made before and after insulating with the bricks, was carried out on a group of nine tanks of widely varying dimensions used for plating, anodising and cleaning processes at temperatures of 180 deg. F.; a reduction in gas consumption of 36.3 per cent. was measured. Particulars are given in report No. 51/3/98 of the Industrial Gas Development Committee of the Gas Council, the information being supplied by the West Midlands Gas Board.

* Address by the Director-General of Production, National Coal Board, to the Annual Conference of the Association of Mining, Electrical and Mechanical Engineers, delivered at Blackpool on June 17th, 1952. Abridged.

* Report of the Royal Commission on Safety in Coal Mines, 1938.

VENTILATION AND HEATING PROBLEMS IN ATOMIC ENERGY ESTABLISHMENTS*.

By W. L. WILSON, B.Sc., A.M.Inst.C.E.

ATOMIC energy, it seems, has come to stay. No doubt, one of these days, we shall have electricity produced from such energy and there will be large numbers of power stations so actuated. If that is the case it seems likely that ventilation problems of some magnitude will be linked not only with them, but with control laboratories which may form part of them. So far as the ventilation engineer is concerned there are several pertinent points that must ever be before him, namely, that radio-active materials in quantity are dangerous to life; in general, beta, gamma and neutron emitters can be lethal, external to and in the body, while alpha emitters are dangerous primarily in the body; the daily dose of radio-activity that a man may safely ingest is quantitatively small and might only be the equivalent of a single two-micron particle; research workers and the public must equally be protected from hazards; activities may decay quickly or extremely slowly, so those with long lives must be kept under rigorous control if their adventitious escape is not to sterilise an area or important plant; activities may be static in position or may move of their own volition; plant must be so designed that it is not subject to abuse by operators whose familiarity with hazards may make them careless; and continuity of operation, cleanliness of surface and ease of maintenance are of prime importance.

The basic principle governing the handling of radio-active material is to contain it. This leads to the following conclusions: (i) if it is small enough in quantity and the processes thereon limited in so far as manual manipulation is concerned, it may be handled in sealed boxes (so-called "dry" boxes); (ii) if flexibility of handling is essential and the quantities are small enough, a fume cupboard with a containing air stream must be used; (iii) even if the working area must be large, it must take the form of (i) or (ii) above, with the possible addition that the operators must work in the land equivalent to the diver's suit (so-called "frogmen").

It is not impossible to find in practice a situation arising where the three conditions must be applied. Certainly, whether condition (i), (ii) or (iii) or a combination of any or all of them arises, ventilation is a *sine qua non*. Thus, in the dry box, a negative pressure must be maintained for obvious reasons; the basis of the fume cupboard is the ingress of air to prevent the egress of activity; and, evidently, air change round a frogman is essential to limit contamination on him and so permit of the removal of his suit with a minimum of hazard. Since all these methods involve the removal of air containing radio-active particles, which must be discharged to atmosphere, filtration is usually required.

The filtration of contaminated air must be extremely efficient. It follows that the filtering media will not be inexpensive and that a first consideration in design must be to economise in the handling of air. Naturally enough, the first conflict can arise with the alternative demand for a high air change or velocity where a source of activity exists. In consequence, the ventilation engineer cannot be divorced from processes. He must be aware of them rather more intimately than is normally the case, and must be in a position to make recommendations on process control to effect his end of economy and efficiency.

THE DRY BOX.

The dry box is simply a rectangular box, the front face of which is manufactured from glass, Perspex or other translucent material. The unit may be of any impermeable smooth workable material, provided that the material is related to the processes proceeding therein. Quite frequently, stainless steel is used because of its resistance to corrosion and the eminently cleanable surface it presents. Not

infrequently, whatever the materials of construction, painting of a special nature is resorted to, for precisely the same reasons. The front face is usually fitted with rubber gloves, carefully sealed to that face and sufficiently long for the operator to handle his experimental apparatus with ease. Replacing these gloves without ever leaving a clear opening into the box can be quite difficult. In the event of the activities under control being of the beta-gamma type rather than alpha, the box may be lead-lined entirely. In this case, the apparatus is handled by remotely controlled mechanical hands, vision being effected by optical means arranged so that there is no direct path of radiation between the source of activity and the worker.

