POWER JETS' GAS-TURBINE PATENTS.—I.

INTRODUCTION.

A STUDY of all the patent specifications published relating to a particular field of technology would afford a picture of the history of invention in that field; it might, incidentally, bring to the attention of the student a ready-made solution to an outstanding problem. The technology relating to gas turbines and their uses comprises several separate but inter-related fields, each of which would need to be investigated to complete the over-all picture; such an investigation would be a colossal task. On the other hand, the patent holding of a particular organisation may, if the organisation has been for long enough engaged in the work, be sufficiently comprehensive to afford, as it were, a vignette of the particular history of invention; the patent holding of the publicly-owned company Power Jets (Research and Development) Limited may, perhaps, be claimed to qualify in this respect, whether the test be as to number of inventions, to diversity of problems tackled and solved or, no less important, to the widespread nature of the sources from which the inventions come. Based on the pioneering work of Sir Frank Whittle and his colleagues in the war-time Power Jets team, the holding is constantly being expanded as a result of the inventive effort of the National Gas Turbine Establishment and other Government departments, of Power Jets' own staff of consulting engineers and of "outside" inventors from whom Power Jets acquire licensing rights so that the inventions concerned may be both protected abroad as a national asset and made available to industry at home under the company's policy of non-discriminatory licensing.

This article is the first of a series reviewing the Power Jets patent holding which, for the convenience of the reader, has been divided into sections according to the subject matter to which the various patents relate. For reasons of space, only the more interesting inventions will be reviewed, subject to the rider that occasionally one invention may give place to another of less importance with a view to widening the historical picture; for other, but quite obvious reasons, only those inventions can be reviewed in respect of which the relevant patent applications have already reached the stage of publication or are otherwise sufficiently advanced. While reference is made to British patents only, the company's policy is to protect all important inventions in a large number of foreign countries.

In view of the aims of the original Power Jets and of the aspirations of the present company, it seems logical that the review should start with sections devoted entirely to aeronautical applications of the gas turbine and proceed to purely industrial applications by way of those sections which relate to components and other matters of interest in both contexts. Within the individual sections, the order will be chronological except where, in isolated cases, some other order is convenient for purposes of comparison or contrast; since history of invention is the key-note, the order generally followed will be that of application for, rather than grant of, patent.

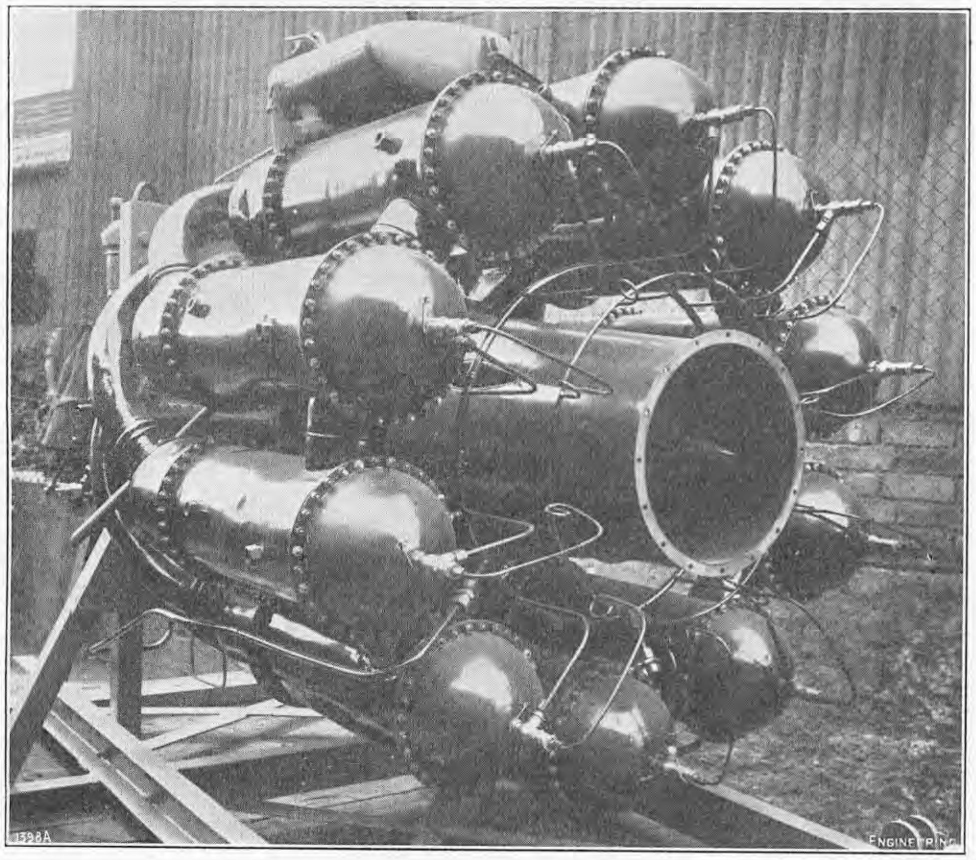
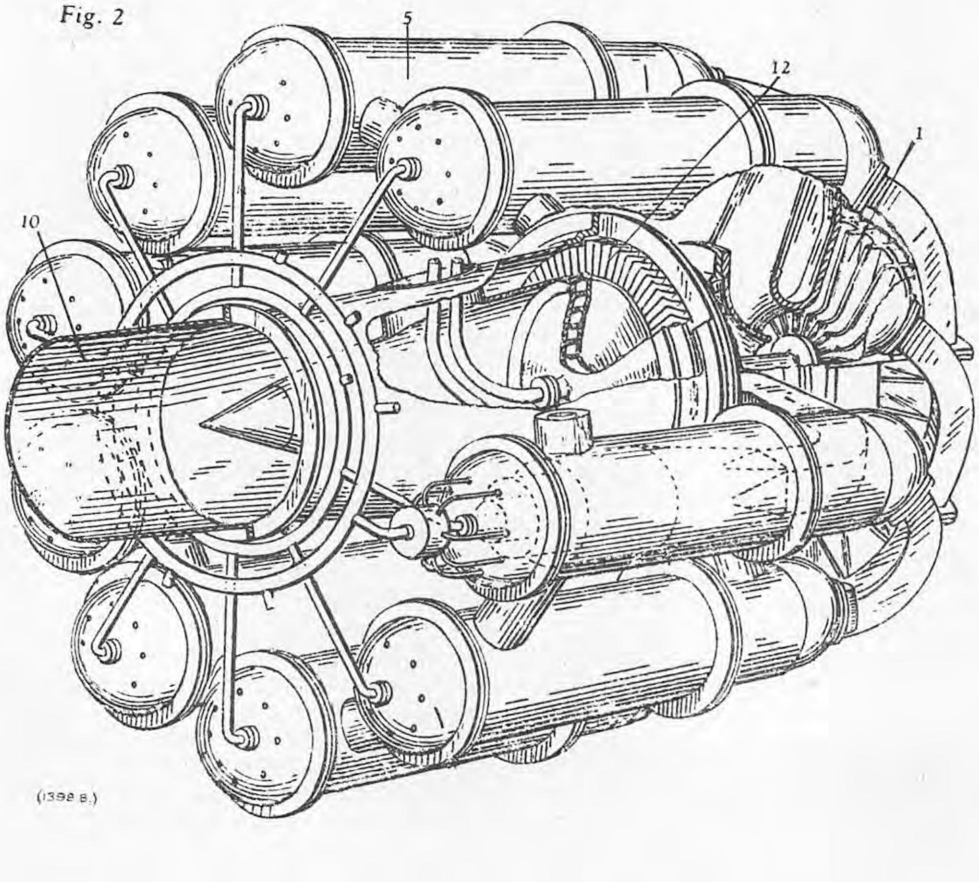


FIG. 1. POWER JETS' W1 ENGINE.

Fig. 2



(1398 B.)

AERO-ENGINE LAYOUTS.

Inasmuch as weight and space are ruling factors in aeronautical engineering, the designer of the aero gas-turbine engine is very much restricted as regards the type of cycle which he may employ; heat exchangers and inter-cooling are "out," to all intents and purposes, largely on account of the weight penalty which they involve. The necessity of saving space, or of "tailoring" shape, on the other hand, may call for considerable ingenuity in the relative disposition of such components as are employed, be the cycle simple or compound. This section is concerned with configurations used or suitable for use in plain turbo-jet and turbo-prop. engines; ducted-fan configurations will be dealt with in a later section concerned with Thrust Augmentation.

It is fitting that, even though chronology is the determining factor, pride of place goes to an early patent drawn to the classic Whittle layout. The jet-propelled Gloster E28/39, the first British gas-turbine aircraft to fly, was powered by a Power Jets W1 engine, of which a photograph is reproduced as Fig. 1, and which affords an example of a configuration in accordance with Patent No. 577,971; as will be seen from Fig. 2, this configuration comprises a centrifugal compressor 1, a compressor-driving turbine 12 and an exhaust duct 10 arranged on a common axis, about which a number of combustion chambers 5 are symmetrically arranged. The reverse-flow combustion chambers of the W1 have an unfamiliar look in these days, but the reader will recognise a general arrangement which has found considerable favour, both in this country and abroad.

It is a far cry, perhaps, from the simple Whittle layout to an engine employing a double compound cycle; the jump must be made, however, if chronological order is to be retained. The layout shown in Fig. 3. which illustrates Patent No. 592,883, is designed to achieve flexibility by avoiding cross-compounding without, at the same time, resorting to the use of concentric shafts or of unduly complicated ducting. In the pusher turbo-prop. unit depicted as an example of a layout in accordance with the invention, air enters radially near the rear of the nacelle and is caused to turn forward, in the direction of flight, to reach the high-pressure compressor 2 by way of the low-pressure compressor 1; this latter compressor is driven by the low-pressure turbine 6, which also drives a pair of contra-rotating airscrews. After leaving the high-pressure turbine 4, by which the high-pressure compressor is driven, the hot gases (produced in the combustion chamber 3) turn through 180 deg. to reach the low-pressure turbine and the rearwardly facing exhaust nozzles; the ducting between the two turbines may be used to provide adequate combustion space for re-heat fuel.

Another patent which is illustrated by a drawing (Fig. 4) showing contra-rotating pusher airscrews, is No. 587,612. Here, there is no resort to a compound cycle, the main feature being the use of contra-rotating power turbines, 57 and 61, to drive the two airscrews.

The next patent, No. 587,526, relates to a configuration which will be recognised as having been adopted in at least two current turbo-prop. designs. As shown by Fig. 5, air enters the power plant radially (perhaps from a plenum chamber) at about mid-length and then flows forward, in the direction of flight, through an axial compressor 3; the direction of air-flow is reversed while passing from the compressor to the combustion chamber 12 and the directions of flow in the compressor and in the turbine 17 which drives it are mutually opposed. The configuration permits a compact construction (either turbo-jet or turbo-prop.) with adequate combustion chamber length, while economising in length (and weight) of shafting.

Patent No. 587,528 relates (so far as this particular section of the review is concerned) to the application to the turbo-prop. layout of the "Rostat" principle, whereby shaft power may be taken off, without the use of high-ratio reduction gearing, at a shaft speed considerably less than that of the turbine rotor or rotors. The drawing Fig. 6, opposite, shows an engine in which the compressor rotor 15 is driven by the turbine 33, whereas the power for driving the airscrew is taken from the rotatable stator 17 of the compressor, which is caused by the air-flow to rotate in the same direction as, but at a lower speed than, the rotor 15. Power for driving the airscrew could, of course, be taken off from the stator of the turbine instead of from that of the compressor and the specification of the patent also includes a drawing (not reproduced here) of a power plant wherein shaft power is taken off from both compressor and turbine stators; in this latter arrangement, it is intended that expansion in the turbine shall be continued down to the practical limit of final pressure, so that application may be to industrial and marine uses as well as to the propulsion of aircraft entirely by airscrew without any element of jet reaction. At the opposite end of the scale, the invention is also applicable to the jet-cum-ducted fan configuration, as will appear from the next section of the review.

With the next patent, No. 588,096, we return to the double compound cycle. Although this patent will also be mentioned again in connection with ducted fans, it is primarily concerned with a "two-spool" layout which is advantageously applicable to both turbo-prop. and turbo-jet units. A turbo-prop. unit which is used as an example in the patent specification is illustrated by Fig. 7, opposite; as

POWER JET'S GAS-TURBINE PATENTS.

Fig. 3.

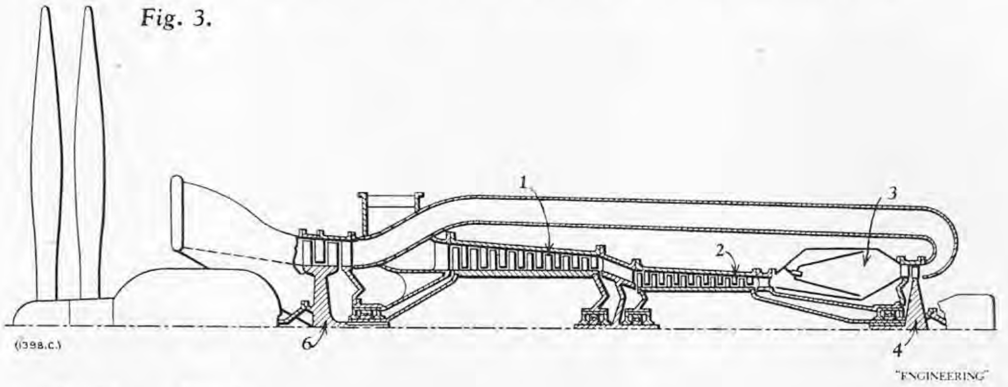


Fig. 4.

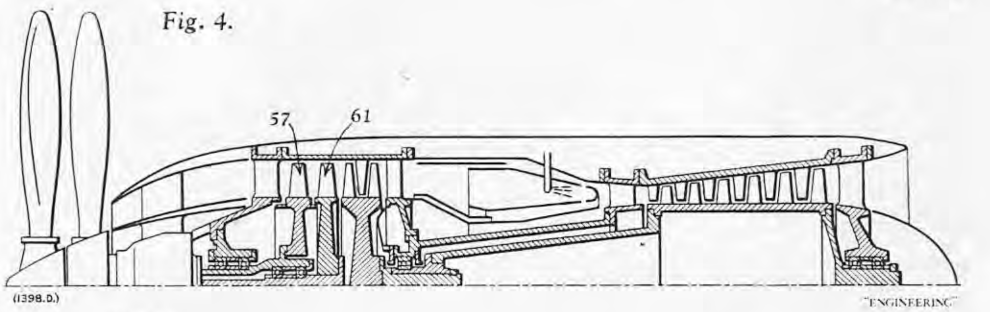
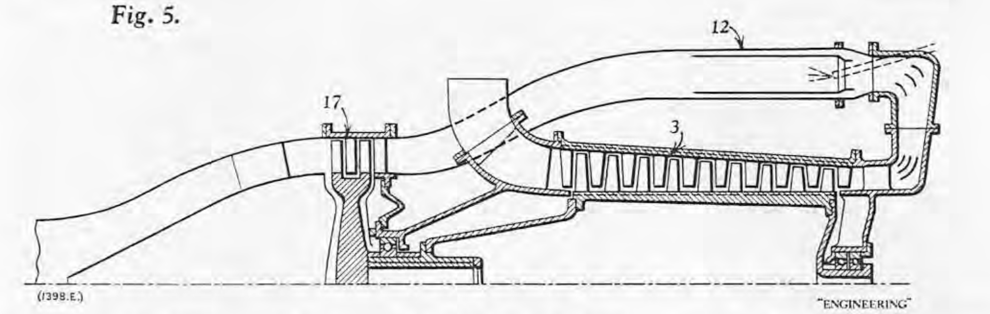


Fig. 5.



shown, it comprises high- and low-pressure axial compressors 27 and 28, the rotors of which are mechanically independent and are driven respectively by the high-pressure and medium-pressure turbines 24 and 16a. The airscrew is driven by a separate low-pressure power turbine 56 through a shaft which is nested concentrically within the hollow shaft by which the low-pressure compressor is driven; the hollow shaft in turn passes through the relatively short and large-diameter shaft coupling the high-pressure compressor to its driving turbine. The use of the separate power turbine, of course, results in a jet thrust considerably lower than that obtainable from the comparable turbo-jet layout in which this turbine and the airscrew are omitted; provision for increasing the residual thrust by afterburning in the exhaust stream is indicated at 50.

The layout illustrated by Fig. 7 permits the attainment of a flexible "two-spool" arrangement with a straight-through air flow. Where short axial length is required, however, the annular combustion chamber indicated (or an equivalent straight-through multi-chamber system) may be replaced by a double-reversal combustion system, say of the Whittle type shown in the illustration of the W1 engine (Fig. 1), symmetrically disposed around the high-pressure compressor.

The patents already reviewed in this section may be said to relate to inventions which are within the bounds of current practice; indeed, several of them are already actually in use. The final case, Patent No. 625,087, may seem, at the present time, however, to relate to an invention with a futuristic flavour, since it enters the realm of the triple-compound cycle comprising three mechanically independent rotors capable of running at different rotational speeds. In such a cycle, considerations of flexibility and ease of starting make it desirable that the high-, medium- and low-pressure compressors are driven by the high-, medium- and low-pressure turbines respectively; the invention is concerned with the provision of such an arrangement, which is compact and wherein the use of concentric shafting is avoided and ducting is made as simple and with as few loss-producing bends as possible. To this purpose, the components are arranged coaxially in the order: low-pressure turbine, low-pressure compressor, intermediate-pressure compressor, intermediate-pressure turbine, high-pressure turbine and high-pressure compressor.

The arrangement shown in Fig. 8, opposite, is a turbo-prop. of the pusher type, the direction of flight being indicated by the arrow. As will be seen, air enters by way of a forwardly facing inlet 1 situated near the rear of the nacelle (or a plenum chamber could be employed) and flows forwardly in a straight path through the low- and medium-pressure compressors 3 and 4; the high-pressure compressor 9 is then reached by way of ducting which runs at a greater radial distance from the axis and in which occurs the only reversal of direction in the whole flow path from low-pressure compressor back to low-pressure turbine and final exhaust. From the high-pressure compressor, the air flows rearwardly to the annular combustion chamber 10, the hot gases from which pass to the high-pressure turbine 13, and thence, perhaps through an optional reheat chamber 15, to the medium-pressure turbine 18. From this turbine, the gases pass to the low-pressure turbine 21 by way of ducting which interdigitates with the air-ducting in passing to and returning from a radial distance from the axis greater than that of the air paths through the compressors and turbines; optional provision for further re-heat is indicated at 24. The contra-rotating pusher airscrew 28 may most conveniently be driven by the low-pressure

POWER JETS' GAS-TURBINE PATENTS.

Fig. 6.

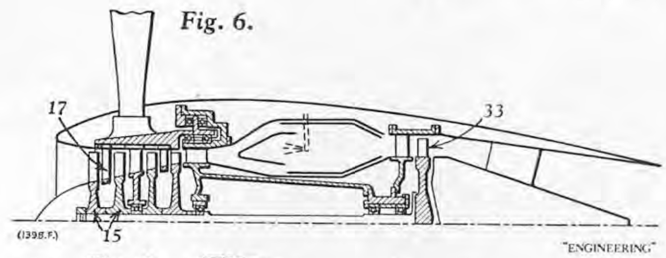


Fig. 7.

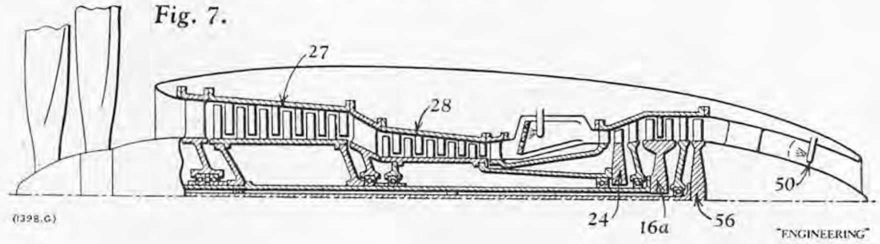
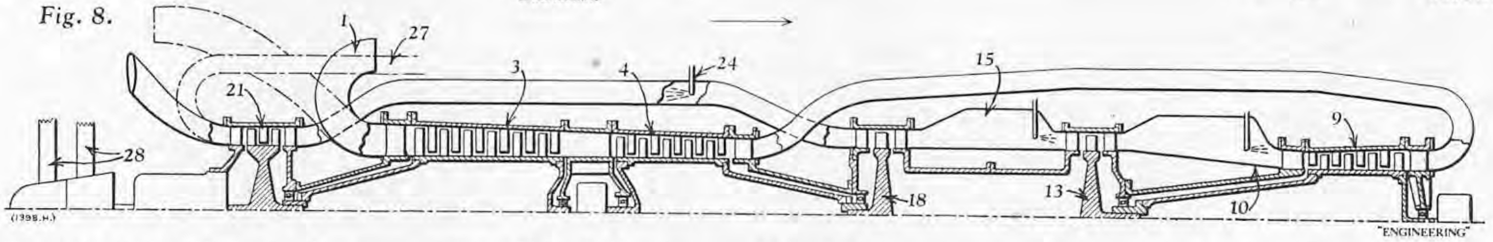


Fig. 8.



turbine, as actually shown or by a separate power turbine; any other of the possible drives mentioned in the specification would involve resort, in some measure, to the use of concentric shafting. If a tractor airscrew were required, the use of concentric shafting could be avoided by driving the airscrew from the high-pressure turbine; moreover, a turbo-prop. or turbo-jet configuration adapted for flight in the opposite direction could be obtained at the expense of a reversal of flow in the ducting (indicated in part by chain-dotted lines at 27) leading from the low-pressure turbine to a rearwardly situated jet nozzle; which ducting, incidentally, would provide adequate combustion space for an afterburner.

LITERATURE.

Buckling Strength of Metal Structures.

By FRIEDRICH BLEICH. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 10 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 85s.]

SOME years ago all universities and research institutions engaged in the investigation of the behaviour of structures under load were approached by the American Column Research Council with a request for information on their work in the field of instability. One of the results of that request is, apparently, Dr. Friedrich Bleich's book. It is, however, much more than a compilation of results from all sources or a survey of the literature. An attempt has obviously been made to select the most useful and practicable methods and, in order to keep the book a reasonable length, every available method has not been recorded.

Problems of instability have for generations attracted the applied mathematicians. While the engineer has undoubtedly profited from their labours, too often the investigations have stopped short of the point where they could be of practical use. Dr. Bleich has considered it his duty to correct this tendency wherever he could by simplifying available theories and by providing information in the form of tables and graphs or approximate formulæ. He has with courage, and on occasions with over-optimism, extended the theories of elastic buckling into the inelastic range. The book is notable, in fact, for the amount of attention given to plastic behaviour, a branch of the subject to which British workers have made significant contributions. The first chapter on the centrally-loaded column brings home to the engineer the limitations of many of the theories and the fact that while something is known of the critical loads of ideal structural members little information is available on what is of real interest to the designer—the load at which the member in a structure ceases to play its full part.

These loads are appreciably different in most practical members because of the effects of inevitable imperfections, of neighbouring members and of the loads they carry. It is only in the case of the buckling of the centrally-loaded column by flexure that anything reliable is known about the difference. The author does not ignore this work but he treats it a little cavalierly. One cannot quarrel with the logic of his argument that the column problem proper represents only a small portion of the entire group of buckling problems and that the design in all cases of instability should be based on one and the same formula. It is, however, small comfort to the designer to be told that such uncertainties as accidental eccentricities and initial crookedness must be taken care of by a factor of safety, when no guidance to the correct factor is given. The British reader will be amazed that this branch of the subject can be discussed without mention of the pioneer work of Perry and that space can be given to the secant formula but none to the curvature formula on which strut curves in this country have been so conveniently based for twenty years. A later chapter is devoted to the effective length of compression members in trusses and the stability of rigid frame structures, but nothing there will help the designer to decide the most appropriate effective length to be assumed in designing even so familiar a structure as a building frame. Mention is, however, made of the experimental side of the work being carried out in Cambridge on the plastic buckling of compression members in rigidly jointed frames, though not of the theoretical contribution. (See *Proc. Roy. Soc.*, A, vol. 198, 1949.)

While some of the apparently simple practical problems remain unsolved, the introduction to the mathematical treatment of stability problems and the stability criteria is excellent, and in some features, such as emphasis on orthogonality relations, unusual. The history of the subject is discussed, but here and there it appears to be somewhat shaky. Surely Rayleigh was the first to use an approximate shape in calculating an eigen value. Kirchhoff and Bryan, to whom the credit is given, merely used the variational method to derive the differential equation from the energy expression. G. I. Taylor is denied the credit for the method ascribed to Trefftz though a later footnote proves his claim. A most reasonable treatment is given of the method of successive approximation, called the Stodola-Vianello method, but without reference to Schwartz, who was the originator. It is unfortunate that in this section no description is given of the relaxation method as applied, for instance, to a practical bridge problem by D. G. Christopherson, Sir Richard Southwell and others (*Phil. Trans. Roy. Soc.*, vol. 239A, 1941). A good summary of the literature and a reasonable presentation of the theory of the buckling of centrally-loaded columns by torsion and flexure, so important in light-alloy structures, is given together with a full and valuable discussion of the lateral buckling of beams, though reference to recent British work, such as that of B. G. Neal (*Phil. Trans. Roy. Soc.*, vol. 242A, 1950) and A. R. Flint (ENGINEERING, vol. 170, page 545, 1950) is omitted.

The references to elastic buckling theory in the chapter on the behaviour of plate elements of columns are very full. The plastic buckling problem is dealt with mostly by the tangent modulus theory of plates. The author is, perhaps, somewhat dogmatic in taking this theory as an established fact, but in doing so he is only following the current trend in American work on this subject. There is no mention of the Royal Aeronautical Society's Data Sheets which give much information on plate buckling in a useful form. Later chapters discuss plates with longitudinal stiffeners, web plates of girders and special problems in the design of ship plating. They will be invaluable to those making a rational approach to the design of complex structures. Dr. Bleich's book is, in fact, a most useful contribution and contains much original work. Though a cursory glance might give another impression, it is not just another mathematical treatise. While maintaining a sound approach the aim has certainly been to concentrate on problems encountered in the design of civil engineering structures, ships and, to a less extent, aircraft, and to give solutions in a practical form.