The dry box may be used in a fume cupboard so that the ingress and egress of the material to be worked on may be effected safely, or it may be only put into a fume cupboard during these circumstances. Normally, either weight considerations or the delicacy of apparatus prevents the latter situation arising. Almost invariably, the dry box is provided with its own small exhaust and filter, the aim of the whole assembly being, for several obvious reasons, to produce an internal depression (say, of 2 in. w.g. or so) with zero extract air movement. Dry boxes may be used singly or may be arranged in series, being coupled by suitably sealed conveyors. Entry to them at some time is essential, and it is most desirable, therefore, to reduce the background of activity which can build up in them. If this is not done, they can become grossly contaminated. One way in which this background can be kept below its natural limit is by fitting to the box a re-cycling system, comprising an exhaust point at an upper edge of the box, followed by a filter and a suitable exhaust, discharging into the opposite lower edge of the box. In such circumstances, filters are provided in parallel in order to provide working and spare units. The re-cycling rate is in the order of 20 changes per hour, but frequently it is based on a velocity through the box sufficiently low not to impede the experiment or pick up powders being processed. Such systems have worked successfully with the box at a negative pressure of 3 in. with respect to atmosphere.

THE FUME CUPBOARD.

In 1946, I was a member of a Ministry of Works party that visited the Canadian Chalk River Atomic Energy Establishment to obtain a working background for the design of the Atomic Energy Research Establishment at Harwell, and to study the problems and initiate the design of a major radio-chemical laboratory. The function of the laboratory was research into the chemistry of radio-active matter, it being clearly postulated that no definite idea of the processes could be given. This forced the conclusion that the most flexible working space should be used, namely, the fume cupboard. It was quite evident, thereafter, that the building itself had to be designed round these units. Immediately an examination was made of those in existence, and it was found that, though considerable quantities of air were passing through them, an excessive amount of radiation existed in the laboratories themselves.

The cupboards were rectangular, provided with sashes in the usual way, and exhausted through a circular duct penetrating the flat top of the unit. A smoke test proved that the lack of streamlining caused considerable eddies to develop, producing pressure pockets and leakage at imperfect joints. Consequently, a prototype cupboard was made with a 15-deg. tapered outlet. A considerable improvement was immediately achieved, but the smoke tended to "roll" out, particularly at the top. To overcome this difficulty (and it did so successfully), 45-deg. fairings were built on the four open sides of the cupboard. Air velocities over the full face of the cupboard varied from about 250 ft. to less than 100 ft. per minute, and no amount of internal fairing reduced this difference substantially. For design purposes, an average face velocity of 150 ft. per minute was, and is still, used for "hot" fume cupboards. The form is still of the shape described, but with the fairings on two sides of the cupboards built into hollow pilasters which contain piping, cabling and controls to the usual service outlets.

A loose tray is provided in each cupboard, in which apparatus stands, so that spills of corrosive or active liquors damage something which is easily and cheaply replaceable. The sliding sash has an opening at the top and bottom, thus ensuring an air flow even when it is closed, and eliminating interference with balanced air systems. The sash has a break in it, controlled by friction hinges, permitting a conventional flush face to be presented to the operator, and also access and clear vision. Where fume cupboards are "banked," the dividing walls are actually sashes, and long horizontal items can be erected in them. There is a concentration on designs which permit a cupboard to be removed and replaced with a minimum of inconvenience. Weighted lazy tongs are being developed to lift sashes, as the pulley and counterweight system requires maintenance, which can be difficult.

PRINCIPLES OF AIR HANDLING.

Economy in air handling is of paramount importance. Re-cycling is not permissible where unprotected personnel work; however, there is no reason why air used in one space cannot be used again in another, providing that the quantities are sufficient to permit of comfort, and that the purity of the air is tolerable to the workers. It is common, in a conventional radio-chemical laboratory building, for this principle to be widely adopted. Plenum air may be fed into the clean change room, pass through the dirty change room and feed, via the access corridor, into the laboratory. The flow is from a non-radio-active area through a contaminated area to a "hot" area, i.e. the place where the activity is handled.

In the ordinary course of events, the flow of air through corridors to the source of activity is governed by the air demands at or near the source. In such cases, the corridor velocities have no great significance. In other cases, it might be important to apply control conditions in a corridor to prevent the egress of activity which might be moving by virtue of its energy. Such cases have arisen and experimental work was undertaken to determine optimum conditions. In certain instances, converging throats have had to be built into the corridors to give consistent velocities over the "barrier" area. In cases examined, air velocities much less than particle velocities have been found to retain the particles at the barrier. In other rather special circumstances, in approaching the source of activity, the varying access corridors, rooms, boxes, etc., may be under an increasing measurable negative pressure. This condition has been achieved by using the dry-box technique, linked with individual extract systems.

Few radio-chemical buildings consist of one room, and considerable thought has been given to providing each room with a controllable plenum and extract unit, or the alternative centralised plenum and extract system. The former idea is attractive to the individual scientist, who greatly desires to be master of his own circumstances, and it has been used in the United States. However, capital expenditure and excessive maintenance outweigh its apparent virtues, and the innumerable discharge points it demands are aesthetically and technically undesirable. The tendency has been to use centralised systems, as they permit greater simplicity in maintenance, skilled control by engineering staff from a central point, and a ready relationship in position of the plenum intake and the gaseous discharge points. This latter is of major importance, as the two must be so disposed that re-cycling of exhaust air is prevented. In practice, the plenum intake is always immediately below the chimney.

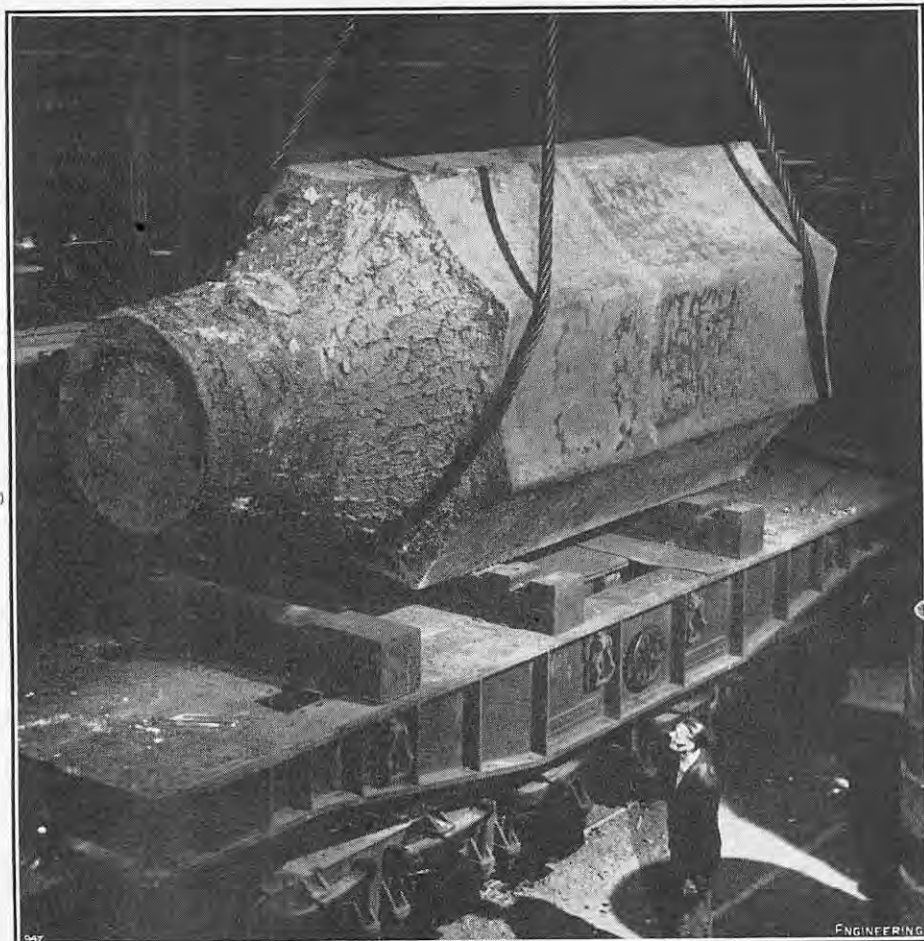
The plenum system is in no way other than conventional in general form and design, except that effective air filtration is resorted to, because many forms of radio-activity adhere to dust particles and so spread themselves round the establishment. Electrostatic precipitators, followed by cotton-wool disposal filters, have frequently been used. Where standby fans have been desirable, these have been installed so that they can work in series normally, giving full service individually, as required, by speed control. The ducting is usually accessible from non-contaminated areas, thus permitting maintenance by conventional means.