BRITISH ELECTRICAL AND ALLIED MANUFACTURERS ASSOCIATION PUBLIC RELATIONS ADVISER.—Editorial Services Ltd., 12, Buckingham-street, London, W.C.2, have been appointed public relations advisers to the British Electrical and Allied Manufacturers Association to counter the sales problems that confront the industry and to improve its standing both in the political sphere and with the general public. The work will be personally supervised by Mr. Claude Simmonds and will be carried out in close conjunction with the Association's Electricity Development Committee, of which Mr. A. S. Lowe is secretary.

MECHANICAL HANDLING OF TIMBER IMPORTS.—Record imports of timber were achieved by Pyman, Bell & Co., Ltd., Newcastle-on-Tyne, during 1952, at their pit-wood storage yard in Yarrow. The yard was laid out, on land reclaimed by the Tyne Improvement Commission in accordance with the company's specifications, for modern methods of mechanical handling. The site is designed to employ five Coles R. 1510 rail cranes, fitted with special swan-neck jib heads for working close to the stacks, and made by Steels Engineering Products, Ltd., Sunderland; three are now in use. Included in the reclamation and levelling work was a diversion of the River Don. The finished site occupies 25 acres, which makes this the largest individual pit-wood storage yard in the United Kingdom. On April 11, 1952, the first cargo was received and by the end of the year approximately 28,000 Gothenburg standards of mining timber were stacked in the yard. One crane can discharge 100 standards from a wagon to a stack in an eight-hour working day. The previous manual storage method required 33 men working for the same period.

THE ENGINEERING OUTLOOK.

XII.—General and Constructional Engineering.

No industry has a more important role to play in the British economy than engineering. To the metal-manufacturing and vehicle industries falls the responsibility of finding over half of the total British income from exports; of providing the bulk of the equipment required for re-armament; and of supplying tools, machinery and equipment to the remainder of British industry in adequate quantity and of sufficient quality to maintain the high standard of efficiency which alone will keep British products competitive in world markets. The re-armament programme has been scaled down so that the makers of engineering equipment may be able to devote more attention to carrying out their other tasks. The improvement in the balance of payments in 1952, and a very substantial rise in currency reserves to over 2,000 million dols. in the past few months have not lessened the need for increasing exports. Reserves are still small in proportion to the total transactions in sterling, which finance about half of the world's trade. The balance in the foreign account has been achieved, moreover, by restricting imports, and, as Mr. R. A. Butler, the Chancellor of the Exchequer, has pointed out, this is a policy which the country cannot afford; more imported raw materials are needed for a higher rate of output, and, unless the United Kingdom can offer a larger market to other countries, these, in turn, cannot offer expanding markets for British goods.

Emphasis on Productivity.

At the Productivity Conference called by the British Productivity Council, Mr. Butler stressed that contraction and restriction led to recession and crisis; a policy of expansion, however, required courage, drive, and vision. It is a common thesis that expansion in trade is dependent upon development of the under-developed countries and of the Commonwealth countries in particular. This is true so far as it goes; but, as Mr. Butler stated, "The key to Commonwealth development lies here in British industry and agriculture. The development of the United Kingdom's ability to increase the volume and efficiency of its production is one of the principal conditions for expansion in the world to-day." Apart from stimulating the demand for the products of the under-developed countries, and hence increasing their incomes, it would enable the United Kingdom to undertake investment in these countries on a scale which would greatly accelerate development. British investment overseas is not negligible at present, though it is very small compared with that of the United States, and smaller still in relation to the opportunities for profitable development. British funds can be made available only for productive schemes of the highest category; the recent application of the Auckland Bridge Authority for a loan of 4·5*l*. millions to be raised in the London capital market did not fall in this category, and had to be refused. Nevertheless, British investment in the Commonwealth is increasing. Mr. Butler recently disclosed that gross sums amounting to 17·5*l*. millions had been invested in Canada alone in the first two and a half months of 1953. The Commonwealth Development Finance Corporation, which has been formed recently with a capital of 15*l*. millions, subscribed jointly by the Bank of England and leading commercial enterprises, should have an important contribution to make.

Failure to increase productivity would seriously diminish the effectiveness of British economic leadership of the sterling area and the Commonwealth. Much ground had already been lost. Sir Ewart Smith, the technical director of Imperial Chemical Industries, Limited, has pointed out that, over the past 50 years, productivity has increased in the United Kingdom at an average rate of between 1 and 2 per cent. per annum; in some countries, and in some British industries, however, productivity had increased at double this rate. The British Productivity Council has been set the task of seeing that the technical knowledge essential for advancing productivity shall be disseminated as widely as possible. Some new techniques have been learned in the United States, but many more have originated in the United Kingdom, and the British Productivity Council will be fulfilling an invaluable function if it can spread the knowledge of these throughout British industry. Accordingly, a new campaign has been launched, which will be financed partly out of the sterling "counterpart" funds of the economic aid allocated under the Mutual Security Act and will cost about 30,000*l*. to 40,000*l*. per annum. Local productivity committees are to be set up in 105 industrial towns and centres with the co-operation of the Regional Boards for Industry, which will provide facilities for contact and discussion among local industrial concerns. Even more interesting is the plan for a "circuit scheme," under which individual industrial concerns are to be invited to form teams of six employees, comprising two from management, two from staff and two from the workshops; each team will be sent once a month to meet another team in the same circuit of ten companies of similar size in the same district. It is hoped that, in many cases, even competing concerns will be able to exchange information, but companies will be asked to choose whether or not they wish to be put in a circuit which includes their competitors.

Discussion and exhortation are valuable, but they will not, of themselves, advance productivity. The production engineer is not likely to show interest in productivity until shortages of steel and raw materials cease to frustrate forward planning. Management will have little incentive to install new machinery and adopt new techniques if, because of the burden of taxation, very little return is to be expected on their outlay. Higher productivity, moreover, will assist British efforts to market goods overseas only if there is a fair degree of elasticity of demand. Price reductions, even if very considerable, may not increase sales of British goods if foreign Governments maintain restrictive import policies, whether designed to remedy temporary monetary difficulties or to give permanent protection to local high-cost manufacturing industries. The future course of world trade depends upon the general adoption of expansionist policies. The United Kingdom has taken the lead by restoring to open general licence a wide range of goods, and increasing the import quotas for many others; it remains for other countries to follow the British example. There is promise that the United States, perhaps the most important of all markets, may adopt a more liberal policy. The appointment of a committee under the chairmanship of Mr. Lewis Douglas, former Ambassador to the United Kingdom, to study the whole question of foreign economic relationships of the United States, is at least a guarantee of earnest intentions.

Meanwhile, British exporters of engineering equipment cannot expect any immediate improvement in marketing conditions overseas. In some countries, notably Australia, import restrictions have been eased a little; but progress towards more liberal trade must be a very slow and gradual process. The sellers' market is likely to persist throughout 1953, and it will require all the sales initiative of which British exporters are capable to maintain British exports in the face of heavy competition from Germany and Japan. In some markets, particularly in South America, low prices and high quality are less attractive selling points than generous credit terms, and, if the United Kingdom is to pursue an expansionist policy which will assist both British exporters and their customers, the nation will have to be prepared to take greater risks over the matter of export credit guarantees. Much business has been lost already to German and Japanese manufacturers, whose governments have been able to assess the credit-worthiness of the importing countries more highly than have the British Government.

Shortages of steel and raw materials should not retard the pursuit of higher productivity in most of the engineering industries. The supply of steel plate will continue to be controlled, since, despite an expected increase of 15 per cent., it will not meet the full requirements of shipbuilders, locomotive builders and boilermakers in 1953. Most other types of steel have been plentiful for some time. There is now a very real danger that the output of steel may shortly be in excess of demand. The world output of steel in 1952 was seriously restricted by the strike in the United States, but, nevertheless, exceeded 208 million tons. In 1953, it could reach 240 million tons, but world trading conditions would have to improve considerably to justify this increase of 15·5 per cent. In the United Kingdom, it has been announced that preparation for the second post-war development plan of the steel industry is almost complete and that, at a cost of 250*l*. millions, the British output of steel will be raised by about 4·5 million to 20·5 million ingot tons by 1958. Steel consumption may admittedly grow at this pace, but only if the export markets for British engineering products are less restricted than in 1952.

The contribution which the engineering industry can make towards raising the productivity of British industry—and, indeed, its ability to increase its own efficiency—might be greatly increased if, in the Budget this week, depreciation allowances are increased so that they bear some relation to the cost of new plant replacements. If, moreover, the sums placed to reserve can be freed from taxation, industrial saving, which at present is inadequate to maintain the national stock of capital, will be greatly stimulated. A reference to the Budget is made on page 499.

Growth of Mechanical Handling.

One of the industries most directly concerned with increasing productivity is that concerned with the manufacture of mechanical-handling plant. British industry is still lagging far behind that of the United States in the use it makes of equipment of this kind, but progress is being made. Particularly encouraging is the increase in the number of industrial power trucks in use. In 1937, only 164 were made in the United Kingdom; production had increased to 4,949 in 1948 and 7,085 in 1952. The greatest increase has been in the output of fork-lift trucks. The fork-lift principle was actually first employed in Britain 30 years ago, but large-scale production did not begin till after the war. The output has grown from 53 trucks in 1946 to 2,306 in 1951 and 3,068 in 1952, when it was valued at 4·2*l*. millions. There are now 20 manufacturers of these trucks. The production of cranes, conveyors, and other types of mechanical equipment has also been increasing (see Fig. 1, opposite). The output of cranes reached 16·9*l*. millions in 1952, compared with 15·9*l*. millions in 1951; the output of conveyors and elevators, 15·0*l*. millions, compared with 13·1*l*. millions; and the output of other mechanical-handling equipment, 14·9*l*. millions, compared with 14·0*l*. millions.

Makers of mechanical-handling equipment have been steadily increasing their exports, which account for about 27 per cent. of the total output. Exports of fork-lift trucks in 1952 were valued at 1·5*l*. millions, and some were even sold in the United States, where production by specialist manufacturers is on a much larger scale than in the United Kingdom. These manufacturers, as well as German and Swedish makers of fork-lift trucks, have been providing keen competition in all the principal export markets. The exports of mechanical-handling equipment are one of the most vital British contributions to the development of overseas resources. This is also true of earth-moving equipment.

The United Kingdom is still dependent on imports from the United States for some types of heavy equipment, but home production has grown rapidly in the past few years. Expansion has been limited only by the lack of steel and physical capacity, though, as in most other branches of engineering, orders fell off somewhat in 1952. The output of all types of contractors' plant in 1952 is estimated to have been about 50*l*. millions, of which half was exported. The exports of earth-moving equipment alone reached 14·3*l*. millions, compared with 9·8*l*. millions in 1951. The range, as well as the volume of equipment produced, is steadily being increased. It has been announced recently that Euclid (Great Britain), Limited, who have already been responsible for the introduction of much new equipment to the United Kingdom, are to produce rubber-tyred tractor and scraper units, which have hitherto been available only in the United States, at their factory at Newhouse. The new machines, which will be 45 ft. long and 11 ft. wide, can scrape up 16 cub. ft. of soil and transport it at speeds of up to 30 miles per hour for dumping in other areas.

Civil Engineering Contracts.

At home, the work of repairing the East Coast sea defences has created an additional demand for contractors' plant and contractors' services. Abroad, British contractors, constructional and consulting engineers have a large volume of work on hand in connection with the various development schemes. The first stage of the Volta River aluminium scheme has already begun, and initial contracts have gone to two British concerns for improving the transport system to Port Tema. Important contracts have gone to British companies for the construction of the Uganda Falls power station and the Nile Dam. Four British companies are co-operating with four Dutch concerns in handling the civil engineering work on this project, which will cost about 6*l*. millions. Work has begun on the building of the stretch of road 122 miles long between Morogoro and Dar-es-Salaam, which will cost about 3·2*l*. millions and is being handled by Stirling-Astaldi, Limited, a new company specially formed by the British and Italian companies who are co-operating in the project.

despite their importance for industrial and agricultural development. The decline occurred mainly in the smaller petrol engines of less than 10 h.p. and was due very largely to import restrictions encountered in such countries as India and Egypt. The demand also declined on the home market, and, as a result, production fell steeply in 1952.

The engine-makers have made substantial price reductions in an effort to stimulate sales, and may be expected to achieve a somewhat higher output in 1953. A review of productivity in the industry, published by the British section of the former Anglo-American Council on Productivity in August, 1952, stated that there is every prospect of continued expansion in the world market for internal-combustion engines, and claimed that the competitive power of British manufacturers had been so strengthened in the past few years that they should obtain a large share of the world market in coming years. There are some sections of the industry where the recommendations of the team which visited the United States in 1950 seem "to have fallen on deaf ears, but these are the sections less likely to survive the present process of rationalisation and the increasing competition in foreign markets." Some engine-makers have already carried the process of rationalisation very far; one company, who produced 22 models in 1948, now produce four, and another, who formerly produced 30, now produce 13. All the more important com-

3·75 million tons achieved in 1951. Castings for the engineering industry account for about 52 per cent. of the total production and are made in more than 1,000 foundries. The increase in output in this branch of the industry has been very considerable since the war. The output of castings of all kinds has increased by about 1·25 million tons per annum, or 50 per cent., as compared with pre-war and about 48 per cent. compared with 1946; the output of engineering castings has increased by about 57 per cent. since 1946. Technological progress appears to be increasing the scope for the employment of iron castings in engineering products, and British engineers have shown themselves ready to make the fullest use of them. In the United Kingdom, the ratio of cast-iron to steel products is about 21 per cent.; in Western Germany it is 16 per cent.; and in the United States only 14 per cent.

Falling Sales of Office Machinery.

In each year since the war, prior to 1952, the British office-machinery industry, which, with an annual output of 45*l*. millions a year, is now second in size only to that of the United States, has set up new output and export records. The value of exports in 1952, 9·7*l*. millions, was still a record, but the volume of exports had dropped from 4,583 tons in 1951 to 4,417 tons. The trend of production was also downwards, as may be seen from Fig. 3, herewith. The output of standard typewriters

FIGS. 1 TO 4. UNITED KINGDOM: PRODUCTION OF MISCELLANEOUS ENGINEERING PRODUCTS. (MONTHLY AVERAGES).

Fig. 1.

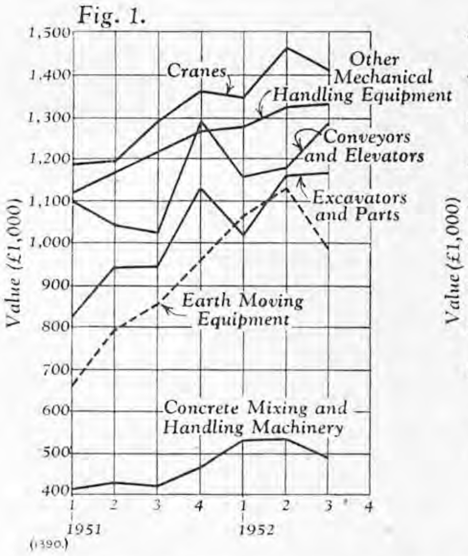


Fig. 2.

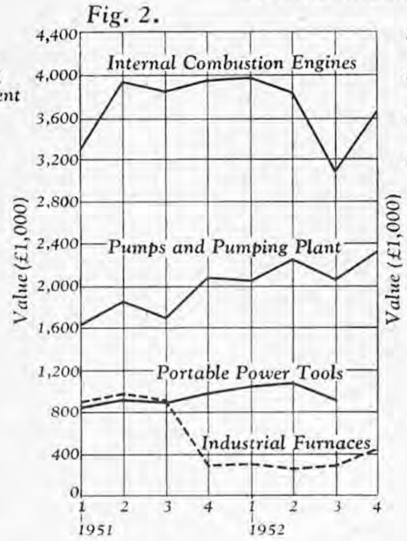


Fig. 3.

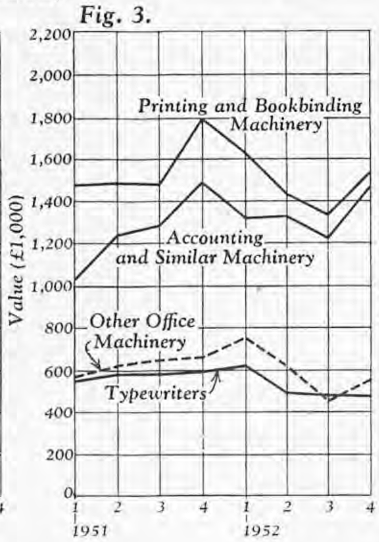
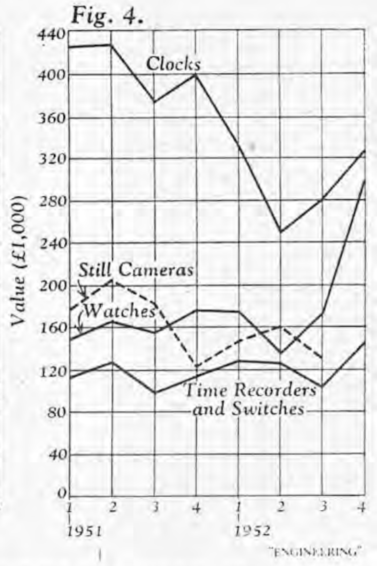


Fig. 4.



Other important contracts on hand include a port development scheme for Colombo, a water-supply project for Teheran, a hydro-electric scheme for New Zealand and multi-storey flats for South Africa and Southern Rhodesia. British companies are sharing in projects for opening up the mineral and other natural resources of Canada. Development work in the North American continent, however, has been very much the prerogative of United States engineers, and British firms took no part in the development of the Alberta oil field and the Labrador iron-ore project. British companies may, however, participate in the construction of the proposed St. Lawrence Seaway. Contracts are expected to be announced towards the end of 1953. Individual British companies, in the past, have tended to have insufficient resources to compete successfully for business in North America. The Export Group for the Construction Industries has been set up, therefore, with the object of securing the co-operation of about 20 British firms, who together should be able to cope with even the largest contracts.

Internal-Combustion Engines.

The output and exports of pumps and pumping plant have followed the upward trend of earth-moving equipment (see Fig. 2, herewith). As a result of the heavy outlay on irrigation and oil-well development schemes abroad, the exports of pumps, valued at 13·3*l*. millions in 1952, were about one-third higher than in 1951. Exports of internal-combustion engines, however, were not maintained,

panies have already concluded a reorganisation process or are in the middle of one.

A notable order for British Diesel engines in 1952, placed with F. Perkins, Limited, was a very good example of Commonwealth co-operation. The order, for 1,355 Diesel engines valued at 1·25 million Canadian dols., was placed by the Canadian Government under the Commonwealth Governments' Colombo Aid Plan. The engines are to be sent direct to India, to be fitted into vehicle chassis separately exported from Canada. The entry of Rolls-Royce, Limited, into the Diesel-engine industry should greatly increase the British export potential. The new oil-engine division has been planned to give a volume of output comparable to that obtained by some of the large manufacturers in the United States. The range includes four-cylinder, six-cylinder and eight-cylinder engines, of from 70 to 250 h.p. Engines are already being supplied for the Vickers V.R. 180 heavy crawler tractor and the Scammell six-wheel-drive tractor. They have also been supplied as power units for mobile oil drillers, generating sets, pumping sets, and launches. Other applications will include cranes, excavators and earth-moving equipment.

A falling demand for many engineering products resulted in a serious drop in orders for iron castings and, by the autumn of 1952, many foundries had to reduce their output. At the end of December, 1952, the number of workpeople in the industry had fallen to 126,400, compared with 130,200 twelve months previously. The total output for the year, however, was probably slightly higher than the

which reached 9,771 in November, 1952, had fallen by nearly one-third to 6,660 in November, 1953. The output of accounting and similar machinery, however, has been better maintained; the output in November, 1952, 1·46*l*. millions, in value, at least, was as high as in November, 1951. The output of duplicators and other miscellaneous office machines has followed the trend of typewriters, and, at the end of 1952, was at a rate 25 per cent. below that of 1951. These drops in production, however, must be considered in the perspective of the progress which has already been made; the output of typewriters in 1952, for example, was still twice as great as in 1949. Surprisingly enough, the largest single overseas market for British office machinery is the United States, which accounted for 15·4 per cent. of the total British exports in 1952. For this the Burroughs Adding Machine Company, Limited, are largely responsible. The production of machines formerly made by this company in the United States has been transferred to their factory at Strathleven. All Burroughs calculators now sold in the United States and Canada are, in fact, made in Scotland. Import restrictions in Australia were responsible for most of the fall in exports in 1951. Exports to that country, valued at 1·3*l*. million, were 800,000*l*. lower than in 1951. Some increase is likely in 1953, but exports of office machinery cannot be expected to expand as rapidly as in the past.

Clocks and Watches.

Another industry which suffered a set-back in 1952 was the manufacture of clocks (see Fig. 4, on page 485); which must be attributed to saturation of the market, following the rapid increase in production of the four leading manufacturers. Keen competition and growing efficiency of manufacture have resulted in price-cutting; one alarm clock, for example, which sold for 29*s.* 6*d.* four years ago, is now priced at 22*s.* 6*d.* Exports of clocks in 1952 were remarkably well sustained, despite the effect of the Australian import restrictions; the number sent overseas, 1·1 million, was only 76,000 fewer than in 1951. The volume was maintained, however, only by selling at keen prices; the value of clock exports in 1952, 897,000*l.*, was 10 per cent. lower than in 1951. It is some consolation at least that Swiss exports of clocks, which fell by 5·6 per cent. in 1952, fared very little better than the British. Despite falling consumer purchasing power, the sales of watches were well sustained in 1952. Imports from Switzerland increased by 164,000 to 1·4 million, and the British watch-making industry succeeded in increasing its output by about one-fifth, to 2 million watches. Lower-priced British watches, with up to five jewels, have little to fear from Swiss competition, at least while they continue to be protected by a 33·3 per cent. tariff. Volume production of these watches can be carried out satisfactorily on highly specialised machinery, tended by semi-skilled operatives. High-quality 15-jewel watches, however, require higher standards of craftmanship, which are easily attainable only in Switzerland, where there is a long tradition of watch-making. Watches account for about 20 per cent. of the total exports of Switzerland, and about 95 per cent. of the output is exported. The value of exports in 1952, 748·6 million Swiss francs, was 6·1 per cent. higher than in 1951. Nevertheless, the number of complete watches exported was lower than in 1951, and some concern has been felt over the possibility of a slump. The Upper House of the Swiss Legislature has recommended that the Federal Administration should prepare a decree to compel the watch industry, which comprises about 2,900 companies, employing 50,000 people, to set up "crisis funds" in accordance with powers granted for combating depression.

Table I.—United Kingdom: Exports of Some Industries, Classified as General Engineering.

—	Value (£1,000).				
	1938.	1949.	1950.	1951.	1952.
Air and gas compressors and exhausters	573	3,042	3,803	4,324	5,279
Boot and shoe machinery	165	624	714	718	902
Cement-making machinery	84	968	1,707	1,506	1,795
Centrifugal drying machinery	209	370	397	566	769
Concrete-mixing machinery	129	1,090	1,011	1,182	1,384
Condensers	296	518	492	654	597
Cranes, hoists and other lifting machinery	1,597	7,775	8,230	7,642	10,620
Dairy machinery	235	1,542	1,823	1,921	1,883
Excavating and similar digging machinery	681	7,942	6,859	9,824	14,264
Fans, power-driven	—	1,538	1,484	2,047	2,514
Food preparation and sterilising machinery	376	3,511	4,584	4,121	5,005
Furnace plant	357	1,088	1,312	1,064	1,519
Gas and chemical machinery	329	3,668	3,143	2,032	2,206
Grain-milling machinery	326	2,123	2,465	4,386	6,239
Hydraulic machinery	253	508	538	1,255	1,364
Laundering and dry-cleaning machinery	149	2,139	5,121	8,908	7,111
Lawn mowers	138	818	1,447	1,835	1,643
Office machinery	638	3,941	5,968	9,245	9,704
Packing, packeting and labelling machinery	188	2,190	2,797	3,117	3,385
Portable power tools	345	2,445	2,997	3,550	3,819
Printing and bookbinding machinery	1,039	7,816	10,013	9,816	9,752
Pulp and papermaking machinery	729	1,731	2,054	2,071	3,201
Pumps	1,561	7,327	8,344	9,819	13,288
Road rollers	253	1,015	1,202	1,072	1,571
Sewing machines and parts	1,262	4,979	5,998	7,032	8,315
Tobacco and cigarette-making machinery	522	2,071	1,945	2,419	2,880
Sugar-making and refinery machinery	566	2,989	2,337	2,327	2,744
Weighing machinery	259	1,063	1,306	1,512	1,647
Welding machinery	—	2,066	2,422	2,714	3,674
Woodworking machinery	231	2,079	2,053	2,200	2,516
Ball and roller bearings	646	2,513	2,531	2,471	3,176
Ophthalmic instruments	442	357	565	853	645
Medical and surgical instruments	465	1,973	2,186	2,492	2,432
All other scientific instruments	903	5,171	6,847	7,796	9,242
Clocks and watches	104	1,240	1,376	1,350	1,123
Total	16,050	92,230	108,071	125,851	148,208

Cycle Industry.

The cycle industry is another in which rapid expansion has taken place since the war; in this case, too, sales fell off in 1952. By the beginning of 1953, the cycle makers were dismissing workpeople, and short time was being worked. The fall in demand has been particularly severe in the home market; the number of cycles exported in 1952, 2·79 millions, was actually 50,000 greater than in 1951, and exports, which accounted for about 75 per cent. of the total output in 1951, accounted for 85 per cent. in 1952. Conditions were difficult, however, in many of the principal markets, and deteriorated towards the end of the year. Exports to India fell by 273,000*l.* to 1·6*l.* million in 1952; exports to Malaya, the largest market, increased by 420,000*l.* to 3·3*l.* millions, but here, as in other countries producing primary commodities, declining income is now taking effect. Export of cycles to the United States also increased by about 69,000, to 185,000 cycles in 1952; but they are reported to have fallen off somewhat in 1953, though some important orders were received at the Cycle and Motor-cycle Show in London in November, 1952. Norman Cycles, Limited, of Ashford, Kent, are reported to have received an order for 25,000 cycles, valued at 700,000 dols.