(To be continued.)

* Paper presented at the summer meeting of the Institution of Heating and Ventilating Engineers, held at Torquay, June 14 to 17, 1952. Abridged.

270-TON INGOT FOR BOILER DRUM.

ENGLISH STEEL CORPORATION LTD., SHEFFIELD.



270-TON STEEL INGOT FOR BOILER DRUM.

We illustrate above what is stated to be the largest steel ingot ever made in Great Britain. It was produced by the English Steel Corporation, Limited, of Sheffield, at their River Don Works. The ingot is 26 ft. long and 9 ft. across the largest octagonal section, and required 270 tons of special steel from four acid open-hearth Siemens furnaces. Apart from the high technical skill required in the casting of such a large ingot, lifting and transporting it set many problems.

Two cranes, coupled by a specially constructed lifting beam, were used; and, to ensure co-ordination of lifting and perfect teamwork in other phases of the operations, several rehearsals were necessary, a smaller ingot of 210 tons being used for this purpose. When stripped from the mould, the ingot was loaded on to a 300-ton 24-wheeled railway bogie, built for the English Steel Corporation for the internal transport of large ingots, forgings and castings, and was taken for further processing.

The ingot will be forged under a 7,000-ton electrohydraulic press at the River Don Works into a single hollow-forged boiler drum; the largest of its type yet made in this country and possibly in the world. It was ordered by Messrs. Clarke, Chapman and Company, Limited, of Gateshead-on-Tyne, for the steam drum of a boiler for the Stella South power station of the British Electricity Authority. When finished, the drum will be 42 ft. long, 6 ft. $2\frac{1}{2}$ in. outside diameter, and 5 ft. 6 in. bore.

ELECTRICITY SUPPLY IN SCOTLAND.—A scheme prepared by the North of Scotland Hydro-Electric Board for erecting a line from a transforming station at Fort Augustus to a point in Glen Truim on the existing line between Tummel and Keith has been approved by the Secretary of State for Scotland (the Rt. Hon. J. Stuart). This line will be used to transmit power for the Garry and Moriston generating stations and thus to reinforce the carrying capacity of the grid.

CONTRACTS.

CRAVENS RAILWAY CARRIAGE AND WAGON CO., LTD., Darnall, Sheffield, 9, have received a contract from the Crown Agents for the Colonies for 66 railway coaches and two light-weight train sets, each of five cars, for the Gold Coast Railways. The value of the contract is nearly 1,000,000/. Delivery is to commence in 18 months.

SMITH'S DOCK CO. LTD., South Bank, Middlesbrough, have obtained orders for two 18,000-ton oil tankers for the Royal Dutch Shell Group.