The growth of cycle-making industries abroad must be expected to depress exports, although since, in many cases, these have been set up by British companies, the United Kingdom will continue to derive large revenues from the countries concerned. One of the most recent ventures in cycle-making overseas is that of Sen-Raleigh Industries of India, Limited. This company has been formed with an authorised capital of 750,000*l.* by Raleigh Industries, Limited, and a leading firm of Indian cycle distributors. A factory occupying 125,000 sq. ft. has been opened near Asansol, in West Bengal, and the output, which initially is at the rate of 100,000 cycles per annum, is to rise later to 200,000. Raleigh Industries had already opened a new factory at Vereeniging, in South Africa; and a new factory in Dublin, erected by Irish Bicycle Industries, Limited, with whom Raleigh have a manufacturing agreement, was due to go into production early in 1953. Manufacturing capacity in the United Kingdom was also increased when an extension to the Nottingham factory was opened. This factory, which covers more than 40 acres and employs 7,000 workpeople, is claimed to be the largest and most modern cycle plant in the world. Compared with foreign manufacturers, the British cycle industry has little to fear on the score of efficiency; in quality and price, British cycles are more than competitive, and, although the total world market for cycles has contracted a little, British manufacturers have increased their share of it. In the middle of 1952, the output in the Japanese cycle industry, although it has not exceeded more than about three-quarters of the pre-war level since the war, had to be cut to about 65 per cent. of its capacity of about 1·8 million cycles per annum.

Table II.—*United Kingdom: Exports of Machinery by value* (£1,000).

Exports to	1950.	1951.	1952.
British West Africa	5,223	5,713	7,935
Union of South Africa	24,890	32,094	35,151
Northern Rhodesia	1,982	1,746	3,151
Southern Rhodesia	3,499	4,496	5,686
British East Africa	5,925	5,953	7,970
India	36,028	34,169	35,626
Pakistan	5,941	8,131	10,298
Malaya	4,365	7,662	9,978
Australia	33,778	47,284	47,586
New Zealand	9,153	11,175	15,430
Canada	9,152	13,334	17,522
British West Indies	3,061	4,074	4,481
Irish Republic	8,512	10,477	10,827
Finland	2,791	4,051	5,118
Sweden	10,663	11,604	10,744
Norway	5,825	5,361	7,959
Denmark	4,259	3,830	3,953
Germany	2,161	2,773	4,241
Netherlands	12,544	13,034	12,893
Belgium	7,919	8,840	9,091
France	8,346	11,493	11,045
Switzerland	2,120	2,616	3,139
Portugal	4,756	4,177	3,960
Spain	2,125	3,268	4,684
Italy	3,710	6,200	12,423
Turkey	2,781	5,096	10,375
Egypt	6,810	6,205	5,201
Iraq	2,304	2,437	3,920
Thailand	1,480	1,981	3,056
Indonesia	2,443	2,274	3,626
United States of America	3,875	7,147	9,281
Venezuela	3,478	3,415	4,089
Brazil	10,789	14,272	17,553
Argentine Republic	6,845	3,562	3,282
Other foreign countries	58,893	53,252	61,462
Total	318,426	363,206	421,736

In the present series of articles, an attempt has been made to review the prospects of the main branches of the engineering industry. Obviously, it has not been possible to cover all the sections, but an indication of the progress of some of those which have been omitted may be gained from the trend of exports shown in Table I, taken from the *Trade and Navigation Accounts.* Conditions in the principal markets have been reviewed in some detail throughout the series; Table II, also from the *Trade and Navigation Accounts*, gives some indication of their relative importance to the engineering industry. The trend of exports, as shown in these Tables, has been steadily upwards; the engineering industry in 1953 may be expected, perhaps, to maintain this trend, but its task will be more difficult than in the past.

REFLOATING AN OVERTURNED SHIP.

During the floods on the night of January 31 last, the s.s. Hebble and a lightship were overturned while they lay shored up in the dry dock of the Humber Graving Dock and Engineering Company at Immingham, due to the sudden flooding of the dock when the River Humber breached its banks. The on-rush of water entering the dock knocked away the supports, when both vessels fell over on to their sides and were quickly submerged. After pumping out the dock, plans to right the vessels were formulated, and the motive power department (Lincoln District) of the Eastern Region of British Railways took part.

Four stanchions were welded to the side of the s.s. Hebble and wire ropes were attached to them through a system of pulleys which gave a mechanical advantage of 14 to 1, the other ends of the ropes being joined to a single wire rope which ran the full length of the dock, across the end, and thence to the railway sidings, where it was connected to a balance mounted on a truck coupled to two 0-4-0 class locomotives from the Immingham depot. Mirrors were mounted on the truck to facilitate reading the dial of the balance from the footplates, where "walkie-talkie" apparatus had also been installed so that the movement of the locomotives (which, of course, were out of sight from the dock) could be exactly controlled. Water was then let into the dock, and by controlling the flow and the pull of the locomotives up to a maximum of 6 tons, the ship was gradually restored to an even keel. The whole operation from start to finish took about half an hour and was carried out smoothly and without hitch.

British European Airways Traffic.—During the financial year 1952 to 1953, British European Airways carried 1,400,000 passengers and 14,100 tons of freight. This represents a 23 per cent. increase in passenger traffic and a 13 per cent. increase in freight over the previous year. The total distance flown was 24,000,000 miles, 11 per cent. more than in the previous year.

A CENTENARY OF INSTRUMENT MAKING.

A SLIDE rule or a set of drawing instruments is to an engineer what a spade is to a gardener or a brush to an artist: an extension of his faculties, and therefore specially personal to him. Even if, as he develops his professional ability, he acquires facility with something more complicated—say, a calculating machine or a harmonic analyser—affection for his first instruments of calculation and measurement persists. And though he be diverted from the main stream of technology and become, alas!, an administrator, he is glad of an excuse, occasionally, to open that little box of instruments, take out a pair of dividers and apply them, with unnecessary ostentation, to a drawing which a junior has placed before him.

The truth is, of course, that an engineer's instruments have a double significance: they are made by engineers and for engineers. They are produced by craftsmen with an honoured tradition of excellence of workmanship; their designs have been developed through long usage; and however complex some of them are to-day, they embody that continuing perfection which is the hallmark of British instrument-making: not only slide rules and drawing instruments, but theodolites, levels, calculators, planimeters, integrators, and a host of others—beautiful instruments all!

This year, a well-known firm in the instrument world celebrate their centenary, or, to use their own words, their "first centenary"—a phrase which suggests that a brief glance backward is not going to prevent them from looking forward. W. F. Stanley and Company, Limited, were founded in 1853 by William Ford Stanley, a young man of 24 with a capital of 100*l*., who rented a London shop with a parlour at the back for 12*s*. a week. The premises were in Great Turnstile, a passage that gave access from Holborn to Lincoln's Inn Fields, and there he made and sold wooden instruments, such as T-squares, set-squares, parallel rulers and curves. His first innovation in the design of instruments—a tapered blade for T-squares, screwed to the stock, which subsequently replaced the old parallel blade dovetailed into the stock—was not generally accepted by the engineering profession for some time; not, indeed, until an article appeared in a technical journal—*The Builder*. To this article he attributed much of his early success.

For a man with a very rudimentary education, he attained—like many others in Nineteenth-Century England—to considerable ability in the theory and practice of his work. He introduced a simplified stereoscope; devised a new type of straight-line dividing machine (which is still in use to-day, though slightly modified); won the only medal for mathematical-instrument work at the 1862 Exhibition; designed an improved centrolinead for drawing circles of from 2 in. to 200 ft. radius; succeeded, by thoughtful design, in halving the number of parts in a theodolite, and at the same time improved its stability and reduced its weight; and took out 78 patents relating to such various apparatus as cameras, barometers, snow gauges, portable galvanic batteries, a heat-conducting cake-tin, and, for physiological purposes, an instrument for measuring lung capacity and an automatic height-measuring machine. His published works included *Mathematical Measuring and Drawing Instruments*; *Experimental Researches into the Properties and Motions of Fluids*; *Notes on the Nebular Theory*; numerous communications to technical journals and papers read before learned societies.

By 1881 the firm's catalogue listed 3,000 items. Additional workshops and a showroom had been acquired, and in 1900 the firm was formed into a limited liability company. Stanley died in 1909, leaving the business in a strong position. In 1911, the firm of J. J. Hicks, well known as makers of clinical thermometers, was amalgamated, and in 1919 an interest was acquired in Motion, Smith and Son, Limited, of Singapore, whose depot was useful for markets in the Far East.

One of the shareholders in this firm was the British firm of Heath and Company, makers of navigation instruments. Stanley's acquired Heath's in 1926; and Heath's works at New Eltham, London, S.E.9, built in 1916, became the works of the combined organisation. George Heath, senior, who had founded his business in 1845, had concentrated on instruments for navigation; and instruments of this type, under the trade name "Hezzanith," have established themselves firmly in the marine world. In 1935, Stanleys also took over Perken, Son and Company, Limited, makers of thermometers for industrial and domestic use, and as the three firms, Heath's, Hick's and Perken's, had all been concerned with the manufacture of thermometers, it was decided in 1951 to form a company to be known as Heath, Hicks and Perken (Thermometers), Limited. A new factory for its products was opened in the same year.

The products of the works at New Eltham include scales, surveying, mathematical, nautical and meteorological instruments, as well as thermometers and thermographs. The work embraces non-ferrous founding, optical work, machining, glassblowing, cabinet-making, and the adjustment, calibration and repair of instruments. A quick tour of the works is enough to reassure an engineer that instrument-making is a stronghold of craftmanship. Mass-production is unknown, and although scientific-instrument makers can certainly not be accused of failing to meet modern needs—the British Scientific Instrument Research Association, of which Stanley's are members, helps to take care of that—some of the techniques employed date back many years, and the special skills used at New Eltham are peculiar to that type of work.

The divided scale in a sextant is cut in an arc-shaped strip of silver which is dovetailed into the brass frame of the instrument. The tool of the dividing machine leaves a fine burr on the edges of each division, and this burr has to be removed in such a way that the edges are not rounded, however slightly, otherwise the filling material which serves to render the divisions more easily visible would not remain in place. A fine grade of emery cloth would only round the edges. It was found, many years ago, that a block of charcoal of a certain quality removed the burrs when it was rubbed over the surface, while leaving an edge of the desired shape. As the charcoal bought from outside sources was not always effective, an investigation into the relation between the method of production and the qualities of charcoal was undertaken in Stanley's laboratories. Willow, partly from old cricket bats, is used. The carbonising temperature was found to be the critical factor; if it is correct, the charcoal produced consists of the original fine silica particles of the wood—which are the abrasive medium—and the matrix of carbon. As a result of this investigation, the firm now make their own charcoal under controlled conditions.

Boxwood is still regarded as the most suitable material for scales, owing to its close-grained structure; but for the same reason it has to be seasoned for several years. The celluloid used for the edges of scales, though admirable in other respects, is not dimensionally stable by itself, but the backing of boxwood ensures that accuracy is retained in service. At the time of our visit to New Eltham, an order was in hand for scales of triangular cross-section. This design is not new, but it went out of favour for some years. It has the advantage, of course, that six separate scales can be provided. Many other methods of construction and production are in use, such as the high-vacuum technique for blooming lenses, the roughing and polishing of lenses and prisms, spinning and other sheet-metal work for ships' binnacles, etc., the intriguing craftsmanship of which cannot be conveyed by the printed word. They are all part of an organisation which the visitor leaves with the feeling that there is no limit to the range of possible instruments which extend the engineer's and scientist's faculties.

HARWELL ISOTOPE SCHOOL.—An additional course has been introduced this year, to be held from July 6 to 31, at the Isotope School, Atomic Energy Research Establishment, Harwell, Berkshire, as a result of the growing use of radioactive isotopes throughout the world. The school was started two years ago to instruct scientists, doctors and industrial research workers in using and handling radioactive materials. Applications for entry to the course should be sent to the Isotope School by June 8.

EMBANKMENT SLIPS IN RAILWAY CUTTINGS.

(*Concluded from page* 457.)

THE SLIP IN SONNING CUTTING.

As at Twyford, the first signs of trouble at Sonning were indicated when the tracks began to move. The slewing effect was not so noticeable however, and, although the track lifted at an alarming rate, the movement was confined to the down main line, the track nearest to the toe of the embankment. A crack developed three-quarters of the way up the bank and began to open rapidly, and the resultant cliff face is shown in Fig. 6, on page 488. The movement of the slip was recorded in terms of the amount that the track had to be lowered to keep it at its original level, the measurement being made by the ganger in charge of the lowering. The sum total of the observations, 3 ft. 9 in., was known to be approximately correct as it agreed with the change in level of the cess drain, which is now well above rail level. A graph showing the rate of growth of the track movement is shown in Fig. 7, on page 488.

The slip developed very rapidly and remedial measures were agreed on the basis of preliminary reports, before a soil-mechanics investigation could be regarded as complete. The slip was reported on January 21, the investigation commenced on February 5, and materials were unloaded on the site on March 3, by which time the down main line had been lowered about 13 in.

The method employed in the soil-mechanics investigation was the same as that which had been successful at Twyford. A geological cross-section was determined at the worst part of the slip. Hand borings were used for holes up to 21 ft. in depth and the two holes 41 ft. and 32 ft. deep were put down with a mechanical-boring rig. The findings of this investigation are shown in Fig. 8, on the next page, which gives the positions of the boreholes as well as the shear strengths of the clay samples. About 32 per cent. of the undisturbed samples were tested in a triaxial-compression machine and the rest by the simple compression test.

The cutting was 54 ft. deep at this point and the sides battered to 1 : 2. The horizontal strata were, for all practical purposes, identical with those at Twyford except for variations in depths. An unusual feature was the presence of a curved sand layer in the position shown in the cross-section; considerable care was taken to verify this unusual configuration, three boreholes being put down within 11 ft. of each other, and the investigation consequently took longer than had been expected. A slip had occurred some 50 years previously of which there is now little record, and the remedial measures then taken consisted of removing a large quantity of clay to the depth shown in Fig. 8 and replacing this by ashes. The type of slip is not known but the remedy adopted was successful, since no movement was noted until the beginning of 1952.

The cutting ran across the natural land drainage towards the Thames and the gravel stratum was saturated with water which flowed down the cutting in large quantities. The water levels observed in the boreholes after leaving them for 48 hours showed that a hydraulic gradient existed between the curved and the horizontal strata. This suggested that there was an outlet for the water through the horizontal layers, possibly via the boreholes, and this implied that the water level observed in the horizontal sand layer was the maximum under existing conditions. The track drainage was in good order, a steady flow being maintained in the direction of Reading; the ballast was dry and very little water was found at the junction between the ballast and the formation.

The cutting at Sonning is a good example of the use of vegetation to stabilise a clay bank; various trees, up to 2 ft. in girth and 40 ft. high, grow throughout the cutting. The slip having once started, however, it was felt that the important thing was to lessen the adverse effect of the wind forces on the slipping mass. The trees in the area were, therefore, cut down to about 15 ft., care being taken that they were not killed in the process. It was recognised that these trees performed a useful function in that their roots reinforced the clay bank. Indeed, it was felt that the movement only reached its maximum rate when the tree roots had been broken, and that without this action the slip might have reached the limit of its movement before the remedial measures could be applied.

It has been suggested that the curved stratum may be the trace of the bank of an old river, and a sharp bend in the river bed might have caused sand to be deposited on its bank in this fashion. Two facts, however, conflict with this suggestion. First, the clay on either side of the layer has similar characteristics, indicating that the clay was deposited on top of the horizontal sand lens and that the curved layer is a later phenomenon. Secondly, the presence of the horizontal layer vertically beneath the curved one is hard to explain by this suggestion.

The position of the curved layer does resemble the slip line of a type of failure similar to that observed at Twyford, and it is possible that the slip which occurred 50 years ago was of this type. The remedial measures could have been effective because they reduced the hydrostatic head by allowing the water to reach the track drainage. This is supported by the fact that the maximum level of water in the sand lens is coincident with the level of the centre cess drain. The slip having once occurred and a drainage channel having been opened, the water passing through the slip plane could have carried sand with it and deposited it to form the stratum. The arguments against this theory are that the sand appears to be a natural deposit and it also resembles closely the sand of the horizontal layer. This last point implies that the sand was deposited by water moving upwards through the slip plane, but this is a very unlikely supposition. The presence of sand in the slip plane is an unusual feature and has yet to be explained adequately.

It is not difficult to explain the slip; the low strength of the sand under hydrostatic head gives a factor of safety of unity for a slip circle with its centre as shown in Fig. 8. The slip was assumed to be circular from ground level on the bank to a point vertically beneath the centre of the slip circle. As can be seen in Fig. 8, this is a close approximation. The stability of the segmental mass depended on the following forces: (1) the out-of-balance moment of the mass; (2) the active resistance of the ballast (this value was taken since the ballast was probably disturbed during the course of maintenance); (3) the passive resistance of the clay between the sand layer and the ballast; and (4) the resistance of the sand layer due to its shear strength. These were the forces that were acting at the time of the first slipping. It was not until the subgrade was disturbed by the slip that its strength was sufficiently reduced to carry the slip circle through it. At a later stage, the slip undoubtedly changed its character, as was shown by the change in the movement of the down road. The path of the slip circle through the subgrade is shown by the dotted line in Fig. 8.

All the forces can be considered in terms of their moments about the centre of the slip circle, and have all been calculated for a strip a foot wide; the results are given below:—

(1) The out-of-balance moment, M_b (assuming the unit weight of the clay to be 136 lb. per cubic foot) = 4,973,000 lb.-ft.

(2) The passive resistance of the clay subgrade is given by the formula

$$P_1 = \frac{H}{2}\left[\gamma H \tan^2\left(45 + \frac{\phi}{2}\right) + 4c \tan\left(45 + \frac{\phi}{2}\right)\right].$$

P_1 (acting at 53 ft. from the centre of the slip circle) = 50,450 lb.

$P_2 = W h H$ = (acting at 52 ft. from the centre of the slip circle) 2,880 lb. M_p (the stabilising moment of the passive earth pressure) = 2,820,000 lb.-ft.

(3) As was found in the calculations for the Twyford slip, on page 457, *ante*, the active earth pressure was negligible.

(4) To give a factor of safety of unity, the moment of the shear strength of the sand layer about the slip circle, M_s, is given by

$M_s = M_b - M_p$, thus M_s = 2,153,000 lb.-ft.

EMBANKMENT SLIP IN RAILWAY CUTTING.

Fig. 6. Slip at Sonning Cutting.

Fig. 7.

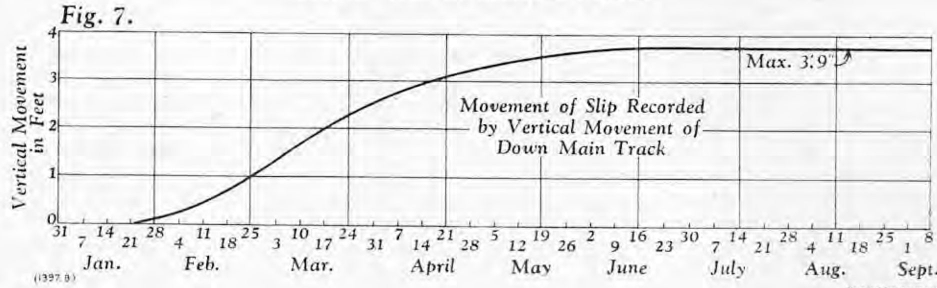
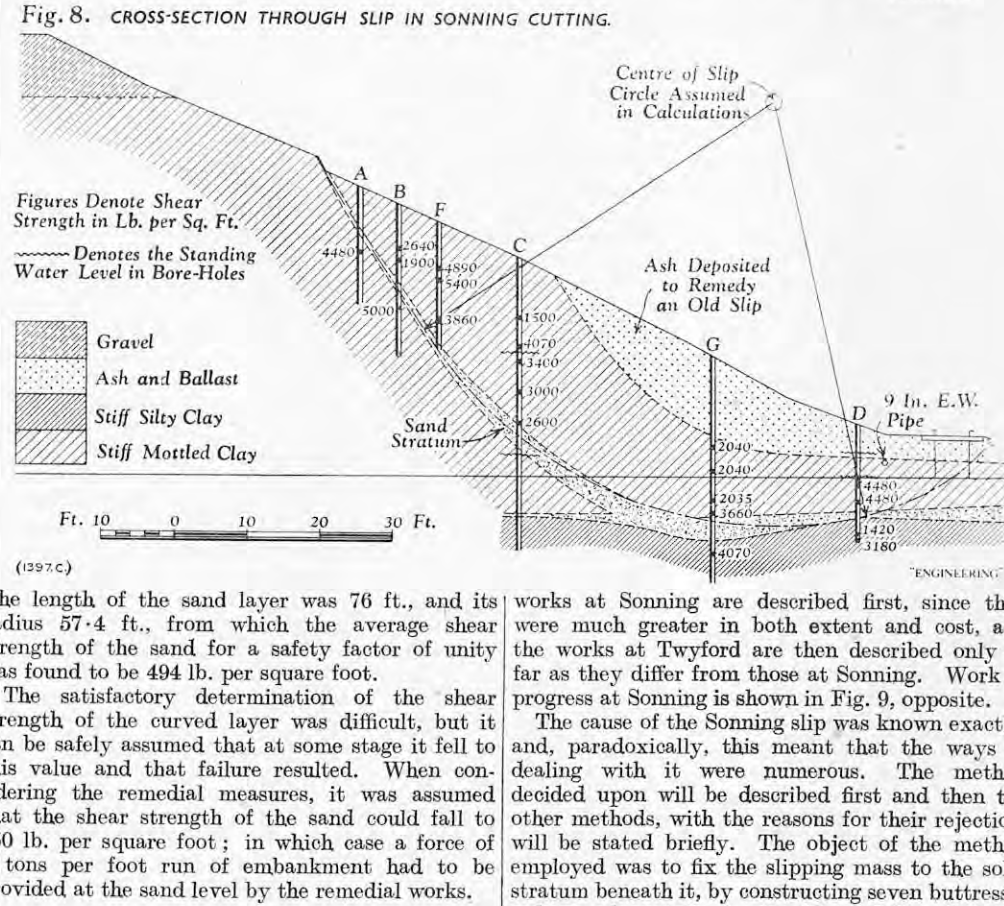


Fig. 8. Cross-section through Slip in Sonning Cutting.



The length of the sand layer was 76 ft., and its radius 57·4 ft., from which the average shear strength of the sand for a safety factor of unity was found to be 494 lb. per square foot.

The satisfactory determination of the shear strength of the curved layer was difficult, but it can be safely assumed that at some stage it fell to this value and that failure resulted. When considering the remedial measures, it was assumed that the shear strength of the sand could fall to 350 lb. per square foot; in which case a force of 5 tons per foot run of embankment had to be provided at the sand level by the remedial works.

Remedial Measures.

In repairing the slips both at Twyford and at Sonning, the same principle was applied. The works at Sonning are described first, since they were much greater in both extent and cost, and the works at Twyford are then described only so far as they differ from those at Sonning. Work in progress at Sonning is shown in Fig. 9, opposite.

The cause of the Sonning slip was known exactly, and, paradoxically, this meant that the ways of dealing with it were numerous. The method decided upon will be described first and then the other methods, with the reasons for their rejection, will be stated briefly. The object of the method employed was to fix the slipping mass to the solid stratum beneath it, by constructing seven buttresses or keys, adequate in size to withstand the calculated forces acting on the moving bank.

These buttresses were made by excavating holes 12 ft. by 7 ft. in plan, in a pattern as shown in

EMBANKMENT SLIP IN RAILWAY CUTTING.

Fig. 9. Remedial Work at Sonning.

Fig. 10. SLIP REPAIRS IN SONNING CUTTING.

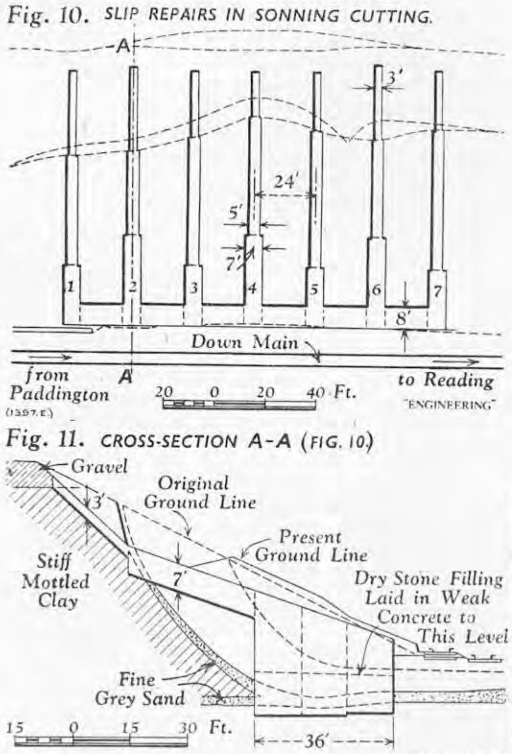


Fig. 11. CROSS-SECTION A-A (FIG. 10)

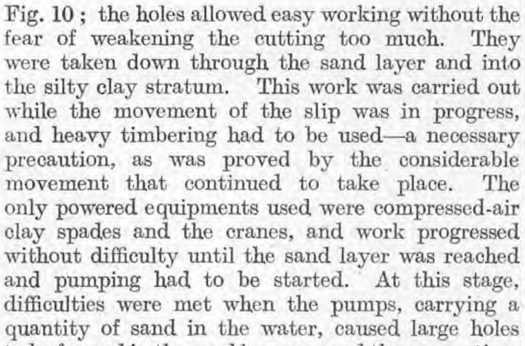


Fig. 12.

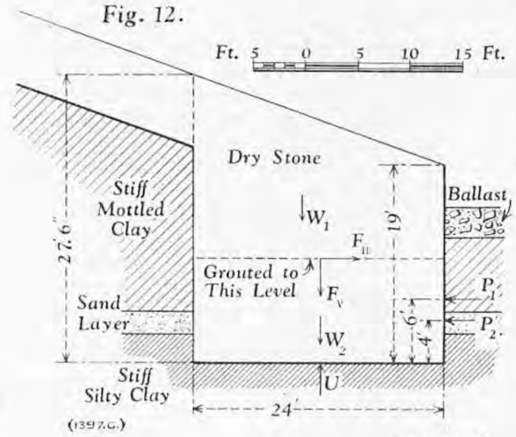


Fig. 10; the holes allowed easy working without the fear of weakening the cutting too much. They were taken down through the sand layer and into the silty clay stratum. This work was carried out while the movement of the slip was in progress, and heavy timbering had to be used—a necessary precaution, as was proved by the considerable movement that continued to take place. The only powered equipments used were compressed-air clay spades and the cranes, and work progressed without difficulty until the sand layer was reached and pumping had to be started. At this stage, difficulties were met when the pumps, carrying a quantity of sand in the water, caused large holes to be formed in the sand layer around the excavation. The timbering was taken successfully into the silty clay layer, however, and the flow of sand nearly eliminated. These holes were filled in when the stone backfill was placed. The stone backfill was set in a 1 : 12 concrete, except in the first two holes to be completed. No concrete was used in these; a 12-in. earthenware pipe was placed vertically in the middle of each to be used as sumps from which the general water level could be kept down, thereby increasing the strength of the sand layer. Gas pipes $1\frac{1}{2}$ in. in diameter were also put in position, so that grouting of the stone could be carried out at a later date.

It will be seen from Fig. 11, herewith, that three successive holes, 12 ft. by 7 ft., were constructed, one behind the other, to form the buttresses, the maximum and minimum depths of excavation being 39 ft. and 21 ft. After the first of the buttresses had been constructed, a noticeable decrease in the rate of movement of the track was apparent. However, the slope of the cutting began to belly out, as can be seen by reference to the cross-sections in Figs. 8 and 11, which show the profiles on February 12 and June 26, 1952, respectively.

In order to facilitate the construction of the second buttress, the timbering on the high side of the first had to be left in place. When these were exposed by the new excavation it was found that they had shifted from a vertical position to such an extent that, in a height of 26 ft., they were 2 ft. 10 in. out of plumb. These developments, which were welcomed in view of the minimising of the threat to the running lines, illustrated that a secondary slip was occurring above the level of the tracks. This state of affairs had been predicted by the calculations, which showed that the most likely type of failure to which the buttresses were subject was overturning. In order to transfer the thrust from the slipping mass on to the buttresses, counterforts 7 ft. deep will be constructed in the bank. These will also serve as drains. The water which collects in the gravel stratum will be tapped by shallow drains connected to the counterforts, and it is intended in this way to prevent surface water running into the exposed top of the sand layer. In addition, the sand layer will be covered with clay and punned down.

The track drainage is to be reinstated where the old earthenware pipes have been broken by the slip. The water will be collected at the top of the grouted part of the buttresses and then transferred into the centre-cess drain, which is about 6 ft. 6 in. below rail level. The new slope will be battered to 1 : 3 over the slipping area, and 1 : $1\frac{1}{2}$ over the unaffected part. This in itself reduces the out-of-balance force by 23 per cent. and will add to the stability of the completed work. The out-of-balance moment equalled 3,819,000 lb.-ft. and this had to be counterbalanced by the moment due to the resistance of the sand layer (assumed strength, 350 lb. per square foot), equal to 1,500,000 lb.-ft. The passive earth pressure has been assumed to reduce the out-of-balance moment between the counterforts only; the pressure on the front of the buttresses has been taken into account when considering their stability. The stabilising moment of passive earth pressure was found to be 2,000,000 lb.-ft., and the unbalanced moment to be withstood by the buttresses, 319,000 lb.-ft.

The criterion for deciding the safety factor was the possible overturning of the concrete portion of the buttress. The forces acting are shown in Fig. 12, herewith, and the calculation given below is for the smaller of the two types of buttress, which was 24 ft. by 7 ft. in plan. The whole of the unbalanced moment was assumed to act through the counterforts and could be resolved into the force F_H and a force F_V which, acting through the centre of the slip circle, had no moment. F_H acted at a perpendicular distance of 51 ft. from the centre of the slip circle and was given by

$$F_H = \frac{319,000}{51 \times 2,240} \times 24 = 67 \text{ tons.}$$

Resolving F_H with F_V and assuming the angle of shearing resistance of the dry stone to be 60 deg., then

$$F_V = F_H \tan\left(\frac{2}{3} \times 60 \text{ deg.}\right) = 36 \text{ tons.}$$

W_1, the weight of the dry stone was found to be 119 tons; W_2, the weight of the concrete part of the buttress, 105 tons; and U, the upthrust on the buttress due to the water surrounding it, 47 tons. The presence of the sand layer was ignored in calculating the values of P_1 and P_2 but they were found in the same way as before.

$$P_1 = 1,890 \text{ lb.} = 0{\cdot}84 \text{ tons.}$$

$$P_2 = 244,300 \text{ lb.} = 105 \text{ tons.}$$

Using the forces given above and the dimensions shown, it was possible to take moments about the toe or heel of the buttress. From this, the reaction on the base was determined and the greatest stress to which it was subjected was found to be 1·4 tons per square foot. The ultimate bearing strength, determined by direct experiment, proved to be 3·5 tons per square foot. The factor of safety for the smaller type of buttress was, therefore, 2·8. The factor of safety for the larger type of buttress was calculated in the same way and found to be 3·1. Thus, the overall safety factor lies somewhere between these values, which are considered to be satisfactory limits.

When remedial measures were first called for, the overriding factor to be considered was the speed with which the movement of the main line would be arrested. The easiest emergency measure to apply was the construction of the buttresses. The job could be started without plant; timber and hand tools were readily available and so was labour, skilled in this type of work. In the first instance, the construction of buttresses was the obvious course, and excavation was started on March 10. Simultaneously, the design calculations and estimates of cost were made. An alternative scheme involved the construction of a reinforced-concrete retaining wall founded in the stable stratum below the sand layer and extending the length of the slipping area. In this scheme, the thrust was to be transferred from the clay mass to the wall and thence to the stable stratum. The cost, for a similar factor of safety, was about the same as that for the scheme adopted; this solution was not used, however, because the skilled labour required for reinforced-concrete construction was not readily available. A satisfactory factor of safety could also have been obtained by compounding the existing slope of 1 : 2 to obtain 1 : 4 over the slip and 1 : 1½ above it. This would have the effect of moving the edge of the slope back by as much at 8 ft. (this would not have involved any movement of the boundary fence). For this scheme, it was intended to make use of a mechanical excavator operating from the stable portion above the slope, but this idea was regretfully abandoned (it involved a saving in cost of about 50 per cent.) since it was felt that the safety of traffic might be endangered.

The prime cause of the failure at Twyford, as was described on page 457, *ante*, was the hydrostatic head which had developed in the sand lens. This was reduced to an economic minimum by the use of 6-in. diameter cast-iron pipes, with perforated ends, which were built into the buttresses, the perforations being at the level of the sand lens. The pipes terminated slightly above the level of the drain in the centre cess, that is, 12 ft. above the sand lens. The buttresses were then connected by earthenware pipes to the centre-cess drain and the hydrostatic head was thus limited to 12 ft. A slip plane having formed, and the effective strength of the clay being very greatly reduced, it was also necessary to provide another stabilising factor, such as a series of buttresses and counterforts similar to those constructed at Sonning. The original slope was not so great as at Sonning and consequently the remedial measures were not so extensive. The buttresses, constructed in dry stone, measured 24 ft. by 7 ft. and were spaced at 21-ft. centres, and the counterforts were made to drain the gravel layer directly.

The works described in the article were the responsibility of Mr. M. G. R. Smith, M.I.C.E., civil engineer to the Western Region (British Railways), assisted by Mr. P. Proto, development assistant, and Mr. D. L. Bartlett. Mr. John B. Slee, B.Sc. (Eng.), also assisted and prepared the material for publication.

SWINDEN LABORATORIES OF THE UNITED STEEL COMPANIES, ROTHERHAM.—An illustrated publication which deals with the new central research and development department of the United Steel Companies, Ltd., namely, the Swinden Laboratories, Moorgate, Rotherham, has just been published by the central office at 17, Westbourne-road, Sheffield, 10. It describes the activities carried on at the Laboratories and their equipment and methods. The materials and services dealt with in the Laboratories, such as minerals, refractories, fuels and furnaces, iron- and steel-making plant, the forming of metals, and metallurgical, chemical and physical research are treated in separate sections, and the publication closes with a brief description of the library and information and other special sections, plans of the various Laboratories and shops, and other data.

THE NAVY'S LAST "SWORDFISH" AIRCRAFT.—The last of the Swordfish aircraft that were employed in almost every phase of Naval air warfare, from 1939 to 1945, has been transferred to the Royal Naval Air Station at Lee-on-Solent from a Ministry of Supply establishment at Gosport, where it has been used for torpedo-dropping trials. At Lee-on-Solent, it will be used in flying displays. The Swordfish, designed by the Fairey Aviation Co. Ltd., Hayes, Middlesex, as a torpedo-spotter-reconnaissance carrier-borne aircraft, flew for the first time in 1935. Throughout the War, Swordfish aircraft were used as dive-bombers, strike and anti-submarine aircraft in the Battle of the Atlantic and in protecting Russian convoys. Among many notable actions in which Swordfish aircraft took part may be mentioned the raid on the Italian fleet at Taranto, which changed the course of the war at sea, and the crippling attack on the German battleship Bismarck which seriously reduced her speed before her ultimate destruction.

CONSTRUCTION OF ADEN OIL REFINERY.

CONSTRUCTION work has recently begun on the new oil refinery which is being built at Aden for the Anglo-Iranian Oil Company, Limited, Britannic House, London, E.C.2. The project, which is expected to take two years to complete, and which will cost between 40,000,000*l*. and 50,000,000*l*., will be able to handle initially five million tons of crude oil a year. Aden is on the direct route from the A.I.O.C.'s Persian Gulf sources of supply to the African and Red Sea markets, and, furthermore, it is expected that a considerable part of the refinery's output will be absorbed directly by the Aden bunkering trade, thus resulting in an economy in tanker transport, since this amount of fuel would not then require re-shipment. The proposed site for the refinery—the topography of the area can be seen in the illustrations in Figs. 1 to 4, on page 496—is at Little Aden, on the western side of the Bandar Tawayih, to the south of the entrance to the Khor bir Ahmed, approximately seven miles by water from Aden town and twenty-eight miles by road. Sufficient good building land is available, fresh water is obtainable at an economic distance, a sea-channel approach is to be dredged and jetties are to be built that will accommodate the largest tankers now afloat. The company's existing bunkering installations at Aden are to be supplied by a short pipeline round the bay.

Two hundred and seventy acres will be taken over for the refinery and tank farms. The major plant will comprise two atmospheric-distillation units, complete with stabilisers and soda washers, one platforming unit and one sulphur-dioxide extraction unit. The installed capacity of the power station will be 30,000 kW and that of the boiler battery, 600,000 lb. of steam per hour. The cooling water will be obtained from the sea and will be returned through the most modern type of oil-water separators, thus ensuring the minimum loss of oil to the sea. The principal contractor for the construction of the refinery is the Middle East Bechtel Corporation, who will be assisted by a number of specialist sub-contractors. Already, orders for material and equipment worth more than 6,500,000*l*. have been placed by the contractors, of which about 80 per cent. is with British industries. Approximately 100,000 tons of steel will be required for the erection of the refinery plants and the storage tanks and over 1,500,000 ft. of pipeline, varying in diameter from ½ in. to 5 ft., will be laid. In the multiple conductor cables carrying power, light and telephone communications throughout the refinery area, there will be a total of about 2,500 miles of single-strand wire. The early work of installing a concrete-batching plant at the refinery site is shown in Fig. 3.

The contract for the construction of the harbour has been let to George Wimpey and Company, Limited, Hammersmith-grove, London, W.6, and the main works involved are the building of a breakwater and bund and the construction of three oil jetties and one cargo jetty. Also involved in the new harbour works is the dredging of the harbour area itself and the sea approaches to a depth of 40 ft. at low tides; this work is being undertaken by K. L. Kalis, Sons and Company, Limited, Stone House, Bishopsgate, London, E.C.4, who are working in association with the Dredging and Construction Company, Limited, 9, New Conduit-street, King's Lynn. The total length of the breakwater will be 3,700 ft., and that of the bund 9,000 ft., both being constructed of rock tipped directly into the sea from heavy dumper trucks. At the sea end, the breakwater has a greatest depth of 28 ft. and one and a quarter million cubic yards of rock will have to be excavated from the three quarries that have been opened up to provide the material. Work in hand at one of the quarries is shown in Fig. 2. The flanks of the breakwater are to be armoured by a double skin of stone blocks of which the inner skin will be composed of blocks weighing between 2 and 5 tons, and the outer skin of blocks of between 5 and 8 tons. Large crawler cranes working their way along the core of the breakwater will be used to place these blocks in position. The bund will be more lightly armoured by a single skin similar to the inner skin of the breakwater. All the landward sides of the banks will be sealed with layers of crusher-run material to prevent the dredged material from percolating through. A concrete wave wall will be built along the crest of the breakwater after the stone work has been completed.

The oil jetties comprise one two-berth finger jetty and two one-berth T-headed jetties that will be able to accommodate the largest tankers afloat. For their construction, steel piles 90 ft. long of a modified Larssen box-type section are to be used. Owing to limitation in shipping space, they will be taken overseas in two lengths and welded together on site, where they will be given a second coating of bitumastic paint. Vertical piles will be driven from floating craft and the rakers in the jetty head and the dolphins will be driven from the decks, which will have been constructed by then. The steel deck beams will be bedded on to landing plates welded to the heads of the piles and the connections secured by casting blocks of concrete around the ends of the beams and the clusters of piles heads. The deck will be reinforced-concrete slabs spanning between successive cross-girders. Rubber-mounted fenders are to be installed along the jetties.

It is estimated that about 500 British workmen and staff, together with 100 Italians, 80 Indians, and some 1,200 men from the immediate surroundings, will be employed in the construction of the harbour. For building the refinery, 350 British and American engineers will be required and at the peak of construction more than 10,000 European and local labour will be housed in two camps that are now being built. At present, and until these camps are sufficiently advanced, the British and American personnel are accommodated in the liner Dorsetshire, which is at present lying in Aden harbour, having been chartered for the purpose.

Until the commencement of the project, the Little Aden peninsula was completely undeveloped, save for the small fishing village of some 500 inhabitants shown in Fig. 4, on page 496. Nevertheless, it is the intention of the A.I.O.C., as has been their practice in the past, to avoid creating an exclusively industrial community, consisting solely of the 300 British staff and the 2,000 other employees, skilled and unskilled, who will be required to operate the refinery. The area will be developed as a natural expansion of the existing town of Aden and it is hoped that, eventually, houses will be built by other interests so that the community will become a cross-section of the people of the Colony. The Aden Government will control the orderly development of the area and will take over the public utility services—roads, lighting, water supplies and drainage—in order to operate them as part of the local township authority.

MODEL OF BRITISH ATOMIC PILE AT MILAN TRADE FAIR.—The Ministry of Supply has organised a stand at the Milan Trade Fair, which opened on Sunday, April 12, to demonstrate the value of radioactive isotopes in combating disease, in improving efficiency and production in industry and in many branches of scientific research. The display includes a one-sixth scale model of the larger of the two atomic piles at Harwell (BEPO), which is cut away to show the graphite blocks and uranium rods. The arrangements by which the reactions in the pile are controlled, the uranium rods inserted and the radioactive isotopes produced is also being demonstrated. Over 200 consignments of isotopes were sent to Italy from Harwell during 1952.

BRAKE PRESSURE "WARNING" INDICATOR.—Bosch Limited, Stuttgart, Germany, whose London office is at 45, South Audley-street, London, W.1, have developed a brake-pressure warning indicator for motor lorries. It is a small compressed-air cylinder with a piston which actuates an indicator arm when the pressure in the brake system of the vehicle falls below 56 lb. per square inch. The cylinder can be attached to any part of the windscreen frame, and the indicator arm, which is 14 in. long with a red flash at one end, can be arranged so that it swings out into the centre of the windscreen to give warning of the falling pressure. As soon as the pressure in the system builds up the indicator will return to its normal position. The advantage claimed for this indicator is that the driver can keep his eyes ahead when travelling through heavy traffic and know at the same time that sufficient pressure is held in reserve for braking.

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

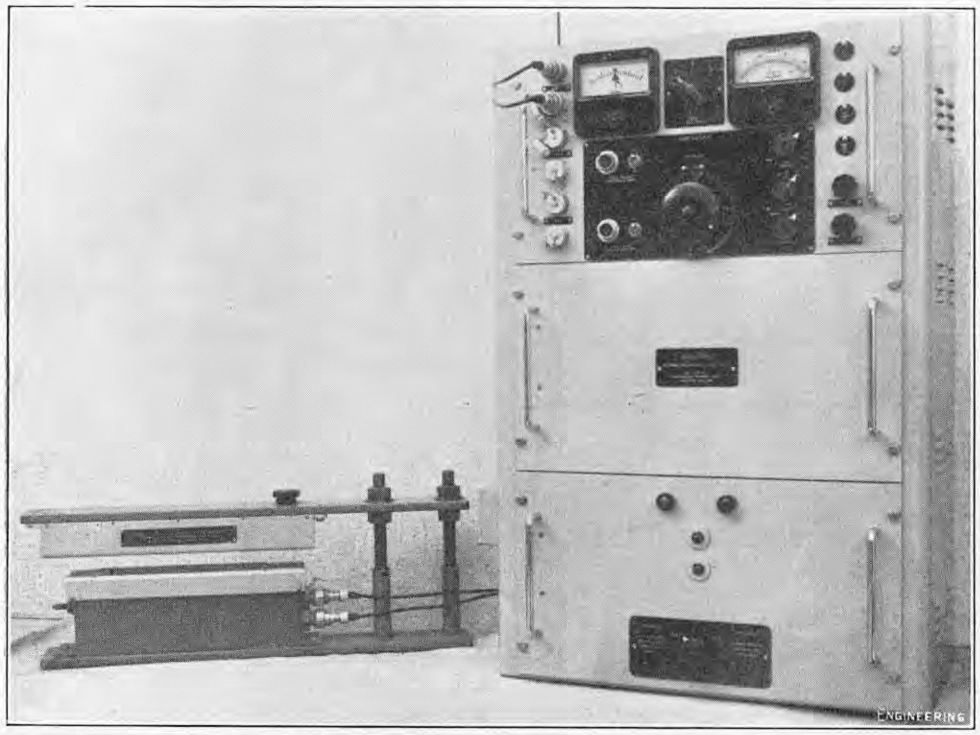


Fig. 1. Radiation Thickness Gauge; Baldwin Instrument Co., Ltd.

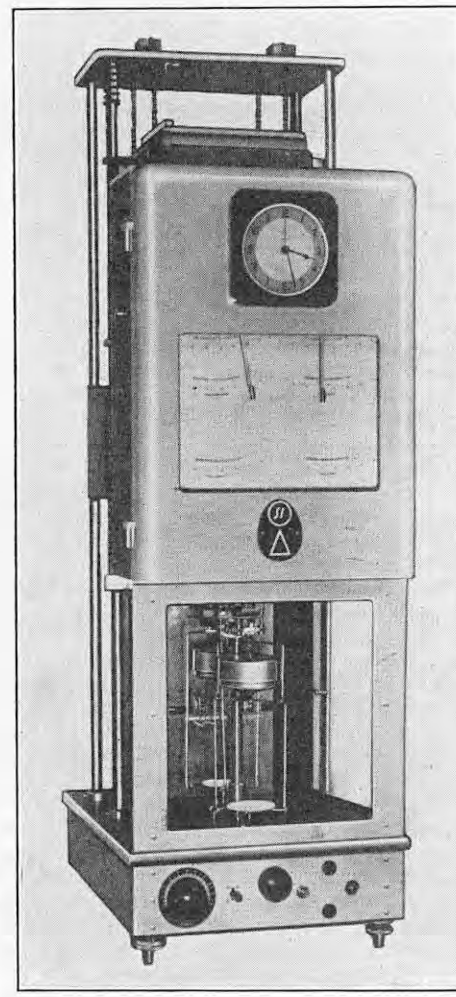


Fig. 2. Recording Thermo-Balance; Stanton Instruments, Ltd.

THE PHYSICAL SOCIETY'S EXHIBITION.

The 37th annual exhibition of scientific instruments and apparatus arranged by the Physical Society was opened by Professor R. Whiddington, F.R.S., at the Imperial College of Science and Technology, Imperial Institute-road, London, S.W.7, on Monday, April 13, and closes to-day, Friday, April 17. On this occasion, a return has been made to the practice of former years of arranging the whole of the exhibition in the main buildings of the college, with the sole exception that the Imperial College computing engine and other similar equipments are on view in the Huxley Building. The circuiting of the Imperial College machine, which was demonstrated unofficially last year, has been improved: and it is now capable of performing all the basic operations of arithmetic on 20-digit binary numbers in about one second. Numerical information can be fed into it from a Hollerith tabulator and the results printed in decimal form on the print unit. The engine differs from most other modern calculating machines in that the numbers and instructions are stored separately.

The official catalogue of the exhibition contains the names of 134 exhibitors, which is rather less than last year. The instruments and apparatus displayed have, generally speaking, been designed to meet a wide range of requirements in both science and engineering, and represent some of the latest achievements in this field. Viewed as a whole, they reflect the ever-increasing importance of the various branches of science, such as radio and electronic engineering, and of the techniques involving the use of X-rays and radioactivity. Other departments of scientific knowledge are, however, well represented. In addition to the apparatus, the entries for the craftsmanship and draughtsmanship competitions are also on view, and the prizes for these competitions were distributed during the early afternoon of the first day.

Turning to the individual exhibits, Fig. 1, on this page, illustrates the "Atomat" radiation thickness or weight gauge, which is being shown by the Baldwin Instrument Company, Limited, Dartford, Kent. The operation of this instrument is based on the principle that β-radiation is stopped by any substance in its path to an extent proportional to the mass of the material. A source of radioactivity—in this case thallium 204—is mounted in a metal holder which is, in turn, housed in a casing with a safety shutter, so that all emission is cut off during transport or handling. In use, radiation is allowed to pass through the material to be gauged and falls on a detector. This detector is mounted in a sealed chamber containing air, which becomes ionised and conducts electricity at a rate proportional to the degree that it is radiated. The ionisation current thus set up is transmitted to the instrument cabinet, illustrated in Fig. 1, where it is amplified and used to operate two indicators, one of which shows the weight of the material per unit area in any desired units, or, when dealing with a material of constant density, the thickness. The other shows the deviation above or below a given thickness or weight.

The instrument cabinet, which is 32 in. high by $21\frac{1}{2}$ in. broad by $10\frac{1}{2}$ in. deep, contains three separate racks: one for the power pack and voltage stabilising transformer, one for the amplifier, and the third for the instruments, controls and switches. These racks are interconnected by plugs and sockets, and can be withdrawn separately for servicing.

Another instrument shown on the same stand is an absorptiometer consisting of eight spectrum filters in a slide, the transmission band-width of which can be reduced and the linear range extended by an interference wedge filter. The vacuum photocell and its associated amplifier, which form part of the apparatus, compensate for the loss in light transmission. The absorptiometer also incorporates a beam splitter. This is mounted on a slide operated by a lever, so that the instrument can be used with a single beam for rapid determinations or with two beams in null balance for more accurate measurement. When using the single beam method the light intensity is adjusted to obtain zero reading on the indicator with blank solution in the beam. On substituting the cell containing the unknown solution, the result is shown on the indicator. When the absorptiometer is used as a null balance instrument with the beam splitter in the light path the calibrated brightness control in the main beam is set to zero, while the uncalibrated brightness control is adjusted so that a zero reading is obtained on the indicator. The cell containing the unknown solution is then substituted and the calibrated brightness control adjusted to restore balance. The beam splitter is placed after the condenser lens and colour filter, so that errors arising from the use of two separate beams, each with its own colour filter, are eliminated.

Stanton Instruments, Limited, 119, Oxford-street, London, W.1, are exhibiting the recording thermo-balance illustrated in Fig. 2. This comprises a main balance of the conventional three-knife-edge type, which is air-damped and capable of carrying a total load of 100 grammes. For "thermo" work, it is surmounted by a bifilar nichrome-wound furnace with an internal bore of 2 in. and a silica lining. The furnace shown is suitable for a temperature of 1,000 deg. C. and, when it is desired to heat the charge in a gas atmosphere, is provided with an inner silica sheath. This sheath has its own low-voltage transformer and is counter-balanced, so that it can be raised or lowered over the charge. Its position above the balance is such that the convection currents are innocuous, while stray radiation is rendered negligible by providing shields between the furnace and the balance. The bifilar winding eliminates field effects when magnetic or conductive materials are being heated.

The object to be tested may be placed on either the lower pan of the balance or on a silica platform in the furnace and mounted on a silica rod which rises from the top of the rear suspension piece. The furnace temperature and change of weight are recorded simultaneously on a twin-pen electronic recorder which is placed above the balance in front of the furnace, as shown in the illustration. Both pans are driven by servo motors and are actuated by a platinum-rhodium-platinum thermo-couple and a capacity-follower plate over the balance beam. This plate accurately follows every movement of the beam without being in mechanical contact with it. Thus, the balance may be arranged for a sensitivity of either 1 or 1/10 milligram with the same proportional accuracy of scale. The instrument once set will record changes in time, temperature and weight for periods up to several days. Three chart speeds are available and, at the lowest speed, the spool holds sufficient paper to last for 20 days.

THE PHYSICAL SOCIETY'S EXHIBITION.

An interesting development in the field of electrical measuring instruments is the high-voltage mains-operated "Megger" insulation tester shown on the stand of Messrs. Evershed and Vignoles, Limited, Acton-lane Works, Chiswick, London, W.4, and illustrated in Fig. 3, on this page. This has been designed to comply with some of the latest developments in insulation testing, which require that the test be continued for periods ranging from a few minutes to half an hour or more. To comply with this condition, the familiar hand-driven generator has been replaced by a static rectifier, which is supplied from the alternating-current mains through a step-up transformer.

To increase its usefulness the instrument has three testing voltages—5,000, 2,500 and 1,000 volts —and two megohm ranges for each voltage, both voltage and megohm ranges being selected by a six-position switch on top of the instrument. The instrument is provided with the double scale, which has been a feature of its predecessors, and both scales are calibrated to read directly on the 5,000-volt range. The outer scale reads from 30 to 100,000 megohms and the inner from zero to 500 megohms. When testing at 2,500 volts or 1,000 volts, the readings on each scale must be divided by two or five, respectively.

The movement is of the same pivoted construction as in the hand-driven instrument, and as it is designed to respond to a current of 1/100 micro-ampere it is clear that special precautions have had to be taken to keep it "free." Another important point is that the effect of mains-voltage variations has been almost completely eliminated, so that the new "Megger" can be used for testing high capacitance circuits. As a high capacitance charged to 5,000 volts would be dangerous, an automatic switch has been fitted which, when the mains supply to the instrument is switched off, disconnects the test terminals from the instrument circuit, short-circuits them and thus discharges the capacitance. As a further precaution, a red pilot lamp on the top of the instruments indicates that the set is alive.