THE BIRTLEY CO. LTD., Birtley, Co. Durham, have received a contract, valued at about 400,000/., for coal-handling plant for the new Stella North power station, near Newcastle-upon-Tyne, now being built for the British Electricity Authority. The equipment is to be ready in just over two years. The Birtley Co. have other orders in hand for similar plant for a South African power station, the North Thames Gas Board, and a steelworks in Lincolnshire.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby, have on order for the New South Wales Government Railways ten 1,000-h.p. Diesel-electric switching and shunting locomotives and are supplying the main and auxiliary generators, the motors and the control equipment. The manufacture of the mechanical parts is being carried out by the METROPOLITAN-CAMMELL CARRIAGE AND WAGON CO., LTD., and the Diesel engines are being supplied by DAVEY, PAXMAN & CO. LTD. The designed tractive effort of the locomotive, at starting, is 48,000 lb., and continuously 22,800 lb. The maximum speed will be 57 miles per hour. In full running order, the approximate weight of each locomotive is 72 tons. The wheel arrangement will be of the Bo-Bo type.

GILBERT GILKES AND GORDON LTD., Kendal, have received orders for a 940-h.p. Turgo impulse wheels for the Yukon Hydro-Electric Co. of Canada, and for two 750-h.p. Pelton wheels for the constructional plant of the Kilembe hydro-electric scheme, Uganda. The Zomba power scheme, Nyasaland, is to be extended and a second 440-h.p. Pelton wheel, operating under a head of 1,350 ft., has now been ordered. The firm were also the main contractors for the turbines and alternators for the North of Scotland Hydro-Electric Board's new stations at Gairloch, Ross-shire, and Storr Lochs, Isle of Skye, opened on May 29 and 31, respectively.

AIRCRAFT FOR CAR FERRY SERVICES.

THE cross-channel aerial ferry for cars, motor-cycles and bicycles, operated by Silver City Airways, Limited, 11, Great Cumberland-place, London, W.1, has proved a most successful development in air transport. In 1948, when the service was opened, 170 vehicles were carried between Lympne and Le Touquet. In 1951, the traffic had increased to 13,000 vehicles. This year, three alternative cross-channel routes are available, and Silver City Airways are operating a fleet of nine Bristol Freighter aircraft. The company expect and are preparing for a considerable expansion of their ferrying services, according to their managing director, Air Commodore G. J. Powell, C.B.E. In the spring of 1953, they expect delivery of six improved long-nosed Bristol Freighters, now being constructed to their specification by the Bristol Aeroplane Company, Limited, Filton, Bristol. In the new Freighters, the overall length of the aircraft has been increased by about 5 ft. to 73 ft. 6 in. The length of the car hold has been extended from 31 ft. 8 in. to 37 ft. 6 in., and it is capable of further extension to 42 ft. 3 in. It could then accommodate three cars 14 ft. long. Behind the car hold there will be a sound-proofed cabin for 20 passengers—eight more than in the present version—and a toilet compartment will be provided. To compensate for the increased fuselage side area forward of the centre of gravity, the fin area has been increased by about 10 sq. ft., by a semi-circular extension of 2 ft. 9 in. radius at the top of the fin and by building up the dorsal fin. The Freighter has two Bristol Hercules engines, each developing 2,000 h.p. for take-off and giving a cruising speed of 166 m.p.h. at 5,000 ft. With the maximum payload, 11,000 lb., the still air range is 370 miles. The maximum still-air range is 1,680 miles, the payload in this case being limited to 4,875 lb.

By 1955, Silver City Airways hope to introduce a direct London-to-Paris ferry, and for economical operation a larger aircraft will be required. If the Universal Freighter developed by Messrs. Blackburn and General Aircraft, Limited, goes into production, they intend to order three of these aircraft. Otherwise, they will have to go to France for a suitable machine—the Breguet Deux-Ponts, constructed by the Société Anonyme des Avions Louis Breguet, Paris. Both these aircraft are capable of carrying six average cars or eight small cars, six motorcycles, 12 bicycles, and about 40 passengers.