Another new instrument on this stand is the Evershed-Straub de-gassing condenser, which has been designed to remove dissolved gases such as ammonia, carbon dioxide and hydrogen sulphide from steam and thus to provide a gas-free sample which may be tested for conductivity in a Dionic water-purity meter.

On this occasion, the Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1, are showing some of the equipment that they have made during the past few years for special or research applications, including apparatus developed during the war years, which it has not been possible to describe previously for security reasons. These include the apparatus which was used to protect ships against the explosion of German magnetic mines. These mines, it may be recalled, were operated by changes in the earth's vertical magnetic field caused by the passage of a ship. It was found, however, that the consequent disturbance could be reduced by passing a known direct-current through coils wound round the ship in various ways. The measurement of the magnetic effect of the ship was therefore a vital matter, and this was solved by moving it over a search coil on the bottom of the sea, which worked in conjunction with a suspended fluxmeter of the Grassot type. To obtain a complete picture of the underwater magnetic field of the ship a number of coils were laid in a line on the sea bed and records were taken by an equal number of fluxmeters. A typical control box designed for this purpose is illustrated in Fig. 4, on Plate X, and is on view, although it has only been possible to show three fluxmeters.

Another instrument on the same stand is the universal measuring machine, which we illustrate in Fig. 5, Plate X. This has been designed to measure objects, diagrams and either opaque or translucent photographs in rectangular co-ordinates. It is also suitable for checking reseau, the dividing of scales and the pitch of micrometer screws. The object to be measured is carried on or between plates of clear glass, which are mounted on a table with a transverse movement. The viewing microscope is mounted on a second carriage which can be moved longitudinally. The transverse carriage is provided with an illuminated Nilex steel scale,

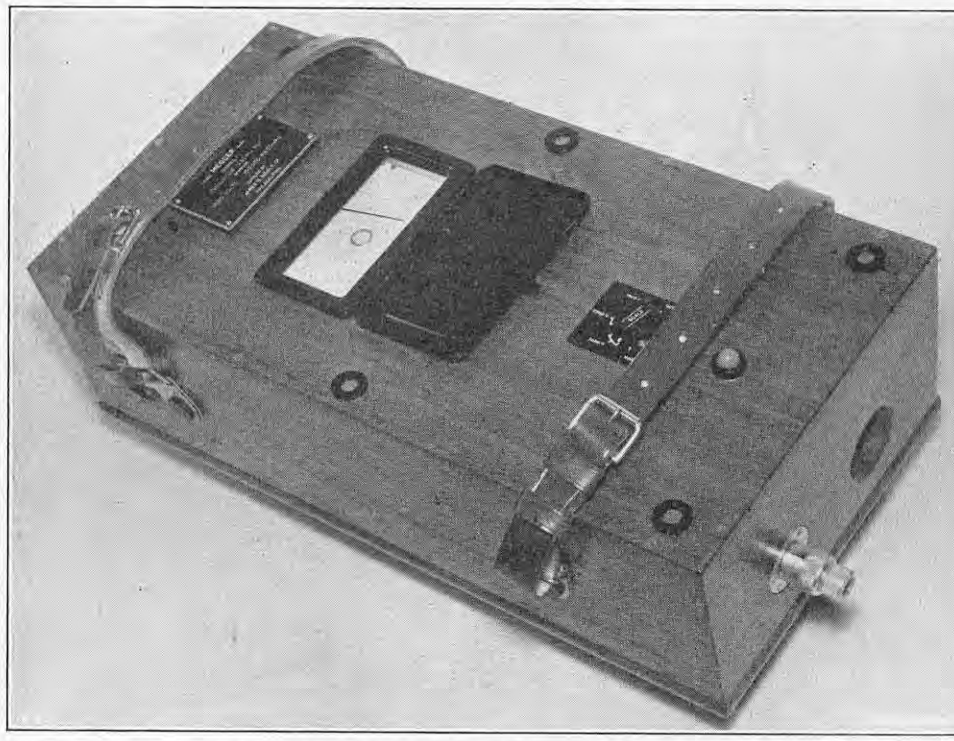


Fig. 3. High-Voltage Mains-Operated "Megger"; Evershed and Vignoles, Ltd.

which moves below a reading microscope on the main frame. There is a second reading microscope in addition to the viewing microscope mounted on the longitudinal carriage. This second reading microscope is focused on a second Nilex scale on the frame. The positions of both reading microscopes can be adjusted by micrometers and thus the two co-ordinates of any point of an object can be established.

Both the transverse and longitudinal carriages are moved by hand along their guides to an approximate position and then by slow-motion heads, which operate fine-pitched screws over a range of 20 mm. Both carriages are mounted geometrically on ground rustless-steel tubes, their weight being sufficient to keep them in position without any form of restraint. The base casting carries an opal glass plate that may be tilted to act as a suitable reflector when working on translucent records. A film-rolling device for 35-mm. film, enabling a long length of film to be explored without cutting, can be fitted.

The principal exhibits on the stand of Messrs. Muirhead and Company, Limited, Beckenham, Kent, are an 18-in. chart transmitter and a recorder which together provide a complete system for the dissemination of meteorological information in the form of weather charts by radio or landline. The transmitter, which is illustrated in Fig. 6, Plate X, is designed so that an 18-in. by 22-in. weather chart can be wrapped round its drum. This drum, which is 6 in. in diameter and 22 in. long, is then rotated at a speed of $\frac{1}{2}$, 1 or 2 revolutions per second by a synchronous hysteresis motor, which is supplied with current at 1,000 cycles per second from a valve-maintained tuning fork through a 20-volt-ampere amplifier. At the same time, a spot of light traverses the surface of the drum in a direction parallel to its spindle at the rate of $\frac{1}{96}$ in. per revolution of the drum. Thus, the chart is scanned in the form of a helix. The image of the illuminated portion of the chart falls on a photo-multiplier cell which transmits a current proportional to the illumination. This current is amplified and converted to either an amplitude-modulated signal or to a frequency-modulated sub-carrier signal. A phasing signal is transmitted to start the recorder in the correct relative position and a loud speaker is used for monitoring purposes. The instrument, which is self-contained, is designed to stand on a bench or table. The main operating controls are arranged on two panels, one at either end of the drum. The left-hand panel carries switches for starting and stopping the driving mechanism and for changing the speed of transmission, while on the right-hand panel are the setting-up controls and a key for selecting calling amplitude modulation or frequency-modulated sub-carrier transmission. Other controls are mounted on the front and rear of the instrument. An important feature is that charts with coloured contour lines can be transmitted.

The recorder, with which the transmitter is associated, is illustrated in Fig. 7, Plate X. It continuously records the received signals on a roll of Mufax electro-sensitive paper 18 in. wide, which is contained in an airtight compartment at the front of the machine and is drawn at a constant speed between a stainless-steel writing edge and a rotating helix. This helix and the paper-feed rollers are both driven by a 1,000-cycle hysteresis motor, which is supplied from a high-stability valve-maintained tuning fork and power amplifier. Current is passed through the paper at the point of contact and a stain is produced by chemical action. The density of this stain depends on the strength of the current which is, in turn, controlled by the received signal. The rotation of the helix and the movement of the paper together cause the point of contact to traverse the paper in a series of horizontal lines, a mark being made whenever the current passes, so that the chart is gradually built up. The paper advances at 96 lines per inch and each line takes one second to trace at normal speed.

The recorder can be used on either a telephone line or a radio link. In the first case, it is designed to operate from an amplitude-modulated signal and in the second from a frequency-modulated sub-carrier transmission or a carrier-shift transmission. The main controls are grouped on two panels on the front of the recorder and comprise a level meter, setting-up controls and a switch for selecting the method of reception as well as a speed-change key and start and stop buttons. Other controls include a picture-shift button, which is used for centralising the record if the phasing signal has been missed; a paper run-off button which is used to remove the first few inches of dry paper when the machine has been idle for some time; and a switch which enables the machine to be started from either a black or white phasing signal or to receive a transmission with a black/white ratio of either 12 or 15 decibels. In addition, preset controls are provided to control the fork frequency and motor input voltage.

(*To be continued.*)

(To face page 492.)

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

(For Description, see Page 491.)

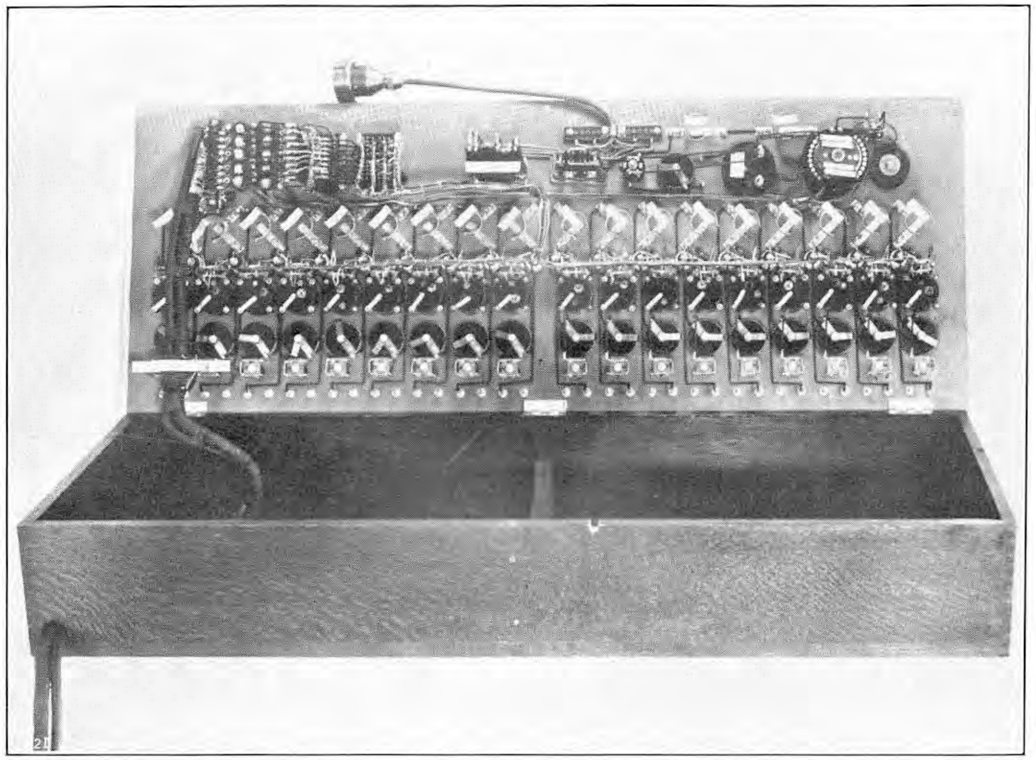


FIG. 4. CONTROL BOX FOR DEGAUSSING FLUXMETERS; CAMBRIDGE INSTRUMENT CO., LTD.

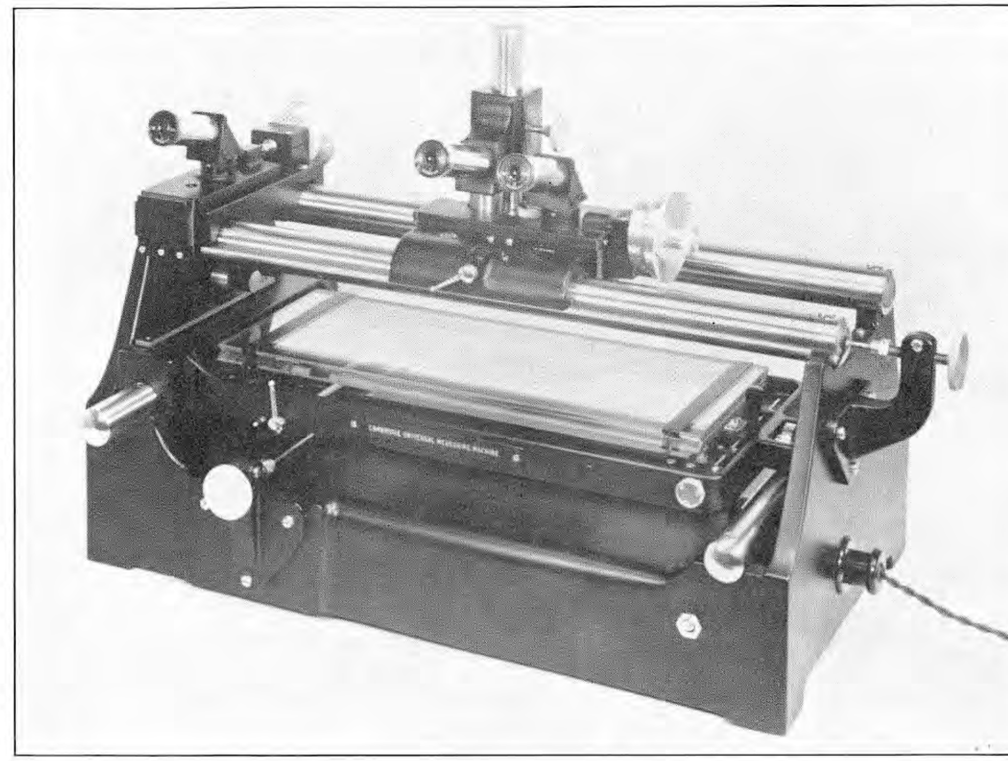


FIG. 5. UNIVERSAL MEASURING MACHINE; CAMBRIDGE INSTRUMENT CO., LTD.

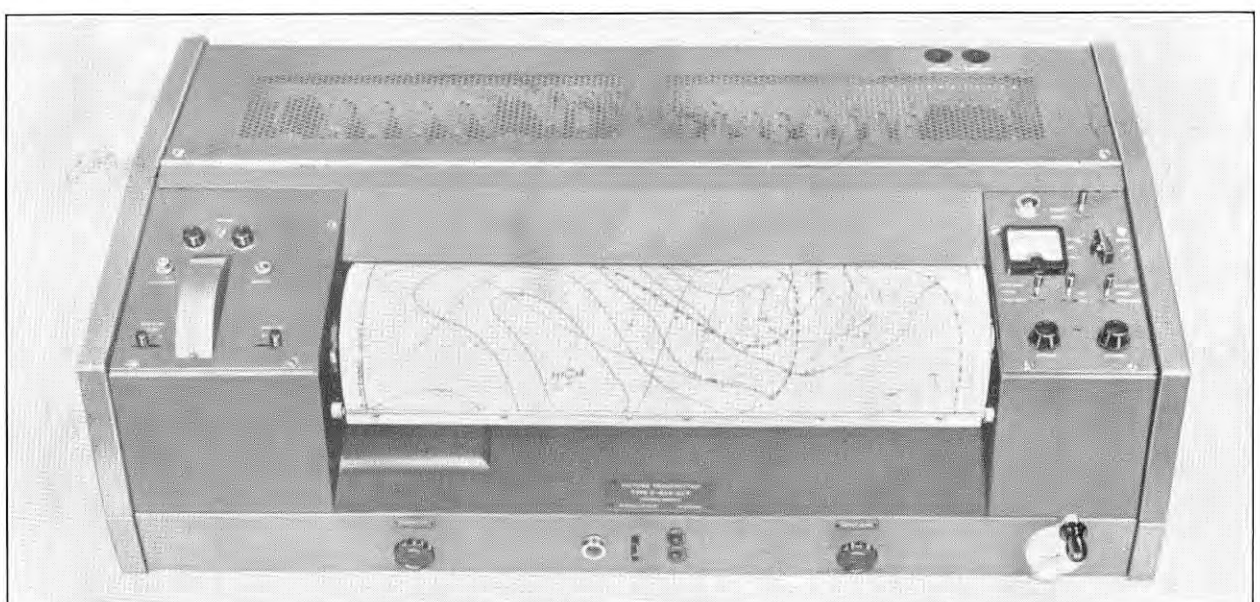


FIG. 6. "MUFAX" CHART TRANSMITTER: MUIRHEAD AND CO., LTD.

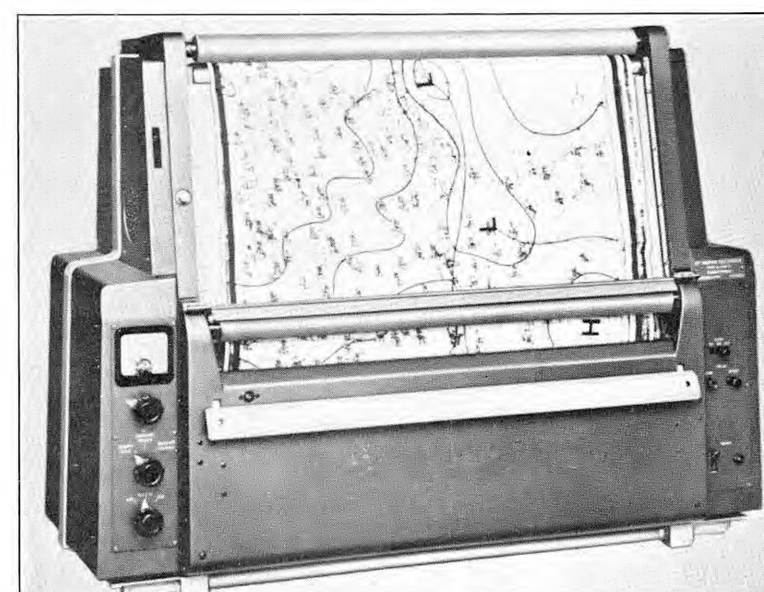


FIG. 7. "MUFAX" CHART RECORDER; MUIRHEAD AND CO., LTD.

STEAM TUG "HORUS" FOR SUEZ CANAL.

JOHN I. THORNYCROFT & CO., LTD., SOUTHAMPTON.

STEAM TUG "HORUS" FOR SUEZ CANAL.

THE single-screw steam tug Horus, shown in the accompanying illustration, is able to develop a maximum static pull of 15·5 tons at normal full power. She has been built to the order of the Compagnie Universelle du Canal Maritime de Suez for abreast towing of barges along the canal and has been designed and constructed by John I. Thornycroft and Company, Limited, at their Woolston Works, Southampton. The leading dimensions of the vessel are: overall length, 138 ft.; moulded breadth, 26 ft.; and maximum draught, 13 ft. 6 in. During recent trials, the Horus attained a mean speed of 12·34 knots.

The vessel is propelled by a triple-expansion surface-condensing engine of the open type rated at 1,150 indicated horse-power, the condenser being capable of maintaining a vacuum of 25 in. under a prevailing canal temperature of 85 deg. F. Steam for the engine is supplied at 200 lb. per square inch from an oil-fired boiler fitted with a type of oil-burning equipment that has been developed recently by Thornycrofts. Economic working is made possible by the installation of an electrically-driven forced-draught fan and heating unit. The oil-fuel pumping and heating unit is of the duplex type with vertical pumps that are steam operated. Before being passed into the boiler, the feed water is filtered and pre-heated by the exhaust steam.

Twin steam turbo-generators, each developing 120 kW, are fitted in a separate compartment located aft of the main engine room. The turbines have been supplied by Belliss and Morcom and Company, Limited, Birmingham, and the generators by Campbell and Isherwood and Company, Limited, Liverpool. A Diesel-driven generating set, developing 5 kW for harbour use, has been installed in the same compartment.

Particular attention has been paid to the equipment that has been fitted to overcome the hot, damp climate of Egypt. All accommodation spaces and the engine room are mechanically ventilated by an electrically-driven fan mounted on the main deck. Living accommodation, in one, two and three-berth cabins for the crew of eleven, has been built below deck and forward of the engine room, together with a lobby and galley. The galley is fitted with an oil-burning cooking range, domestic refrigeration and other storage space, while a cooled drinking-water fountain is fitted in the lobby. Portable canvas awnings are available for both the forward and aft deck spaces and a permanent wooden awning has been built over the navigating bridge.

As can be seen in the illustration, solid bulwarks have been erected both fore and aft, but for some 65 ft. of the length only posts and rails have been employed, to facilitate the handling of barges. Both the bulwarks and rails have been set in from the side of the vessel so that the deck-space that is outside the rails, together with the 10-in. wide fender set flush with the deck, form a walkway round the hull for the easier management of tow lines. In addition to the upper fender, a second fender of similar size has been added just above the water-line and extends for about three-quarters of the length of the vessel amidships. Vertical fenders, at about 4-ft. centres and between the upper and lower longitudinals, give added protection to the hull. A hold, which is served by a derrick pole slung from the mainmast, will be used for the transport of stores and small general cargo. Auxiliary equipment includes a searchlight on the roof of the wheelhouse, controlled from within, and a 4-in. monitor for firefighting.

THE DORMAN LONG CLEVELAND AND LACKENBY WORKS.

A COMMENCEMENT has been made on the third stage of the post-war development plan of Dorman, Long and Company, Limited, Middlesbrough. This stage, which has been formally approved by the Iron and Steel Corporation of Great Britain, is much more extensive than the two preceding stages and involves a total expenditure of approximately 36,000,000*l*. The first two stages have been referred to in our columns. The first included the construction and equipment of the ore-unloading, ore-preparation and sinter plants at the Cleveland Works of the company, and the second stage, now nearing completion, comprised the erection of the basic open-hearth steelworks at Lackenby, which will have an output of 500,000 tons of steel ingots per annum. It also includes considerable site preparation for the third stage and the provision of services which will be common to both stage two and stage three. The capital expenditure on the first two stages amounts to 14,000,000*l*., the whole of which is to be provided from the company's own resources.

The largest item in the third stage is the installation, at Lackenby, of a universal beam and heavy-section mill having an annual output of 400,000 tons of rolled products. A fifth steel furnace is being added to the Lackenby melting shop to bring the annual output of these new steelworks up to 625,000 tons of ingots. Other items in the third stage are two blast furnaces, each with a hearth diameter of 27 ft. 6 in., and having a joint capacity of 750,000 tons of iron per annum, and a large new coke-oven plant at the Cleveland Works capable of carbonising 1,300,000 tons of coal annually. To process the extra tar and benzole from these coke ovens, the Clarence Works will be enlarged, and the output of refined by-products considerably increased. Also included in the third stage at the Cleveland Works are a new blooming rolling mill, additions to an existing blooming mill and a new medium-section mill, the latter having an annual output of 175,000 tons. A high-capacity rod and bar mill, also having an annual capacity of 175,000 tons, and expanded capacity for wire production and processing will, moreover, be laid down.

The completion of these numerous projects may take up to five years and it is anticipated that when the third stage has been finished the firm's annual production capacity will include 1,481,000 tons of blast-furnace coke, 1,690,000 tons of pig iron, 2,315,000 tons of steel ingots and 1,879,000 tons of rolled steel. In point of fact, the rolled steel produced by the company last year was 1,347,000 tons. It is added that the transfer of employees from Middlesbrough to the modern works in the Cleveland-Lackenby-Redcar area will be gradual. The completion of the present second stage will bring into commission the Lackenby Steelworks, with the consequential closing down of the Britannia Steelworks. Similarly, the rolling of heavy structural sections and of rods and bars at the Britannia Works will continue until the new rolling mills at Lackenby come into operation. In the same way, it is considered that it should be possible to dispense with the old coke-oven battery at the Acklam Works when the new ovens come into operation at Cleveland. Other plants in the Acklam and Britannia Works, however, will continue in operation after the third stage of the development plan is finished. The total number of the company's employees in the iron and steel and related works, on September 30, 1952, was 19,136, and it is anticipated that when the third stage is completed, the number will be increased by 300 or 400 men.

PREVENTION OF STICKING ON FEED ROLLERS.—The Edison Swan Electric Co., Ltd., 21, Bruton-street, London, W.1, have introduced a method for coating rollers and other cylindrical parts with polytetrafluoroethylene, and it is thought that this process will interest food manufacturers and others who use this type of roller. Polytetrafluoroethylene is an organic compound, chemically inert and possessing toughness over a wide range of temperatures. It is claimed that it will withstand the attack of all materials except alkali metals; it can be boiled in alkali hydroxides, hydrofluoric acid, fuming nitric acid or aqua regia, with no change in its weight or properties. It is also resistant to all high boiling solvents and other organic compounds. The material has zero water absorption, high impact strength and form stability. When applied to rollers it is claimed that it prevents sticking and that contamination is practically impossible. It is known as P.T.F.E., and is made in rod, sheet and tape form. At present it is being used in industry for gaskets, joints, and valve seats.

STANDARDISATION OF PERMANENT-WAY TOOLS.—With the object of achieving economy both in initial cost and repairs, British Railways are considering standardising more than one hundred different kinds of hand tools—shovels, hammers, tampers, etc.—now in use by the permanent-way gangs. A total of a quarter of a million such tools are at present in use with wide variations existing between the types of tools used in different parts of the country and standardisation should reduce the spares held in stock.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Engineering Centre to be Closed.—The directors of the Engineering Centre Limited, 351, Sauchiehall-street, Glasgow, C.2, inform us that they have resolved to close the Centre on September 30. They add that certain industries, trade associations and large manufacturers have shown preference for arranging their own exhibition of their products and the tendency is for these organisations to select areas of their own choice for such exhibitions. When these new sectional enterprises become firmly established the directors believe that it would be impossible to carry on the existing Engineering Centre as a permanent exhibition which would be truly representative of the engineering industry as a whole.

Scarcity of Shipbuilding Orders.—Scottish shipbuilding firms are concerned over the scarcity of new orders and of inquiries for new tonnage this year. Since January, contracts have been announced for five shipyards, covering the building of only six vessels, two of which are motor launches of 160 tons displacement. Two inquiries in circulation recently refer to the building of a passenger-cargo vessel of 10,000 tons for the Zim Israel Navigation Company, and a ferry ship for the Canadian Pacific Railway. A contract in the first case is dependent on a financial arrangement which has not yet been completed. Tenders for the Canadian vessel are at present under consideration.

P. and O. Liner to be Broken Up.—The twin-screw P. and O. liner Chitral, of 15,555 tons gross, built in 1925 by Alexander Stephen & Sons, Ltd., Govan, has arrived in the Clyde from London to be broken up by Messrs. Arnott Young & Co., Ltd., Dalmuir.

The M.S. Devonshire.—The Bibby Line motorship Devonshire, of 11,275 tons, which has been engaged on trooping duties for some time, has arrived in the Clyde to undergo an extensive overhaul by her builders, the Fairfield Shipbuilding and Engineering Co., Ltd., Govan.