At present, the amount of time spent in loading and unloading the freighter aircraft is as much as the actual flying time across the channel. As a long-term development, the firm are considering using a large helicopter in two detachable units—the upper unit providing the power for flight, all the services, and the crew accommodation, and the lower unit to be simply a load-carrying "pannier" for passengers, in a forward cabin, and freight in a rear hold. The lower unit could thus be landed, detached from the "prime-mover" unit, and unloaded and reloaded ready for the return flight, while the original prime-mover unit hovers and picks up a pannier, already loaded, and ferries it. A small number of prime-mover units could thus handle a large volume of traffic at a high load factor. The idea is being considered by certain aircraft constructors. The mechanical difficulties of attaching the two units together satisfactorily, and in a manner acceptable to passengers, would appear to be considerable, and the estimate of six to seven years for the introduction of such a service, which Silver City Airways envisage, very optimistic. If the difficulties can be overcome, however, the idea clearly has possibilities of some significance, both in the civil and military fields.

ELEVATOR FOR CASES, CRATES AND BALES.—The British Wedge Wire Co., Ltd., Academy-street, Warrington, have recently introduced a new type of elevator known as the Twin Lift, for use in conjunction with gravity roller conveyors, for transferring cases, cartons, bales, barrels, etc., from one floor to another. It will lift approximately 720 articles in an hour, and has an automatic feed and discharge.

NOTES ON NEW BOOKS.

Three Hundred Years on London River: The Hay's Wharf Story, 1651-1951.

By AYTOUN ELLIS. The Bodley Head, 28, Little Russell-street, London, W.C.1. [Price 30s. net.]

THE admirable volumes of *The Survey of London* have not yet extended to Bermondsey, but those students of London's history whose interest is especially in its shipping and commerce have something substantial to go on, with in this informative study of one of the oldest commercial undertakings associated with the trade of "London River," and of the merchant families who have guided its fortunes for three centuries. Alexander Hay was a brewer who became a wharfinger by acquiring the "Pipe Boarers' Wharf," on which elm trunks were bored out to form water pipes for the New River Company. The last of his descendants to be connected with Hay's Wharf was Francis Theodore Hay, who died in 1838. The links with the other wharfingers whose properties are now included in the present undertaking, and with the banking family of Smith, who are still prominent in it, are brought out with a wealth of detail that is relevant and some which is not, but which is fully justified by its "background" interest; and the illustrations, many from old prints and portraits, worthily support the text. We referred to the engineering side of the firm's activities in a note in our issue of November 24, 1950 (vol. 170, page 400), and to the celebration of their tercentenary in that of June 15, 1951 (vol. 171, page 727). Mr. Ellis's book has little to do with engineering aspects, but it may be commended to engineers, nevertheless, as showing the development of one of the largest cold-storage and cargo-handling businesses in the world. They may not appreciate the labour involved in writing the history of a firm of long standing—only those who have experienced it can really do that; but, if they read this book, they can hardly fail thereafter to regard in a new light the warehouses and the line of level-luffing cranes on the south bank of the Pool.

Marine Steam Engines and Turbines.

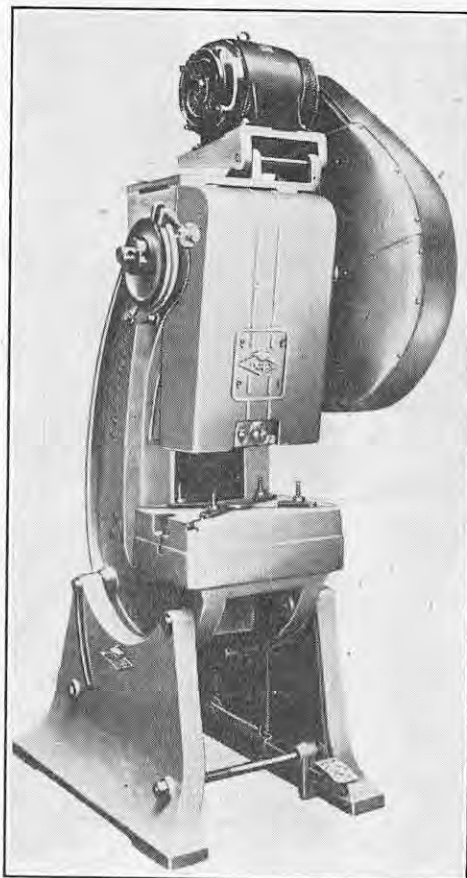
By W. J. FOX, A.M.I.Mech.E., M.I.Mar.E., and S. C. McBURNE, A.M.I.Mech.E., A.M.I.E.S. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 35s. net.]