The Late Mr. John Douglas.—Mr. John Douglas, a director of P. and W. MacLellan, Ltd., Glasgow, died at his home in Kilwinning on April 5. He was connected with the Scottish shipbreaking and scrap-metal trade for more than 50 years. In 1938 he was elected President of the National Federation of Scrap Iron and Steel Merchants. He was also President of the Scottish section of the Federation, and, some years ago, served as President of the Iron, Steel, and Ironmongery Benevolent Association.

CLEVELAND AND THE NORTHERN COUNTIES.

Teesport Deep-Water Quays.—At the monthly meeting of the Tees Conservancy Commission, it was reported that the Minister of Transport, Mr. A. Lennox-Boyd, had promised to let the Commission know by July whether work could be commenced on the new deep-water quays at Teesport. It was possible, it was stated, that a commencement would be made in 1955. In the meantime, dredging and other preliminary work will be carried out by the Commission. The deep-water quays scheme is part of a development programme drawn up some years ago by the Tees Commissioners, but the project had to be deferred on Government instructions for reasons of economy. It has also been announced that Shell-Mex and B.P. Ltd. may begin work this summer on the foundations for their new oil-storage plant at Teesport.

Middlesbrough Dock Improvement Scheme.—The Docks and Inland Waterways Executive, with the approval of the British Transport Commission, are to undertake an improvement scheme at Middlesbrough Dock at an estimated cost of 470,000*l*. To meet the requirements of shipowners and traders, No. 10 Quay—hitherto used exclusively for shipping coal—is to be developed for general cargo working by the provision of two single-storey transit sheds, respectively 385 ft. and 350 ft. long, eight 6-ton and two 10-ton level-luffing electric cranes, and additional rail and road access. The scheme also provides for improved facilities, including a new road, at No. 2 Quay. The commencement of the work is subject to the approval of the Minister of Transport.

Shipbuilding at Wallsend-on-Tyne.—The annual report of Swan, Hunter, and Wigham Richardson Ltd., the Wallsend shipbuilders, states that orders totalling 499,720 gross tons, and sufficient to last three years, are being handled by the firm. Of these, 53 per cent. constitute oil tankers. Mr. J. W. Elliott, the chairman of the company, states that there has been a slowing-down in the flow of orders. This was partly due to the fact that deliveries could only be made a long time ahead, that shipping operation showed reduced earnings and that shipbuilding costs were high.

Sunderland Oil Depot.—A new oil distribution depot erected at South Docks, Sunderland, by the Vacuum Oil Co. Ltd., will be opened on May 7. The first oil to be stored is due in the near future. When in operation, the depot will be able to load a 2,490-gallon road tanker in a quarter of an hour and will have a total capacity of more than a million gallons.

Bristol Aeroplane Company's Factory, Sunderland.—A new factory planned at Sunderland for the Bristol Aeroplane Co., Ltd., is expected to be completed in June next year. Machine tools for the factory have already been delivered at Sunderland, but, pending the completion of the new premises, some of these will be used at the existing works The new factory will have a floor space of about 67,000 sq. ft. and employ 250 people, bringing the firm's payroll in the area to about 1,000.

Weardale Fluorspar Mine.—The United Steel Companies of Sheffield are to reopen a fluorspar mine at Weardale, County Durham. The mine was originally operated as a lead mine, but ceased production in 1860. It is being reopened for the extraction of about 5,000 tons of fluorspar annually.

LANCASHIRE AND SOUTH YORKSHIRE.

From Rearmament to Commercial Work.—The Yorkshire Engine Co., Ltd., report that they have finished their rearmament contracts, and have now turned to peacetime work. Orders for locomotives will keep the works busy for two years. Among them is a contract for seven Diesel-electric and other locomotives for Paraguay.

Foundry Developments.—Millspaugh Ltd., a firm "hived off" from Hadfields Ltd., when the steelworks were nationalised are to convert the former Hadfield forge at their Asling Lane Works into a modern centrifugal bronze foundry capable of producing the largest rollers needed for paper-making plant. At present, Millspaugh carry out their foundry work in part of the Hadfield works. The new foundry, it is stated, will treble the production rate with no additional labour force and will enable night-shift working to be dispensed with.

THE MIDLANDS.

Water Supplies in South Worcestershire.—The Rural District Council of Pershore, Worcestershire, have made considerable progress with a scheme which will supply piped water to 31 parishes in the area. The scheme provides for the construction of pipelines in two stages, one of which will supply 18 parishes, and the other the remaining 13 parishes. The cost is about 210,000*l*. for the first part of the scheme, and 96,000*l*. for the second. In the past, water supplies in the area have been of a very primitive nature. Water in the northern part of the new supply area will be taken from Worcester, while in the southern part it will come partly from Tewkesbury and partly from a new main which is being laid to serve Coventry.

Walsall Technical College.—The Staffordshire County Architect, Mr. A. C. H. Stillman, and his staff, have made a model of the new Staffordshire County and Walsall Technical College, which shows the building as it will be when it is completed. The model is to be placed on exhibition to the public at Walsall. The College is being built in five stages, the first of which, the workshop block, has already been completed, at a cost of 88,000*l*. The next stage will involve the erection of electrical and mechanical engineering laboratories, and an automobile shop, and will cost 126,000*l*. At a later date, an assembly room and further lecture rooms will be added, and extra amenities will be provided.

Old Steam Roller.—An old steam roller, which is intended for preservation in the Museum of Science and Industry, Birmingham, is at present being overhauled at an engineering works at Oldbury, Worcestershire. The roller, which is 61 years old, was the first to be registered in Worcestershire, and it was in regular use in the Midlands until 1950, when a boiler defect caused it to be withdrawn from service. The boiler has now been re-tubed, and the roller has been restored to its original condition. The work of restoration has been undertaken by two Birmingham model makers, Mr. A. J. Kent and Mr. F. H. Tapper, in their spare time. The work is almost complete, and it is intended that the roller shall travel from Oldbury to Birmingham under its own steam.

Gas Alarm Lamp for Collieries.—Mr. J. Tighe, a mine employee in Nottinghamshire, has developed a gas-detector lamp which not only shows a red light, in the normal way, but also rings an alarm bell, if the gas concentration exceeds a certain figure. A prototype lamp has been made and tested at Thoresby Colliery, near Ollerton, and the idea has been submitted to the Ministry of Fuel and Power. It is now under consideration by the Ministry, and it is intended that further tests shall be carried out.

Presentation of Long-Service Awards in Birmingham.—A scheme to recognise long service was inaugurated at the end of last year by James Booth & Co. Ltd., and John Wilkes, Sons and Mapplebeck, Ltd., Birmingham, and the first awards were presented by Dr. Horace W. Clarke, the managing director of both companies, at a dinner held at the company's Kitts Green canteen, Birmingham, on Saturday, March 28.

Medium-Power Stand-By Television Transmitters at Sutton Coldfield.—The British Broadcasting Corporation announce that stand-by transmitters with an output of 5 kW for vision and 2 kW for sound have been installed at the Sutton Coldfield television transmitting station. The transmitters, which were manufactured by Marconi's Wireless Telegraph Co., Ltd., Chelmsford, will work with either the main or reserve systems and will enable the service to be maintained on reduced power in the event of a major breakdown of the main equipment.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Oil Exhibition Designed for Museums.—A scientific and technical oil exhibition designed expressly for visitors to museums is now on view in the City Museum, Bristol, until May 2, prior to touring other provincial museums. Developed by the Shell Petroleum Co., Ltd., the exhibition aims both to attract and to educate. It traces the story of oil from its origin, through exploration, drilling and oil-field development to the different means of transport; and from refining, manufacture and research to the distribution of products to consumers. There are 22 portable display cases containing models, reliefs, dioramas and photographs.

Welsh Industrial Progress.—At the end of a two-day visit to South Wales, Mr. Duncan Sandys, Minister of Supply, stated that Wales was to be congratulated on the progress made in recent years in the diversification of her industry. There was at present hardly any major product which was not made in whole or in part in the Principality and new industries were continuing to start up there. It was most important to encourage this trend, above all in west South Wales, where a special problem had arisen in connection with the modernisation of the tin-plate industry. Tin-plate production was essentially a Welsh industry. Production of tin-plate in South Wales was now running at a rate of nearly a million tons a year. This represented virtually the whole of the tin-plate output of the United Kingdom. In considering the present difficulties in regard to tin-plate. it should always be remembered that the problem had not arisen through any setback in the industry. On the contrary, it was solely the result of the remarkable technical progress which the industry had made in recent years.

Large Order for Tin-Plates.—The Metal Box Co., Ltd., have placed an order for 1,000,000*l*. worth of tin-plates with the Steel Company of Wales and Richard Thomas and Baldwins, Ltd. Making the announcement, Sir Robert Barlow, chairman of the Metal Box Co., Ltd., appealed to other users of Welsh tin-plates to place additional orders to restore normal working at the Welsh works. Recently, because of the accumulation of supplies at old-type hand tin-plate works, a dozen or so of these plants in the area bounded by Lydney and Llanelly were closed for a month.

South-Wales Ports Traffic.—Trade at the South Wales ports of Cardiff, Newport, Swansea, Barry, Port Talbot, Penarth and Briton Ferry, during the period from January 1 to March 22 this year, totalled 4,943,642 tons compared with 5,060,099 tons for the corresponding period of 1952. Shipments of coal abroad rose from 745,986 tons to 854,173 tons and those of tin-plate from 58,854 tons to 63,845 tons. Activity in the steel industry was reflected in an increase of almost 100,000 tons to 503,486 tons in imports of iron ore.

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.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Education Discussion Circle:* Monday, April 20, 6 p.m., Victoria-embankment, W.C.2. Discussion on "Laboratory Experiments on Protective Gear," opened by Mr. H. P. Young. *North-Eastern Centre:* Tuesday, April 21, 7 p.m., City Hall, Newcastle-upon-Tyne. Faraday Lecture on "Light from the Dark Ages, or the Evolution of Electricity Supply," by Mr. A. R. Cooper. *North Midland Centre:* Tuesday, April 21, 7.15 p.m., Offices of the Yorkshire Electricity Board, Ferensway, Hull. "The Economics of Low-Voltage Electricity Supplies to New Housing Estates," by Mr. F. G. Copland. *South Midland Centre:* Tuesday, April 21, 7.15 p.m., Winter Gardens Restaurant, Great Malvern. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. *Radio Section:* Wednesday, April 22, 5.30 p.m., Victoria-embankment, W.C.2. (i) "An Investigation of the Characteristics of Cylindrical Surface Waves," by Professor H. M. Barlow and Mr. A. E. Karbowiak; and (ii) "Surface Waves," by Professor H. M. Barlow and Dr. A. L. Cullen. *Southern Centre:* Wednesday, April 22, 6.30 p.m., South Dorset Technical College, Weymouth. "Television Broadcasting Stations," by Mr. P. A. T. Bevan. *Institution:* Thursday, April 23, 5.30 p.m., Victoria-embankment, W.C.2. The Forty-Fourth Kelvin Lecture on "The Dilemma of Lord Kelvin," by Professor P. I. Dee, F.R.S.

INSTITUTION OF ENGINEERING INSPECTION.—Monday, April 20, 6 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "The British Productivity Council's Report on Inspection in Industry," by Dr. J. Barnett.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Central London Branch:* Monday, April 20, 7 p.m., St. Ermin's Hotel, Caxton-street, S.W.1. "Industrial Fire Protection," by Mr. E. M. Woodman. *Association:* Tuesday, April 21, 6.30 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Electrical Appliances: Notes on Design and Testing," by Mr. J. I. Bernard.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, April 20, 7 p.m., College of Art, Green-lane, Derby. "Textile Engineering," by Mr. C. E. Roper. *North-Eastern Section:* Monday, April 20, 7 p.m., Technical College, Enfield Durham-road, Gateshead-on-Tyne. Annual General Meeting and inspection of the new engineering and laboratory wing. *Manchester Section:* Monday, April 20, 7.15 p.m., College of Technology, Sackville-street, Manchester. "The Machine-Tool Industry," by Mr. W. J. Morgan. *Sheffield Graduate Section:* Tuesday, April 21, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. Annual General Meeting. *Stoke-on-Trent Sub-Section:* Tuesday, April 21, 7.30 p.m., Mechanics' Institution, Crewe. "Mechanical Handling Techniques," by Mr. J. Bain. *Wolverhampton Graduate Section:* Thursday, April 23, 7.30 p.m., Star and Garter Royal Hotel, Wolverhampton. "The Mechanised Production of Light- and Medium-Weight Moulds," by Mr. J. Hill. *London Graduate Section:* Tuesday, April 28, 7.15 p.m., 36, Portman-square, W.1. "The Factories Act as It Affects the Production Engineer," by Mr. A. Stockbridge. *Luton Section:* Tuesday, April 28, 7.15 p.m., Offices of W. H. Allen, Sons, & Co., Ltd., Queen's Engineering Works, Bedford. "Rolling-Mill Equipment and Practice," by Dr. L. P. Underwood.

INCORPORATED PLANT ENGINEERS.—*Liverpool and North Wales Branch:* Monday, April 20, 7.15 p.m., Radiant House, Bold-street, Liverpool. "The Engineer and the Brewing Industry," by Mr. G. W. Campbell. *Glasgow Branch:* Tuesday, April 21, 7 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow. Films on "Mobile Mechanical-Handling Plant." *Hertfordshire Discussion Group:* Tuesday, April 21, 7.30 p.m., Peahen Hotel, St. Albans. "Industrial Lighting," by Mr. W. S. Veness. *Birmingham Branch:* Friday, April 24, 7.30 p.m., Imperial Hotel, Birmingham. "The Approach to Maintenance," by Mr. H. G. Hilton. *West and East Yorkshire Branch:* Monday, April 27, 7.30 p.m., The University, Leeds. Ten-minute talks by branch members. *South Yorkshire Branch:* Thursday, April 30, 7.30 p.m., Grand Hotel, Sheffield. Film and Discussion on "The Making of Glass."

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS.—Tuesday, April 21, 2.15 p.m., Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Discussion on "Farm Transport, Including Loading and Unloading."

INSTITUTE OF REFRIGERATION.—Tuesday, April 21, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "An Analysis of the Factors Affecting Performance of Small Compressors," by Mr. W. B. Gosney.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 21, 5.30 p.m., Great George-street, S.W.1. "The Preservation of Timber," by Mr. N. A. Richardson. *Public Health Division:* Thursday, April 23, 5.30 p.m., Great George-street, S.W.1. "Bacteria in Relation to Water," by Dr. E. Windle Taylor. *Yorkshire Association:* Friday, April 24, 7 p.m., Great Northern Station Hotel, Leeds. Annual General Meeting. "The Examination, Assessment, Repair, Maintenance and Renewal of Old Railway Bridges," by Mr. A. Dean.

INSTITUTE OF FUEL.—*Midland Section:* Tuesday, April 21, 6 p.m., James Watt Memorial Institute, Birmingham. "The Preparation and Use of Coal," by Dr. J. Bronowski. *Institute:* Tuesday, April 28, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Refractory Recuperators," by Professor A. L. Roberts.

INSTITUTE OF PETROLEUM.—Tuesday, April 21, 6 p.m., Manson House, 26, Portland-place, W.1. Presidential Address on "Two Oilfields in Northern Iraq," by Mr. H. S. Gibson. Wednesday, April 22, 2.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Symposium on "The Engine Testing of Lubricating Oils."

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Eastern Centre:* Tuesday, April 21, 7 p.m., Marshall's Airport, Cambridge. Annual General Meeting. *Institute:* Thursday, April 23, 7.15 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "The Wilson Gearbox in the Field of Commercial Transport," by Mr. A. Gordon Wilson and Mr. A. A. Miller. *Scottish Centre:* Monday, April 27, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual General Meeting. *North-East of England Group:* Tuesday, April 28, 7 p.m., Royal County Hotel, Durham City. Annual General Meeting and Film Display.

SHEFFIELD METALLURGICAL ASSOCIATION.—*Methods of Analysis Group:* Tuesday, April 21, 7 p.m., Grand Hotel, Sheffield. "Modern Rapid Methods of Fuel Analysis," by Dr. R. A. Mott.

INSTITUTION OF MECHANICAL ENGINEERS.—*Luton Graduates' Section:* Tuesday, April 21, 7.30 p.m., Town Hall, Luton. Annual General Meeting. "The Resurrection of a 1912 Belsize Motor Car," by Mr. A. MacDonald. *Institution:* Friday, April 24, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "The Problem of Fuel Oil Ash Deposition in Open-Cycle Gas Turbines," by Dr. A. T. Bowden, Mr. P. Draper and Mr. H. Rowling.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Yorkshire Branch:* Wednesday, April 22, 6.30 p.m., The University, Leeds. Annual General Meeting. "Sea Defence Works," by Mr. J. Dossor. *Midland Counties Branch:* Friday, April 24, 6 p.m., James Watt Memorial Institute, Birmingham. "Reinforced-Concrete Foundations and Structures for Blast Furnaces and Materials and Handling Plant at Shotton, near Chester," by Mr. O. W. Jones. *Lancashire and Cheshire Branch:* Wednesday, April 29, 6.30 p.m., College of Technology, Manchester. Annual General Meeting and Film Display.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham Branch:* Wednesday, April 22, 7.15 p.m., James Watt Memorial Institute, Birmingham. Annual General Meeting. "The Production of Match Plates by the Aluminium Pressure-Cast Method," by Mr. D. H. Potts. *West Riding of Yorkshire Branch:* Saturday, April 25, 6.30 p.m., Technical College, Bradford. Annual General Meeting. *Coventry Students' Section:* Tuesday, April 28, 7.15 p.m., Coventry Technical College, Coventry. "Castings for Internal-Combustion Engines," by Mr. C. R. van der Ben. *Southampton Section:* Wednesday, April 29, 7 p.m., Technical College, St. Mary-street, Southampton. Annual General Meeting. "Diecasting in the United States" (with film), by Mr. C. J. Williams.

ROYAL AERONAUTICAL SOCIETY.—*Graduates' and Students' Section:* Wednesday, April 22, 7.30 p.m., 4, Hamilton-place, W.1. "Aircraft Accident Investigation," by Mr. H. Caplan. *Society:* Thursday, April 23, 7.30 p.m., Royal Technical College, Glasgow. "Civil Jet Operations," by Captain A. J. Majendie.

ROYAL SOCIETY.—Thursday, April 23, 4.30 p.m., Burlington House, Piccadilly, W.1. (i) "Experimental Study of Standing Waves," by Sir Geoffrey Taylor, F.R.S.; and (ii) "Forced Flow of a Rotating Viscous Fluid Which is Heated from Below," by Mr. T. V. Davies.

ROYAL STATISTICAL SOCIETY.—*South Wales Industrial Applications Group:* Thursday, April 23, 7 p.m., Technical College of Monmouthshire, Crumlin. "Application of Statistical Methods to Problems of Mining," by Mr. B. H. P. Rivett. *Leicester Industrial Applications Group:* Thursday, April 23, 7 p.m., Bell Hotel, Leicester. Annual General Meeting and Brains Trust.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 24, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "The Use of Heavy Fuels in Diesel Engines of Marine Auxiliary Sizes," by Mr. J. Smith.

INSTITUTE OF MARINE ENGINEERS and BARROW ASSOCIATION OF ENGINEERS.—Friday, April 24, 7.30 p.m., Technical College, Barrow-in-Furness. "Ships That Serve Ships," with film, by T. Clark.

PERSONAL.

VISCOUNT CALDECOTE, D.S.C., M.A., A.M.Inst.N.A., has been elected a director of the English Electric Co. Ltd.

SIR ARCHIBALD ROWLANDS, G.B.E., has joined the board of directors of Henry Simon (Holdings) Ltd., Cheadle Heath, Stockport.

COLONEL B. H. LEESON, O.B.E., T.D., M.I.E.E., has been re-elected chairman of the Association of Short-Circuit Testing Authorities, 36, Kingsway, London, W.C.2.

MR. F. H. BEASANT, B.Sc., M.I.E.E., M.I.Mech.E., is leaving Crompton Parkinson Ltd. to join the board of the Anti-Attrition Group of Companies.

MR. J. T. RYMER, until recently managing director of Mirrlees, Bickerton and Day, Ltd., Hazel Grove, Cheshire, has resigned this position to take up that of managing director of Sentinel (Shrewsbury) Ltd., Shrewsbury.

MR. JOHN STEVENSON has retired after 50 years of service as engineer at Millhall Colliery, Stirling.

MR. R. S. ATKINSON, A.M.I.Mech.E., A.M.I.E.E., group I generation engineer (operation) London Division, British Electricity Authority, has been appointed chief generation engineer (operation), Merseyside and North Wales Division. He succeeds MR. R. L. BATLEY, O.B.E., who is now controller of the Midlands Division.

MR. G. J. W. TURNER, managing director of Wright's Ropes Ltd., Birmingham, has been elected a director of Wellington Tube Works Ltd., Great Bridge, Tipton, Staffordshire.

MR. F. A. BENGER, who has been assistant chief of motive power and rolling stock, Canadian Pacific Railway, since 1938, has been appointed chief of that department, in succession to the late MR. W. A. NEWMAN.

MR. C. L. G. FAIRFIELD, M.A., M.I.E.E., A.M.I. Mech.E., has been appointed manager, overseas division, the Telegraph Construction and Maintenance Co., Ltd., Telcon Works, Greenwich, London, S.E.10.

MR. WILFRED SAMPSON, B.A., A.M.I.E.E., has been appointed commercial manager of Telcon Telecommunications Ltd.

MR. W. G. ARDLEY, joint managing director of George Kent Ltd., Luton, Bedfordshire, has been elected to honorary membership of the Institution of Water Engineers.

MR. A. H. CARMICHAEL has been appointed director of the Cable Makers Association, High Holborn House, London, W.C.1, in succession to SIR JOHN DALTON, now chairman of W. T. Henley's Telegraph Works Co., Ltd. Mr. Carmichael has been director of the Brass and Copper Tube Association, Birmingham, for the past 16 years.

MR. G. AINSWORTH WATES, B.A. (Cantab.), has been elected to the board of directors of Johnson and Phillips, Ltd., Charlton, London, S.E.7.

MR. T. F. O'CONNOR, B.Eng., A.M.I.Mech.E., chief adviser on time study and incentives to British Insulated Callender's Cables Ltd. and associated companies until he left England at the end of January, is now practising as an industrial consultant at 2817, Otis Drive, Alameda, California, U.S.A.

Sheepbridge Engineering Ltd., Chesterfield, announce that following the transference of their group sales office from London to Chesterfield, MR. M. M. HALLETT, formerly research and development manager, has been appointed director of sales.

METALASTIK LTD. have concluded an agreement with the Italian concern, S.A.G.A.-Pirelli, providing for an exchange of patents and also technical and commercial co-operation for the manufacture of rubber-to-metal bonded components.

BRITISH INDUSTRIAL SOLVENTS LTD. have ceased trading as a separate limited company and as from April 1, the business has been conducted by a new division of the parent company, namely: BRITISH INDUSTRIAL SOLVENTS—A DIVISION OF THE DISTILLERS CO. LTD., 4, Cavendish-square, London, W.1.

CHARLES WINN & CO. LTD., Granville-street, Birmingham, 1, have become the sole concessionaires and sales agents for the British Isles for "EFEM" self-opening precision die heads.

MANCHESTER OIL REFINERY LTD., Twining-road, Trafford Park, Manchester, 17, have ceased to trade and, as from April 1, have transferred the whole of their undertaking to a subsidiary company, BARTON REFINERY LTD.

THE BLOXWICH LOCK AND STAMPING CO. LTD., Bloxwich, Walsall, Staffordshire, have entered into an agreement with an American firm, the ATTWOOD VACUUM MACHINE CO., to establish a joint subsidiary company in Canada, to be known as LAKE SIMCOE INDUSTRIES LTD.

CONSTRUCTION OF ADEN OIL REFINERY.

(For Description, see Page 490.)

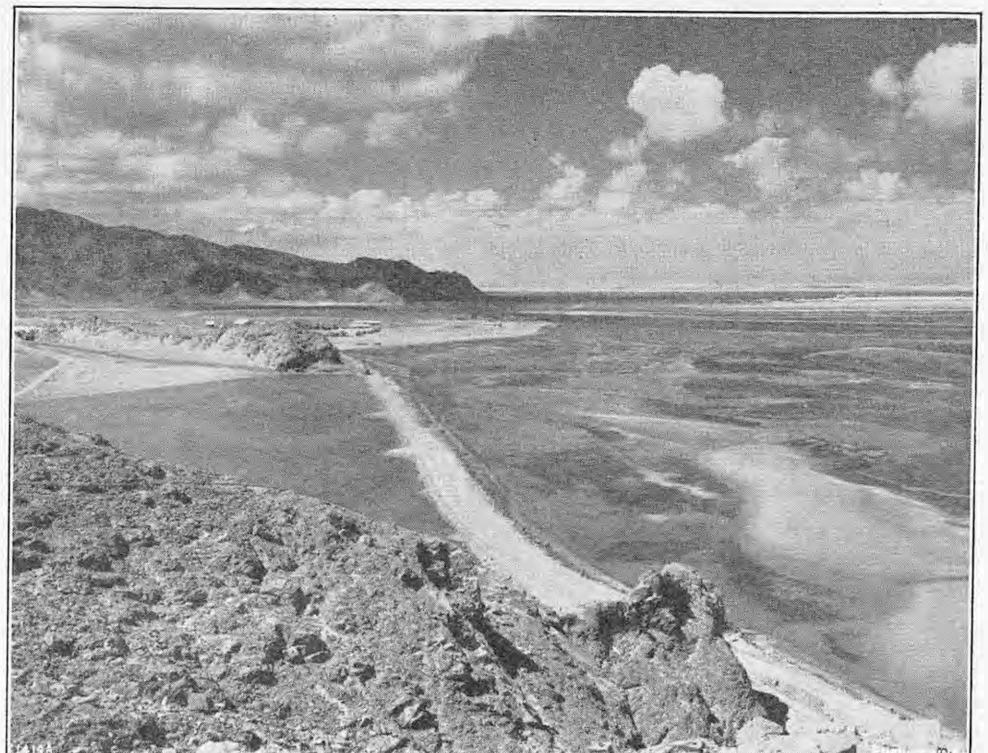


FIG. 1. SITE FOR LITTLE ADEN HARBOUR.

FIG. 2. WORK AT A QUARRY FACE.

FIG. 3. CONCRETE BATCHING PLANT ON REFINERY SITE.

FIG. 4. EXISTING FISHING VILLAGE.

ENGINEERING

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

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Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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ENGINEERING may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
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Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

CONTENTS.

ENGINEERING

FRIDAY, APRIL 17, 1953.

VOL. 175. No. 4551.

ATHLONE FELLOWS.

A HUNDRED years ago it was the young man setting out to seek his fortune in the New World who was the adventurer; his equivalent in 1953, it seems, is the graduate who crosses from east to west to seek knowledge and wisdom in Europe. Renouncing the proferred 400-dols.-a-month post, the automobile, the central heating and the washing machine, he comes to an English university or engineering firm, intent on post-graduate study in the erstwhile workshop of the world. Dr. W. Abbott told a story, at a joint meeting of the Institutions of Civil, Mechanical and Electrical Engineers last Friday, of a graduate engineer in Quebec whose application for an Athlone Fellowship had been unsuccessful. Being enterprising, and determined to gain experience in this country, he approached the Fellowship authorities in Canada and told them that he planned to come to Great Britain under his own steam. "I have saved enough money, and I should like to come and get practical experience in the United Kingdom. If I come, will you look after me? Will you place me and help me as if I were an Athlone Fellow?" His doggedness succeeded. A vacancy occurred and he came over to England as an Athlone Fellow. Machine tools in British factories may be rather old, laboratories may be frugally equipped (as speakers at the joint meeting pointed out), but these outward signs of a temporary economic problem have not clouded the clear atmosphere of British thought and practice in engineering.

Dr. Abbott had presented a paper on the Athlone Fellowship Scheme, now in its third year of operation, under which 38 Canadian graduates in engineering come to Great Britain every year for post-graduate studies. The Fellowships have a duration of two years and are tenable in industry, in universities, or partly in each of these. The scheme was originated, in this country, because it was realised that trade between Canada and Great Britain was unbalanced (in 1951 the imports from Canada, compared with exports to Canada, were in the ratio of 3 to 2); that it would be to the advantage of the two nations if, during Canada's development in the future, more British machinery could be exported to Canada; and that Canadian engineers are probably becoming increasingly familiar with the products and resources of organisations in the United States. As a result, Sir Arthur Fleming and Dr. Abbott visited Canada in 1949 to discuss a scholarship scheme with Canadian Ministers and Government officers, leaders in industry and commerce, university representatives and officials of trade organisations.

The outcome of the discussions and of a visit to Britain of a group of Canadian educationists was that the proposals were clearly favoured in both countries. The scheme, which is named in honour of a former Governor General of Canada, the Earl of Athlone, provides for fellowships of two kinds: Group A, for those about to graduate, the awards being allocated to the several Canadian universities and colleges on a quota basis; and Group B, for those who have already graduated and are at work, the awards in this category being made on a national basis. Each Fellowship covers the cost of travel, a subsistence allowance of 6*l.* 10*s.* per week (net), the cost of tuition at a university, an allowance towards text-books, and a travel grant of 25*l.* per annum for journeys within the United Kingdom. The net cost of the scheme is borne by the British Government, and industrial employers are asked to pay into a central fund the wages they would normally pay to a trainee of the college apprentice type.

In his paper, Dr. Abbott described, in more detail, these facts concerning the inception and working of the scheme. He ended with a résumé of the difficulties which have arisen in practice, his object being to encourage a frank expression of views from those concerned. His paper certainly achieved this object: seldom has an "open" meeting of British engineers indulged in so much healthy discussion of the commercial and educational factors on which future prosperity depends. The prime difficulty which the administrators of the scheme have encountered is the fact that only a minority of the candidates has wished to enter British industry and familiarise themselves with British products and techniques. Most have preferred to enter a university for post-graduate study, partly because North America is "higher-degree conscious" to a much greater extent than Great Britain (and the Fellows are therefore attracted by the idea of using the award to obtain a qualification with a definite value in the engineering world); and partly because the graduate who is prepared to go into industry is offered very attractive inducements by industry in both Canada and the United States. As Dr. Abbott said, it requires considerable courage for a young man to put these fine opportunities aside and elect instead to accept the prospect of two years' further training under somewhat austere living conditions in a country far from home. Yet if this trend of outlook among candidates continues, the original aim of the scheme, it is felt, will be defeated.

It is not altogether surprising that Canadian graduates should view the choice in this way. Scientists in this country have emphasised for some years that Britain excels in research, particularly fundamental research. British productivity, however, is generally supposed to be inferior to that in North America, but it should not be forgotten, that productivity is not the only criterion of industrial efficiency; quality of design and workmanship still counts for much, and in certain industries—shipbuilding, for example—British costs of production compare very favourably with those in any other country. In any case, who can say whether the experience an Athlone Fellow gains in Britain, and at a British university, is not as valuable to this country, in the long run, as the experience he would gain by working in engineering firms. The type of engineer who succeeds in reaching a senior position in middle age finds, more often than not, that he is engaged in work quite different from that for which he was trained. Twenty or thirty years ahead, how many ex-Athlone Fellows will be in positions which allow them to influence directly the placing of orders with British firms with whom they had been trained? It is not idle speculation to suggest that the value of this imaginative scheme lies rather in the intangible but none the less real ties which it will forge between engineers of the two sister nations. There is abundant evidence of goodwill towards Britain among young Canadian engineers and there is apparently no shortage of applicants for Fellowships. As Professor Sutton Pippard said in opening the discussion on the paper, the Fellows coming to this country should be given the very best education and training that can be provided, without considering the ulterior motives.

Many speakers in the discussion commented unfavourably on the scale of the financial grants which Fellows receive. It was held that they are inadequate to attract the right men from a country which enjoys a high standard of living, though one speaker—a Canadian—remarked that English engineers seemed to have exaggerated ideas (due, no doubt, to Hollywood) of Canadian wealth. As Mr. F. R. Livock said: " It is not the cash which is bringing the young men here. They will continue to come only if the training which is given to them is absolutely first-class and something better than that which they can get in any other part of the world." Mr. J. Y. Rousseau, an Athlone Fellow, suggested that the difficulty could be overcome, with several other advantages, if the scheme were modified to include a higher proportion of candidates from Canadian industries than of those about to graduate. This would allow a candidate to save some money while serving in a Canadian firm, and thus come to this country free of financial worries. It would also have the advantages that the Fellow would be better able to benefit from his two years in the United Kingdom; he would be less inclined to go in for post-graduate studies, having spent two years away from text-books while working in a Canadian firm; and, finally, the opportunity for advanced training, which is non-existent in Canada, would render the scheme very attractive. The idea behind this proposal was echoed by several speakers from Canada and the United States, as well as from this country.

When Dr. Abbott came to reply to the discussion it was clear that the suggestions which had been put forward did not fully solve his problems—though he acknowledged the help that they would prove to be in formulating future policy. He intimated that it might be possible to arrange for some Athlone Fellows to stay in this country for one year instead of two, thereby overcoming the objection which Canadian industrialists had raised to the fact that, at present, they had to part with a man for too long a period. Dr. Abbott's paper was written largely to provoke free discussion, and for that reason it probably gave the impression, before the meeting, that the scheme was to some extent failing. But at the meeting it became clear, from the remarks of speakers (particularly Athlone Fellows) and Dr. Abbott's own reply, that in fact it has achieved remarkable success. The success may not be in quite the form that was originally intended, but it is a significant indication of friendship and close ties between the two great nations of the Commonwealth.

A NEW ELECTRICAL ERA.

THE contents of the annual report of the British Electrical and Allied Manufacturers Association for 1952-53, which was published at the end of last week, are a blend of tempered complacency about the past and of cautious optimism regarding the future. Despite some falling off in certain fields, the achievements of the industry during the year under review, it is claimed, were outstanding. Another record was established in the export market, the value of the products sent overseas being some 218*l.* million, an increase of 15 per cent. over the figure for the previous year. Much of this increase, it is satisfactory to note, was due to an improvement of 10·5*l.* million in the exports of electrical machinery and of 8·5*l.* million in wires and cables, two branches of the British electrical industry which have long established a reputation for quality. As a result, electrical engineering has resumed its place as the second largest exporter in the country, and by increasing its overseas output by one-third since 1950, has achieved a greater improvement than has any other industry. It is therefore not too much to say that the role played by electrical engineering in the national economy is of the highest importance.

The time when good wine needed no bush is, however, passing, if it ever existed. Quality by itself is not enough; the attention of potential buyers must be continuously drawn to its existence. Considerable credit for the results obtained must, therefore, be given to the Export Panel of the Association which, during the year, has done good work in assisting members and others to secure business in the face of increasing competition and deteriorating financial conditions. In this connection special mention may be made of two of the efforts of this body. The first is the establishment of an Electrical Industry Export Service, which is a descendant of the Export Group Scheme inaugurated by the Board of Trade some years ago. This is available to every electrical manufacturer interested in export development, whether a member of the Association or not. The second is the publication of a new edition of what is modestly known as the *Beama Catalogue*, a volume of encyclopædic proportions of which 15,000 copies have been distributed to buyers and potential consumers all over the world. This, in common with other printed matter, should form a useful stimulus to the increase of overseas trade.

While the export picture, as outlined in the report, is almost entirely rosy, there is more shadow when conditions at home come to be reviewed. Once again the heavy side of the industry shows the more satisfactory results. Some 1,540 MW of generating plant were installed in the power stations of the British Electricity Authority during the year, compared with 1,235 MW during the previous twelve months, this being additional to the 900 MW which were exported. It is, however, correctly emphasised that this is still not good enough and that for complete economic recovery it is necessary for an extra 2,000 MW to be made available each year. It is hardly necessary to reiterate that this additional plant is required not only to meet the increasing demand for electric power, but to bring about a much needed improvement in the coal consumption per kilowatt-hour generated, an improvement which is now being reflected in the increasing thermal efficiency of British power stations, as shown by figures recently published.

Against these favourable aspects, upon which the industry must be congratulated, heavy taxation fell with increasing weight on individual firms, thus preventing them from building up out of profits sufficient working capital and reserves to maintain their enterprises. Moreover, the domestic-appliance side of the industry was hampered by high rates of purchase tax and by restrictions on hire and hire-purchase agreements. It is therefore satisfactory to note that some of these obstacles to development will be alleviated, even though they will not be entirely eliminated by the removal of the excess profits levy, the reductions in income tax and purchase tax, and the increase in the allowances for capital expenditure on buildings, plant and machinery which were introduced in the Budget introduced by the Chancellor of the Exchequer last Tuesday.

A further difficulty which the electrical industry has had to face is that of hostile propaganda. To combat this, the Association during the year set up a Development Committee, the objects of which are to answer criticisms against the use of electricity and to promote active measures to bring the whole problem into proper perspective. Another important step, which has just been announced, is the appointment of a Public Relations Adviser to deal with the sales problems that confront the industry and to improve its standing both in the political sphere and with the general public. Considering the part played by " public relations " nowadays, a question which has been skilfully analysed in a pamphlet recently issued by the Acton Trust, such a step was perhaps inevitable. It is not, however, without its risks since to translate the technical, and even the economic, problems which encompass the industry into language which will enable the layman to appreciate their complexities is a task the difficulties of which it is hard to exaggerate. Moreover, both the official and the general public are becoming increasingly impervious to anything of a nature which is frequently irreverently described as " dope." To overcome this resistance and to achieve the desired results will, therefore, require both skill and patience, as speedy results cannot be expected. We should make it clear, however, that the appointment is not the less to be welcomed for those reasons and we shall await the results of the new policy with interest.

A paragraph in the report calls attention, a little plaintively, to the fact that during the year the Association and the industry have had to assume the burden of an inquiry by the Monopolies Commission. While welcoming the opportunity of showing how they are serving the public interest, it is pointed out that such investigations necessitate the expenditure by executives in all branches of a tremendous amount of time and energy which might be better spent otherwise. On more than one occasion we have analysed the reports made by this body and, although we recognise their historical value, we have several times expressed doubts whether they will attain the object in view, even if it were perfectly clear what that object is. We should have thought that at the present time there were more important activities to pursue.

In making these comments on an account of the doings of an important British industry we have naturally had to confine ourselves to certain outstanding matters. It would give a false picture of this position, however, to conclude without pointing out that the Association is dealing with a number of other questions of great importance, both by itself and in collaboration with other branches of the industry. Such problems as transformer and switchgear standardisation, general conditions of contract and the contribution of electricity to fuel economy, as well as opposition to the Government's proposals to restrict the British Electricity Authority's capital investment programme, international contract practices in engineering and the iron and steel bill, to mention only a few, have all received attention. It is clear, in fact, that the Association is a living body, and that its operations make it well worthy to represent an industry which is, perhaps, a little grandiloquently described in the report as the spearhead of economic recovery and prosperity in this new Elizabethan era

NOTES.

THE BUDGET.

THE engineering industry more than any other has cause to applaud Mr. Butler's budget; not primarily because the Budget reduces the contribution individuals and firms have to make to the Exchequer (welcome though that is), but because it recognises the fact that modern industry—especially the engineering industry—prospers only if it is run on a foundation of long-term plans. "We must look beyond the immediate export difficulties," the Chancellor said, "and, whatever happens, plan ahead to improve our competitive position. The time and opportunities we now have must be used to re-equip and modernise our factories, to expand capacity in lines which command a ready market abroad, and to develop new lines and new techniques." He then announced his intention of reinstating the system of initial allowances for capital expenditure on plant and machinery, on the construction of industrial buildings, and on mining works. These initial allowances are to operate for profits tax as well as income tax. The rate for plant and machinery is to be 20 per cent. in respect of capital expenditure, on agricultural machinery as well as industrial equipment. For the construction of industrial buildings the rate is 10 per cent., and for new mining works, both at home and overseas, a generous rate—40 per cent.—is allowed so as to encourage this work of national importance. The allowance refers to pit shafts, oil wells, etc., but not to plant and machinery. The other Budget change which will have the greatest effect on industry—in addition to the all-round reductions in income tax and purchase tax, which favour the finances of firms as much as those of individuals—is the decision to end the excess profits levy as from January 1, 1954. This levy was introduced as a temporary measure to deal with the exceptional circumstances of the period of rearmament, but now that this period is expected to be longer and the rate of rearmament to be correspondingly reduced, the Chancellor has found it possible to abolish the levy altogether. Thus the terms of the Budget confirm the main theme: "the need to give a real boost to production," and engineers throughout the country will respond to the Chancellor's call to "launch a drive to show the world that our highly concentrated industry and our developing agriculture are taking on a new lease of competition, life and hope."

"VISCOUNT" PROPELLER-TURBINE AIR-LINER SERVICE.

With the inauguration of the world's first regular propeller-turbine passenger air services on Saturday, April 18, British European Airways (B.E.A.) will introduce into operaton on their longer Continental routes an aircraft far in advance, in performance and passenger appeal, of its economic competitors. The aircraft to be used are the Viscount 701 "Discovery"-class air liners, designed and constructed by Vickers-Armstrongs Limited, Weybridge, Surrey; 26 of these aircraft have been ordered by B.E.A. and so far four have been delivered. Orders have also been placed by B.E.A. for 12 Viscount 801 aircraft, a larger aircraft with increased seating capacity, for use on their shorter routes; delivery of these is expected in about two years time. Initially, the "Discovery"-class air liners will fly between London-Rome-Athens-Nicosia (Cyprus), starting on April 18, and London-Rome-Athens-Istambul, starting on April 19. The scheduled block times between the stages are as follows: London and Rome (896 miles), 3 hours 40 minutes; Rome and Athens (666 miles), 2 hours 50 minutes; Athens and Nicosia (578 miles), 2 hours 30 minutes; Athens and Istambul (345 miles), 1 hour 50 minutes. On April 24, a Viscount service between London and Zürich will commence, and late this summer, between London and Geneva and London-Copenhagen-Stockholm. A description of the prototype Viscount Series 700, it may be recalled, was given on page 260 of our 170th volume (1950). Since then the all-up weight of the aircraft destined for B.E.A. has been increased to 56,000 lb., and seating accommodation is provided for 40 or 47 passengers. The Viscount is fitted with four Rolls-Royce Dart centrifugal-flow gas turbines, each developing a static sea-level power of 1,400 brake horse-power plus 365 lb. jet thrust, and driving four-blade Rotol propellers. We recently had the opportunity of flying with British European Airways, in their Viscount "Robert Falcon Scott," from London to Cyprus and back, spending a night in Nicosia before the return journey. The low level of vibration in the Viscount has already been the subject of much publicity and needs no further comment. Equally important for the passenger's comfort, the air conditioning of the Viscount is excellent and compares most favourably with that of most of its competitors on European routes. Largely as a result of unusually large windows, but also partly due to the slender Dart nacelles, it is possible to obtain a good view from every window station. The cruising speed at which B.E.A. operate the aircraft depends on its weight, height and ambient conditions, but as a general indication, for economical cruising an average true air speed of approximately 300 m.p.h. is adopted at a height of about 20,000 ft.; the height also is related to atmospheric conditions, and to air-traffic control procedures. In conclusion, it should be mentioned that, like the Comet air liner and the Ambassador aircraft of B.E.A.'s "Elizabethan" fleet, the Viscount complies fully with the 1951 British Civil Airworthiness Requirements, probably the most comprehensive and realistic airworthiness regulations yet in force, demanding, among other things, that the performance of the aircraft shall be matched with the routes over which it is to be flown and the prevailing temperature conditions at the time of the flight.

THE RECRUITMENT OF YOUNG ENGINEERS.

During his speech at the opening of the new laboratories at the University of Nottingham (a description of which is given on page 500 of this issue), Lord Hives, managing director, Rolls-Royce, Limited, drew attention to the relatively small number of university students who were taking courses in technological subjects. The proportion of such students was, in fact, only 12·4 per cent. of the full-time undergraduate population, a state of affairs which was causing both educationists and industrialists much anxiety. The Government were attempting to tackle the problem by increasing the resources for technological education, but he was doubtful whether such a measure alone would provide a solution. In his opinion, the root of the matter was to be found in the schools and in the attitude of the parents. Engineering was not taught in the schools, with the result that a young man went up to a university with no first-hand knowledge of one of this country's greatest possible careers. Careers masters, too, were ill-informed of the great opportunities which at present existed for young men in all branches of engineering. The idea of inviting schoolmasters from all over the country to visit the engineering departments at Nottingham was therefore to be welcomed and should establish a personal link between university and school, which would be of great value. As regards parents, some still held the view that a career in industry was not so respectable as one in the services or professions. As long as that idea persisted, England would never have the skilled men that it required.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION.

The 32nd annual report of the above-named Association, which this time covers the period October 2, 1951, to December 31, 1952, was presented at the annual general meeting held at the Connaught Rooms, London, on Friday, April 10. In a foreword to the report Mr. H. Astbury, chairman of Council, explains that it was decided that the financial year and the budget year should cover the same period and be taken to December 31 in any year. It is stated in the report that the Association's total income has increased to over 250,000*l*., but, on the other hand, salaries and wages have increased generally during the year. A total of 94 reports were issued to members and an increasing number of technical inquiries were answered; others were passed to "technical liaison" and the research staff. The report includes a useful summary of the various researches in progress, covering such matters as insulation and dielectrics, switch and control gear, the use of wind power for generating electricity, insulated cables, overhead lines, surge phenomena, magnetic materials, transformers and other subjects. After the meeting, the annual luncheon, at which Sir John Hacking, M.I.E.E., presided, was held in the Connaught Rooms. The toast of the "E.R.A." was proposed by Sir David Brunt, M.A., D.Sc., Sec. R.S., who, speaking as a meteorologist, referred to the connection between meteorology and the work of the Association, particularly regarding the use of wind power for the generation of electricity. The response was made by Sir John Hacking, who first thanked the members for inviting him to be President of the Association for the ensuing year. Referring to the income of the Association, Sir John remarked that the supply industry contributed about one-third of the total, which was less than was received from the D.S.I.R. It was difficult to assess the value of research and although he did not like to do so in terms of money spent, that was the only practical yardstick to employ. The manufacturing industry contributed only about one-quarter of the Association's income and he asked if that could be regarded as adequate. The industry spent something like 7*l*. million annually on its own research and its contribution to the Association's income was not more than one per cent. of this amount.

THE ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.

The annual dinner of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, W.C.2, on Friday, April 10, the President (Mr. C. T. Melling) being in the chair. The toast of "The Electrical Industry" was proposed by Sir David Brunt, chairman of the Electricity Supply Research Council, British Electricity Authority, who, although he could not claim to be an electrical engineer, said he had been concerned with many of their affairs during the past 20 years. In particular, he recalled that he had been asked whether the erection of 360-ft. chimneys at Battersea power station would prevent politicians being asphyxiated and, with some regret, had reported that it would. It was clear at the present time that research covered a multitude of—perhaps too many—"jobs for the boys" and that the generation of electricity by atomic energy was becoming a possibility, although it would be a long time before existing power stations were superseded. This, however, was an age rather of domination by committees than of atomic energy. The Royal Society alone sponsored 83 committees and there were many others. Herein lay a real danger, as too many scientists were engaged on too many committees when they might be doing more useful work. In reply, Mr. T. G. N. Haldane expressed confidence in the future of the electrical industry. In time, he said, we should be able to make an assessment of the working of the nationalised industries and he predicted that we should then reach the usual British compromise in which the two types of ownership would be harmonised in the interests both of the individual and the community.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

An interesting development of the work of the British Iron and Steel Research Association is that the construction of a plant laboratory in the Mechanical Working Division of the Association at Hoyle-street, Sheffield, 3, has recently been completed, thus providing good facilities for research in the hot and cold working of steel and other ferrous metals. A 200-ton forging press, an experimental section rolling mill and a small 6-in. by 5-in. rolling mill have been installed. A high-speed four-high cold-rolling mill, a bar-drawing bench and other equipment are in various stages of erection, while a high-speed wire-drawing machine has been promised for early delivery. It is stated in the ninth annual report of the Association, which covers the year 1952 and was published this week, that further alterations and improvements have been made to the premises acquired at Battersea in 1951. Moreover, on the North-East Coast, an additional building has been provided by a member firm where the Association is extending its pilot-plant trials on the agglomeration of ore fines. In addition to dealing with various engineering aspects of the design and maintenance of iron and steel works, the mechanical- and civil-engineering sections of the Plant Engineering Division of the Association have been concerned with work for the imported ore-handling advisory committee. Arising from an increase in research of an operational engineering nature, a new section, entitled the works operation section, has been set up. It is interesting to read, in the report, that there are now altogether 400 research projects in hand and that the great majority of these are supervised by the Association's 65 panels and research committees. Some researches involve fundamental and long-term problems, while other questions are capable of much earlier solution. In conclusion, it may be useful to record the steady growth of the Association since its establishment. In 1945, the industrial income, in round figures, was 64,000*l*., earning a Government grant of 30,000*l*. In 1952, the industrial income was over 312,000*l*., which earned the maximum Government grant of 150,000*l*. In the same period, the staff has grown from a small nucleus to the present total of nearly 400. There are two categories of members in the Association, namely, ordinary and associate. The former now number 286 and they together employ 85 per cent. of the labour force of the whole industry. The 31 associate members are drawn from suppliers of raw materials, makers of steelworks plant and from processers and users of iron and steel.

RADIO AND ELECTRONIC COMPONENTS EXHIBITION.

The tenth exhibition of the Radio and Electronic Component Manufacturers' Federation was opened by the President (Sir Robert Renwick, Bt.), at Grosvenor House, London, on Tuesday, April 14, and closed yesterday (Thursday, April 16). About 120 firms and organisations exhibited and the displays showed clearly that manufacturers in this branch of the electrical industry are well maintaining their reputation for ingenuity and high quality. Another feature was the increasing proportion of their products which are being used in radar, scientific instruments, medical apparatus and electronic equipment of all kinds. "Miniaturisation" was a further keynote. This last point may be illustrated by referrring to the reactors exhibited by Dubilier Condenser Company (1925), Limited, North Acton, London, W.3, and the rotary instrument shown by Painton and Company, Limited, Northampton, which incorporates a 40-step bridge T-network. A sub-miniature volume control with on/off switch, was exhibited by Egen Electric, Limited, Canvey Island, Essex, and the same firm displayed a pre-set sub-miniature control for the electronic equipment that might be used in guided missiles. The switches made by Messrs. A. F. Bulgin and Company, Limited, Barking, which can carry up to $1\frac{1}{2}$ amperes at 250 volts, are said to be the smallest in the world. A number of types of miniature valves were also on view. The General Electric Company, Limited, Kingsway, London, W.C.2, were showing a new quiet audio-frequency pentode, which is suitable as a first-stage valve in high-gain amplifiers, and a new high-slope radio-frequency pentode with characteristics which make it suitable for video amplification. The Westinghouse Brake and Signal Company, Limited, York-way, London, N.1, were exhibiting an aluminium-based lightweight rectifier for aircraft power supplies. The cable makers were well represented, the products shown indicating the increasing use that is being made of the new insulating materials, including one made from silicone elastometer. The Telegraph Construction and Maintenance Company, Limited, 22, Old Broad-street, London, E.C.2, were exhibiting the aluminium-clad iron which is being manufactured in experimental quantities for valve electrodes, as well as Telconal, a nickel-free alloy which has been developed as a substitute for constantan.

LETTER TO THE EDITOR.

MARINE CONDENSER TUBES.

TO THE EDITOR OF ENGINEERING.

SIR,—I was interested to read, on page 308 of your issue of March 6, a letter from Messrs. G. and J. Weir, Limited, regarding the velocity of circulating water through tubes of marine condensers.

My experience shows that the majority of firms supplying condensing plants for land power stations design for a velocity of from 5·5 up to 6 ft. per second. Whilst doubtless a higher velocity would improve the heat transmission, it is considered that there are other disadvantages, such as increased erosion, which may render increased velocities of doubtful value. I have never come across a case where the velocity has been as low as the 4 ft. per second mentioned in the "Notes" to which the letter refers. I suggest, however, that there could be some small increase over a velocity of 6 ft. per second, using, perhaps, $\frac{5}{8}$ in. tubes in those cases where the cleanliness of the water is above suspicion.

Yours faithfully,
I. V. ROBINSON.

Carisbrooke,
Walton-on-Thames,
April 8, 1953.

OBITUARY.

MR. GANO DUNN.