THE dual purpose of this book, the authors state, is to meet the needs of students preparing for the marine-engineering examinations of the Ministry of Transport and of those who are "at the stage of knowing little or nothing about the subject." In the former category, presumably, are also deck officers, who are now required to have some knowledge of marine machinery. If they, in company with the complete novices, find that the book goes into rather more detail than they can readily assimilate, they should not regard this as matter for complaint; in fact, it does contain more than they require in a professed introduction, but to have treated the subject more superficially would not have served the needs of the other class of readers envisaged, namely, those who intend to make marine engineering their career. The text is, in general, clear and concise, the typical examples are really helpful, and the illustrations—mostly line diagrams—are well drawn; though that of the Michell thrust block (wrongly spelt "Mitchell" in the index) is open to criticism and greatly exaggerates the depth of the "step" on the back of the pad. The book treats of main engines almost exclusively, boilers and auxiliary machinery being the subjects of separate works in the publishers' Marine Engineering Series.

THE LATE MR. L. D. DERRY.—We note with regret the death of Mr. Leonard Dodd Derry, which occurred on June 6 in the Muhlenberg Hospital, Plainfield, New Jersey, following an illness which developed unexpectedly during a business visit to the United States. Mr. Derry was in charge of lubricants research in the Esso European Laboratories of the Esso Development Co., Ltd., Esso House, near Abingdon, Berkshire. He was elected an associate member of the Institution of Mechanical Engineers in 1942.

INCLINABLE POWER PRESS.

WE illustrate herewith the Model B.A., Mark II, "Besco" inclinable power press; a new machine, based on a previous design, which has been put on the market by Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1. It is made in three sizes, the smallest having a stroke adjustable between $\frac{3}{8}$ in. and $1\frac{1}{2}$ in., and the two others, a stroke of $2\frac{3}{8}$ in. to $2\frac{1}{2}$ in. The pressures exerted are 10, 18 and 28 tons, respectively, for the three sizes, which are designated the B.A. Mark II No. 18, No. 19 and No. 20. The press is substantially constructed, with a ram of ample length to avoid deflection, and to ensure maximum efficiency and a long working life for both tools and dies. The sizes of the ram faces over the V-slides are $7\frac{3}{4}$ in., with a tool hole $1\frac{1}{2}$ in. in diameter in the ram, in the case of the No. 18 machine; and $9\frac{3}{4}$ in., with a 2-in. diameter tool hole, for the No. 19 and No. 20 models. The connection between the pitman and the slide is by a buttress-thread ball-



ended screw, made of high-carbon chrome steel, heat-treated. The crankshaft is a nickel-chrome-molybdenum steel forging, heat-treated, with liberally-proportioned bearings. A spring-adjusted friction damper is provided to prevent over-running, and a safety pawl prevents the machine from reversing. The clutch is of the roller-key type and is designed to permit of either single-stroke operation or continuous working. When the machine is set to give single strokes, only a single stroke is made, even though the operator may keep his foot pressed on the treadle. The change to continuous operation can be readily and quickly made.

The bed and bolster have T slots, and clamps are fitted to hold dies. The widths of the three machines are, respectively, 16 in., $19\frac{1}{2}$ in. and $22\frac{1}{2}$ in.; the dimensions from front to back, $9\frac{3}{4}$ in., $11\frac{1}{2}$ in. and $13\frac{1}{2}$ in.; and the holes for the delivery of the pressings are 8 in. by 6 in., 9 in. by 7 in., and $10\frac{1}{2}$ in. by 8 in. The bolsters are $1\frac{1}{2}$ in., $2\frac{1}{2}$ in. and $2\frac{3}{4}$ in. thick, respectively. The drive is by an electric motor, taking three-phase 50-cycles current at 400 to 440 volts; it is mounted on top of the press frame on a platform which is adjustable to vary the tension of the multiple V-belt. The motors for the three sizes of press are 2 h.p., 3 h.p. and 4 h.p., respectively. A sheet-metal guard is provided to cover the flywheel and the pulley.

BOOKS RECEIVED.

The Lighting of Office Buildings. Post-War Building Studies No. 30. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. 6d. net.]

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. The Director, Department of Terrestrial Magnetism, 5241, Broad Branch-road, Northwest, Washington 15, D.C., U.S.A. [Gratis.]

Productivity Team Report. Iron and Steel. Report of a Productivity Team representing the British Iron and Steel Industry which visited the United States of America in 1951. Anglo-American Council of Productivity, 21, Tothill-street, London, S.W.1. [Price 5s., post free.]

Air Registration Board. Fifteenth Annual Report. Year ended March 31, 1952. Offices of the Board, Brettenham House, Strand, London, W.C.2.

Power Transmission Directory and Trade Names Index, 1952-54. Trade and Technical Press, Limited, 65-66, Chancery-lane, London, W.C.2. [Price 6s. 4d., post free.]

Commercial Eucalyptus Oils. By A. R. PENFOLD and F. R. MORRISON. Fifth edition. Department of Technical Education, Museum of Applied Arts and Sciences, Harris-street, Sydney, Australia. [Price 2s. 6d.]

Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 14th November, 1951, at Queen Street (High Level) Station, Glasgow, in the Scottish Region, British Railways. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. net.]

Electricity Meters and Instrument Transformers. By S. JAMES. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 50s. net.]

The Physical Principles of Thermodynamics. By DR. R. A. SMITH. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 30s. net.]

Mechanics of Vibration. By PROFESSORS H. M. HANSEN and PAUL F. CHENEA. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 8 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 64s. net.]

Annual Report of the Governor of the Panama Canal for the Fiscal Year 1951. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 35 cents.]

United States National Bureau of Standards. Applied Mathematics Series No. 17. Tables of Coulomb Wave Functions. Vol. I. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 2 dols.]

Beton-Kalender 1952. In two volumes. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 16 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 28s.]

La Commande Électromagnétique et Électronique des Machines-Outils. By PROFESSOR A. FOUILLE and J. CANUEL. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 3,250 francs.]

Practical Radiography for Industry. By H. R. CLAUSER. Reinhold Publishing Corporation, 330, West 42nd-street, New York 36, U.S.A. [Price 5.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 60s. net.]

The College of Aeronautics, Cranfield. Report No. 54. The Potential due to a Source Moving through a Compressible Fluid and Applications to some Rotary Derivatives of an Aerofoil. By R. WESTLEY. No. 56. *The Determination in Flight of the Body Drag and the Mean Blade Profile Drag Coefficient of a Helicopter.* By F. E. BARTHOLOMEW and W. S. D. MARSHALL. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5s. each.]

The College of Aeronautics, Cranfield. Report No. 60. An Investigation of the Flexure-Torsion Flutter Characteristics of Aerofoils in Cascade. By G. M. LILLEY. No. 61. *The Theory of General Instability of Cylindrical Shells.* By J. R. M. RADOK. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5s. each.]

Eighty-Eighth Annual Report on Alkali, &c., Works. By the Chief Inspectors. Proceedings during the Year 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. net.]

Automatic Feedback Control. By WILLIAM R. AHRENDT and JOHN F. TAPLIN. The McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18, U.S.A. [Price 7.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. [Price 64s.]

Les Engins Mécaniques de Chantier. By ADIL GABAY. Librairie de l'Université, F. Rouge et Compagnie, S.A., Lausanne, Switzerland. [Price 85 Swiss francs.]

Progress in Metal Physics. 3. Edited by DR. BRUCE CHALMERS. Pergamon Press Limited, 2, 3, and 5, Studio-place, Kinnerton-street, London, S.W.1. [Price 48s.]