INFORMATION has been received of the death of the distinguished American electrical engineer, Mr. Gano Dunn, which occurred in New York on Friday, April 10. He was 82 years of age.

Gano Dunn was born in New York on October 18, 1870, and received his technical education at the College of the City of New York, where he graduated in 1889; and at Columbia University, where he obtained a degree in electrical engineering two years later. He was simultaneously engaged as a night telegraph operator with the Western Union Telegraph Company. In 1891 he joined the Crocker-Wheeler Company, manufacturers of electric motors, of which he soon became vice-president and chief engineer. Twenty years later he joined J. G. White and Company as vice-president and assisted in the organisation of the J. G. White Engineering Corporation. In 1913, he was appointed president of this organisation, which was responsible for carrying out a number of important engineering works, and was still holding this position at the time of his death.

Dunn was elected an associate of the American Institute of Electrical Engineers in 1891 and was transferred to the class of members in 1894, and to that of Fellow in 1912. He served as vice-president from 1900 to 1902 and from 1905 to 1907, and was elected president in 1911. He was the recipient of a number of honours, including the Edison Medal in 1937 for "distinguished contributions in extending the science and art of electrical engineering, in the administration of great engineering works and for inspiring leadership in the profession." He also received the Townend Harris Medal in 1933. He was a member of the American Academy of Arts and Sciences, and chairman of its engineering section, and of the American Philosophical Society, as well as being first chairman of the Engineering Foundation and President from 1913 to 1916 of the United Engineering Society, which owns the building in New York occupied by the principal engineering societies. He was elected a member of the Institution of Electrical Engineers in 1911, and was the representative of the Council of that body in the United States.

JUBILEE OF THE METROPOLITAN WATER BOARD: ERRATUM.—We regret that in reporting the Jubilee Luncheon of the Metropolitan Water Board, on page 435 of our issue of April 3, reference was made to the "deputy chairman (Major F. W. Beech, C.B.E.,)"; it should have been to the vice-chairman of the Board, Mr. A. Gorman. Major Beech is deputy chairman of the London County Council.

NOTTINGHAM UNIVERSITY'S NEW ENGINEERING LABORATORIES.

THE new civil and mechanical engineering laboratories of the University of Nottingham, which were formally opened by Lord Hives of Tuesday, April 14, are an attempt to deal with a formidable educational problem. The original engineering laboratories and drawing offices on the same site in University Park were completed in 1930 at a time when the number of full-time students in civil, mechanical and electrical engineering was less than a score. By 1940, the numbers had increased to 44; in 1946 they had risen to 128, and in 1950 there were no less than 200 students in these three subjects. This large increase was, of course, due to the demand of ex-service men for admission to degree courses, especially in mechanical and civil engineering, and could only be met by organising the work in two shifts, an arrangement which was obviously unsatisfactory.

There were two possible remedies for this situation. A large project of building extensions could have been inaugurated. These, however, would have taken at least six years to complete, during which time the intake of students would have to have been reduced. Alternatively, a less ambitious project, which could be completed in about two years, could have been adopted. It was felt that the latter was the wiser course and the new buildings are the result. It should be added that during the period of construction, which started in 1949, the number of students has been maintained at the 1950 level and there is now accommodation for an annual intake of 20 students in each of the mechanical, civil, electrical and mining branches and of 10 metallurgical students. The new extensions at Nottingham have, in fact, brought the facilities for civil and mechanical engineering education at the University into line with those existing for electrical and mining engineering and have enabled a sub-department of metallurgy to be formed. They have also enabled the number of students to be established at about the 1950 level. Both the civil and mechanical engineering departments are in charge of Professor J. A. Pope, under whom active research schools have also been established. The professor of electrical engineering is Dr. H. Cotton, and of mining engineering and fuel technology Dr. F. B. Hinsley, who is also Dean of the Faculty of Applied Science.

The construction of the new building is utilitarian and much care has been taken to keep down its cost. Unlike the policy at some teaching institutions, the principal stress has been laid on equipment. Arrangements have also been made so that the students in each year shall have their own workroom and that sufficient apparatus and laboratory space shall be available to enable them to carry out experiments in small groups. Laboratory exercises are arranged so that they are maintained in phase with the lectures, a policy which means that a number of sets of the same apparatus have to be available simultaneously, with the consequent necessity that considerable accommodation is required for storage. Arrangements have also been made so that the desks and seats in the workrooms can be converted into benches and the same rooms thus utilised at different times as lecture theatres, drawing offices, and even as "general" laboratories. In general, the laboratories have been designed to fulfil the dual functions of teaching and research.

The "advanced" laboratories, in which experiments are made on engineering materials and machines, include, in the civil and mechanical engineering department, a fatigue laboratory, of which an illustration is given in Fig. 1. This is equipped with a number of machines for testing the properties of metals, and among the researches now being carried out, the greater portion of which are financed by industry, mention may be made of those relating to residual stresses due to the relaxation of thermal stresses, the plastic deformation of metals, the fracture of Diesel engine components and the effect of surface stressing on the fatigue life of metals. In the metrology laboratory, which is temperature-controlled, instruments are

LABORATORIES AT NOTTINGHAM UNIVERSITY.

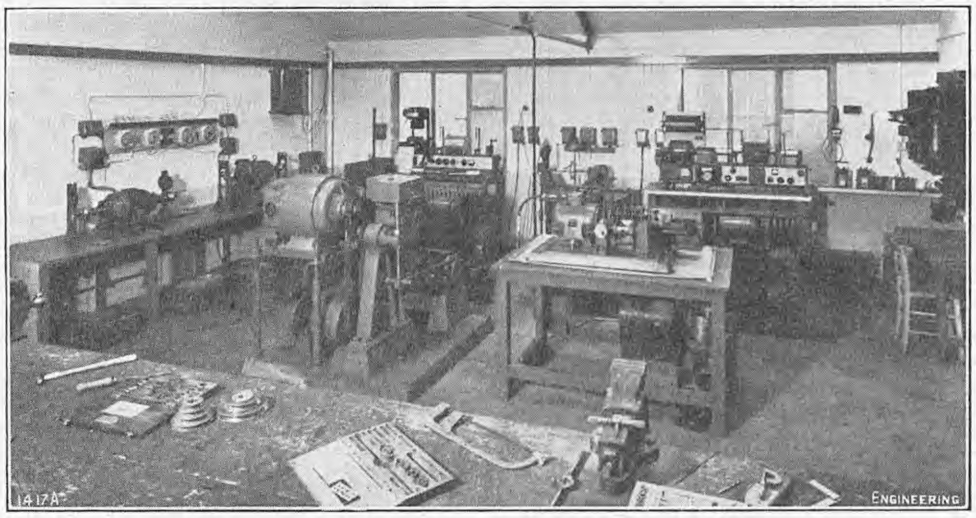


FIG. 1. FATIGUE LABORATORY.

FIG. 2. FURNACE ROOM.

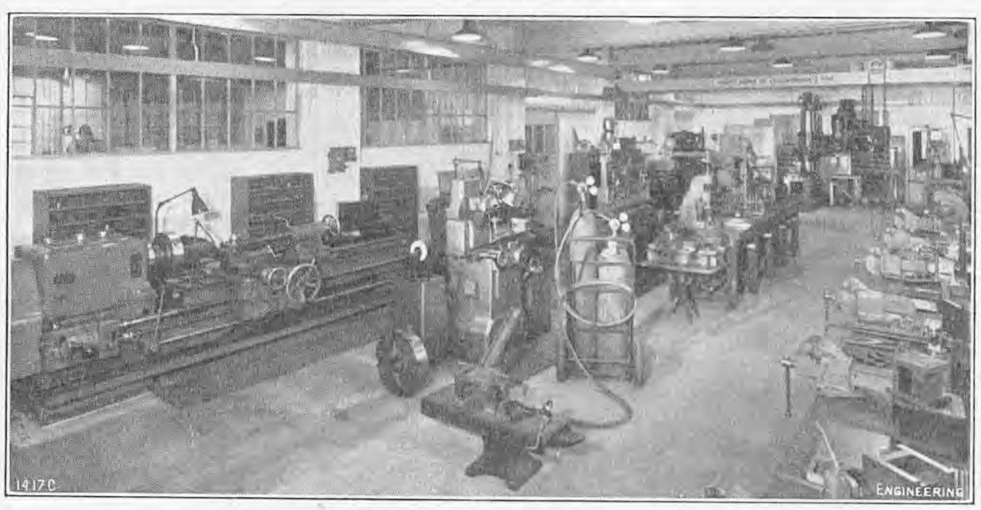


FIG. 3. ONE OF THE WORKSHOPS.

installed for checking the tools used and the items manufactured in the workshops. Provision is also made for research students who wish to make very accurate measurements or to assess surface textures. The principal piece of apparatus in the material and structures laboratories, of which there are two, is a 500-ton testing machine, although there is, of course, a large amount of other apparatus, much of which has been provided by the manufacturers. In addition to providing facilities for the instruction of students, these laboratories are being used for carrying out investigations into the impact properties of metals, the cooling of alternators and the measurement of earth pressures, etc.

The hydraulics laboratory is also well equipped, and the work that is now being conducted in it includes a research into vortex formation in bell-mouthed entries. The furnace room, illustrated in Fig. 2, contains a number of electric and gas-heated furnaces as well as an ammonia cracker, and in the concrete laboratory is vibration apparatus on which tests at varying amplitudes and frequencies can be carried out. In the research laboratory projects being undertaken include investigations into plastic flow due to spherical impact, and the mechanical properties of rubber. In the metallurgical laboratory, research is being carried out into the effect of nitriding on fatigue strengths and in the heat-engines laboratory heat transfer to gas-turbine blading is being determined. One of the workshops is shown in Fig. 3. There is also a soil mechanics laboratory and standards room.

THE INSTITUTE OF METALS.

(*Continued from page* 472.)

WE continue below our report of the symposium on the "Control of Quality in the Melting and Casting of Non-Ferrous Materials" held on Wednesday, March 25, during the annual general meeting of the Institute of Metals which took place in London from March 23 to 26.

CONTROL OF QUALITY IN THE MELTING AND CASTING OF NON-FERROUS MATERIALS.

The next speaker in the discussion, Mr. J. R. Handforth, said that he found it difficult to differentiate between quality control and inspection. Inspection, however, was a part of the system of quality control, and views on inspection varied from works to works and among different people in the same works. While this difference within one organisation was marked, the outside organisations had also to be reckoned with. Thus, Birmetals Limited, Birmingham, had to deal with 16 different inspection organisations, all having their own ideas of inspection and quality control, including many Government departments, Lloyd's and others. The Aeronautical Inspection Department maintained a huge laboratory, probably bigger and more expensive than any in industry, and, during the last war, 20,000 on the inspection staff. The question was whether inspection should be regarded as an industry or as an adjunct to industry.

Mr. P. F. Mills said that Dr. Singer had made a strong plea for the extension of technical control to cover more of the primary variables in manufacture. At the same time, he had rightly said that the essence of control was the detection of variation or error with the maximum speed and certainty, followed by corrective action at the earliest moment. Unfortunately, as previous speakers had pointed out, many of the primary variables in metallurgical manufacture did not lend themselves to rapid determination, and control by secondary variables, in the majority of cases, was a necessity. Hence, one of the major problems confronting metallurgists was the evolution of new methods for the more rapid measurement of primary variables. Dr. Singer had remarked, with regard to statistical control of quality, that the quality-control chart was now a familiar sight in the metallurgical industry. This made good reading, particularly to those who were interested mainly in the inspection aspects, but it did not accord with his own experience.

Mr. P. F. Hancock stated that one of the primary variables was the temperature of the melt, and the desirability of regulating this variable, preferably by full automatic control, was emphasised at several points in the papers of the symposium. In no type of furnace was temperature regulation more readily effected than in the low-frequency induction furnace, and for this reason as well as others, both technical and economic, the extension of the use of this furnace seemed likely. For many years the Ajax-Wyatt furnace had been regarded as the standard for zinc alloys, for example, but had had certain limitations when used for other classes of alloy. Developments in recent years to overcome these limitations had been principally concerned, first with the devising of modified forms of inductor loop for the easy cleaning of channels without emptying the furnace, and secondly with improvements in refractory lining. Resulting from these developments, the low-frequency furnace had been applied to an increasing extent in the light-alloy fields, where channel blockage had formerly been the difficulty, and on the other hand, to the higher melting point copper-base alloys. Recent trials on a small furnace had been directed towards the possibility of melting aluminium-bronze in the low-frequency furnace of the type developed primarily for light alloys, where the channels were arranged for ready cleaning. While these experiments were as yet in the early stages, the results so far had been promising.

Returning to the specific question of automatic temperature control with low-frequency furnaces, it might be of interest to mention that in these trials, both with aluminium-bronze and with straight copper, a continuously-immersed thermocouple had been used for this purpose and good performance obtained from a heavy silicon-carbide outer sheath and an inner sheath of pure silica or alumina, to prevent contact of the precious-metal couple with the silicon carbide and the contamination resulting from this. This arrangement had worked well, and the continuous control of temperature had been quite satisfactory.

Professor A. J. Murphy, in answer to Mr. J. R. Handforth, said that the object of the control of quality was to avoid the necessity for huge organisations for post-mortem inspection. Moreover, the title of the symposium was not "Quality Control in Melting and Casting." It was "The Control of Quality in Melting and Casting." "Quality control" had a special meaning. The next speaker, Dr. C. J. Smithells, said that the subject of the discussion was the control of quality, but before quality could be controlled, the particular factor to be controlled should be understood thoroughly. Seven or eight years ago blister in aluminium in certain qualities had caused trouble. For years attempts had been made to find a cure for it, without understanding the real phenomenon. The investigators did not know whether the blisters consisted mainly of hydrogen or of something else. Finally, fundamental experiments had been conducted to find out exactly what was the solubility of hydrogen in solid and liquid aluminium and how it diffused, and after a good deal of study of the fundamentals in the relations between gases and metals, methods of controlling blister trouble had been instituted, so that at present it was no longer a problem. There were still many other factors which could be controlled but about which not enough was known for these control mechanisms to be applied. Innumerable factory trials, followed by statistical analyses of the results, would not furnish the answer, this would only be given by fundamental work in the laboratory, based on a proper understanding of the real phenomena which prevailed.

Mr. A. B. Graham said that productivity was allied, of course, with other things such as payment by results. In some industries it was very easy to pay by results, where a finished product could be examined and classed without hesitation as good or bad. When, however, the casting of ingots or billets was considered, in some materials at present, the specification was so rigid and the tests to be applied so complex that billets might lie about for some considerable time, and, in the interval, the man who cast the billet or ingot had to be paid. Hence, some system had to be devised whereby he could be paid for the good ones. This was a difficult proposition to which he could find no satisfactory answer. The composition and the dimensions could be controlled, but not the constitution.

At the conclusion of Mr. Graham's speech, the President adjourned the meeting until 2.30 that afternoon, and when the members reassembled to continue the discussion of the symposium, Mr. W. J. Thomas, chairman of the Metallurgical Engineering Committee of the Institute, occupied the chair. He stated that he had a very simple definition of the control of quality, namely, the avoidance of defects. To avoid defects it was necessary, as had already been mentioned, to know what they were and be able to measure them and determine their origin if possible. The problem then resolved itself in finding some means of controlling the defects and keeping them under control.

Mr. Charles Paton, who opened the discussion, said that one thing which must be established in this study of the control of quality was just what items must be controlled in order to effect the desired improvement in quality. He had been interested to hear Dr. Smithells state that the blister problem was not now a serious one with his company because, while, in some works, this matter had been brought to some extent under control, serious "blister epidemics" still occurred in others. Nearly all the papers had reported very favourably upon the induction furnace for melting. His experience had shown that difficulties with these furnaces were roughly proportional to their capacity, and much trouble had been experienced with linings in the larger sizes.

It would be generally admitted that, while control of melting procedures was very important, careless pouring could undo all the good which had been previously done. Some of the authors had indicated that holding periods of 1½ hours were necessary. He believed that a limited holding period, perhaps of 15 minutes, was adequate. If the quality of a metal were such that a period of 1½ to 2 hours was needed to clear it up, it was best to flux the melt with chlorine or aluminium chloride. Some mention was made of the grain refinement of the aluminium-manganese alloys by the use of proprietary fluxes. It has always been his experience that there was little relationship between the grain size in the ingot and the grain size in the finished sheet. Some boron fluxes would give a very fine grain in the ingot, but a very coarse grain might be produced in the finished sheet unless the precautions of two intermediate anneals preceded by cold work were observed.

Dr. C. J. Smithells said that before anything could be done concerning controlling the effect of gas in metals and blistering, an accurate method of gas analysis, which had not existed before had had to be developed. The kind of troubles which Mr. Paton had described were exactly those which would face industry so long as industry proceeded on the "hit-and-miss" method of trying to work on experience and not getting down to the scientific basis of the various controlling factors.

Professor A. J. Murphy stated that technical control in the foundry, to be effective, must command the respect of the operatives. Failures of pyrometric equipment still too often caused the operative to feel that these measures were not reliable, and that he must, in the last resort, fall back on the old empirical methods of judgment on which he, or a previous generation, was brought up. If some of the other stages in the production of the ingot or billet were considered, it must be admitted that control was far from being satisfactory. When specifications for mould dressings were drawn up, for example, it would be found that not much real progress had been made. Feeding was another operation about which there was still a surprising difference of view and of practice. This was particularly the case when judging the practice to be adopted in adding feed metal to a large ingot, for example. There was the question of when to add the feed metal. Was it a good idea to add it in small quantities, maintaining the temperature of the feeding metal, or to add it in two or three large portions, or was it better not to add any feeding metal, but to use the hot-top device to make the ingot self-feeding?

All these considerations had a new significance when the advance of continuous casting was considered, because it would be seen at once that quite a number of these ill-controllable variables presented no difficulty at all. The question of mould dressing was practically settled without much debate or anxiety, and the mould surface became a more stable and less troublesome thing, and the problem of feeding was almost completely and automatically settled. As had already been well expressed by Dr. Smithells, control became the less precarious and the more reliable as the true understanding of processes advanced. An important stage in this progress was the ability to isolate, and then to measure, the significant factors. While waiting for this development, which might take some time, it must be realised that control was made unduly onerous by measuring an unnecessary number of data, many of which were ultimately shown to be irrelevant. This struck right at the root of one of the prevailing problems, which was the provision of sufficient numbers of suitably trained men in industry, but the pressure resulting from the lack of these men could be lessened if industrial processes were analysed so as to reduce the number of stages at which close control had to be achieved. The best hope of arriving at that position was for metallurgists to examine, analyse and understand the function of each of the variables in their production processes.

Dr. C. E. Ransley stated that gas content was not now a somewhat mysterious factor to be judged by *ad hoc* methods, but could be measured with considerable precision by vacuum-extraction technique. In the case of hydrogen in aluminium, and probably with other metals as well, it was incorrect to assume that just because the solubility in the solid was a good deal less than it was in the liquid metal, hydrogen was automatically ejected from the liquid in freezing. High-purity metal, when direct chill cast, however, developed a negligible amount of porosity, even when the gas content was as high as 0·6 c.c. per 100 grammes. To put this in the right perspective, it should be stated that the solubility of hydrogen in aluminium was of the order of 0·7 c.c. per 100 grammes. In other words, a gas content representing near saturation of the liquid at the freezing point could be almost completely retained in solid solution on casting at the normal direct chill-casting speeds. The presence of an appreciable freezing range, however, greatly modified this situation. The virtue of the direct chill-casting process over the normal chill-mould casting was not that an expulsion of gas was obtained, but merely a more rapid rate of freezing.

Porosity development in blocks for rolling, though technically undesirable and also capable of leading to indirect effects, need not necessarily result in blister formation in the final rolled sheet. A blister occurred only when, in combination with a high gas content, there were flaws in the rolled sheet which were comparable in depth with the thickness of the overlying metal. It could be seen, therefore, that flaws occurring near the surface of a sheet were important, and it was thus very desirable to avoid porosity near the surface of the cast blocks. The gas content of a bath of freshly-melted metal, whether this were pure or consisted of an alloy, was a variable quantity, and was usually too high for the metal to be cast without any treatment at all. Electric and fuel-fired furnaces of widely different types could be used successfully for aluminium production, provided certain factors were recognised. The most important of these was certainly temperature control. High temperatures were particularly deleterious.

Provided that the gas content was less than a certain figure, there would be no appearance of blister. If it were higher, blister might or might not appear, and, the higher the gas content, the greater the chances of blister occurring. Another factor had an influence, and this was the question of loss of gas in processing. That was a factor on which work was still in progress, and it was certainly very important. Pure aluminium, if held at temperatures of less than 750 deg. C., tended to lose gas by diffusion, and metal of a quality suitable for direct casting could be obtained without much difficulty. Alloying elements, however, could exert a potent effect on gas behaviour. Magnesium, in particular led to marked gas pick-up by the molten metal, so that holding, by itself, was not effective for alloys containing this element. Thus, a quite decisive de-gassing treatment was required if good-quality rolled metal were to be obtained. Since gas pick-up also occured if the melt were allowed to stand subsequent to the de-gassing, casting should take place soon after the de-gassing treatment had been carried out. The best results were obtained only if the metal temperature were kept as low as possible during the de-gassing process.

Mr. W. Vinaver said that when rolling ingots of zinc, cast by the conventional open-top method, there was notoriously a marked difference between the top and the bottom sides of the ingot, and consequently of the rolled sheet. It was usual, in France, in zinc-rolling shops to speak of the "good" side and the "bad" side of the zinc sheet, the "good" side being the lower side and the "bad" side the upper side of the ingot. This difference between the sides could be attributed to different crystal structure, to different chemical composition and to blisters which occurred at the upper surface; but attention had been directed to the fact that, in some cases, it was the "good" side of the sheet which, in fact, was the bad side, and when bending tests were made on the sheets, cracks sometimes occurred in this "good" side but not in the "bad" side. It had been found that, in all these abnormal cases, some zinc-iron intermetallic-compound crystals could be detected at the lower half of the sheet, near to the surface, and the iron content could be as low as 0·025 to 0·030 per cent.

At this stage of the proceedings, the chairman asked the authors if they would care to reply to any points raised in the discussion. In response, Mr. C. W. Roberts said that, in this country, outputs did not justify the expense involved in the semi-continuous casting of zinc. Another author, Mr. R. T. Staples, stated that the problem which Mr. Hurst and he had hoped would provoke discussion had undoubtedly done so, and that was the question of gas control. Using the techniques which they had outlined, gas-content checks on hot-rolled blank showed a hydrogen content as low as 0·17, and quite commonly under 0·2 c.c. per 100 grammes, a level below which troubles should not be experienced subsequently with blisters. In discussing blister, it was perhaps important to note that there was one problem with blister in the Duralumin type of alloys and probably another problem with pure aluminium, and the nearly-pure types. They had not experienced trouble of any serious order with the nearly-pure types. They could produce a Duralumin sheet with only a few per cent. (varying from batch to batch) of blister, and they had such confidence in their technique that they did not do any de-gassing at all in the duplex furnaces.

Mr. J. Sykes said in answer to Mr. Christopher Smith's question regarding the pouring temperature of cadmium copper, that if the temperature were low, bad casting resulted because the metal was sluggish.

Another author, Mr. C. L. M. Cowley, said that a question had been asked as to whether there was any serious iron contamination of the melt when a continuously-immersed thermocouple having an iron-chromium sheath was used. They had found no serious iron contamination from using these couples. The general attack on the couple sheath was relatively small and usually this failed owing to localised attack.

One of the last speakers in the discussion, Dr. R. T. Parker, emphasised the plea put forward by Dr. Smithells for really fundamental work to be carried out if any progress in the control of quality were to be made. Winding up the discussion, the chairman said that the meeting had been most interesting and stimulating and had done a great deal of good in bringing the industry closer together as a whole. A vote of thanks to the individual authors of the papers and to the *rapporteur* terminated the session.

(*To be continued.*)

New Heavy Turbine Shop at Fraser and Chalmers Engineering Works.—The new heavy turbine shop which is now under construction at the Fraser and Chalmers Engineering Works of the General Electric Co., Ltd., at Erith, will have a floor area of 58,000 sq. ft. and will consist of two sections, a main bay 130 ft. by 360 ft. long and an annexe 40 ft. by 280 ft. long. A reinforced-concrete test pit will be provided in the floor of the main bay to accommodate up to three 120-MW sets, and for running tests steam will be available at a pressure of 650 lb. per square inch and at a temperature of 850 deg. F. The equipment will include a planer with two vertical and two side heads for machining the castings for 120-MW turbines. The preparatory work has included the re-alignment of nearly four miles of railway sidings.

King George III Collection of Scientific Instruments.—Approximately one-half of the Science Museum's King George III collection of scientific instruments is now on permanent exhibition in one of the reconstructed galleries, and a descriptive catalogue of the complete collection, price 7*s*. 6*d*., is available. A guide book, price 6*d*., has also been prepared. The collection comprises more than 350 scientific instruments and pieces of apparatus, the majority of which were acquired between 1740 and 1768 for the instruction of George III in his youth. The instruments cover a field of study known then as "experimental philosophy," and while the collection is particularly rich in material for experiments in mechanics, pneumatics and electricity, numerous examples are also included of instruments used in astronomy, optics, surveying, magnetism, acoustics, chemistry and heat.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 470.)

We continue below our report of the discussion which followed the presentation of the paper on "The B.S.R.A. Resistance Tests on the Lucy Ashton," at the Spring Meeting of the Institution of Naval Architects.

Dr. J. F. Allan considered that the detailed results for the Lucy Ashton, ship and models, were a valuable contribution to the study of resistance scale effect and provided evidence on the associated effects of hull roughness, subjects which were receiving particular attention in Great Britain and in other countries concerned with shipbuilding. The seventh International Conference, covering those subjects, was to take place next year, and important decisions would then be taken. It was desirable that as many data as possible should be published before then, and, against that background, the presentation of the results in the paper was very timely. It was particularly important to publish the data in detail, for many people would wish to plot the answers in their own way and come to their own conclusions. The data sheets in Appendix I showed the difficulties encountered in using open water, such as the Gareloch, as well as a large experimental tank. Without detracting from the importance of the work, he noted that it gave only a few spots on the diagrams, rather than a complete picture, a fact which was acknowledged by the authors in their final paragraph, where they pointed out that further similar work was required on larger and fuller forms. The heavy costs involved made progress in that direction difficult, but some comparable work was in progress in Holland and the United States, and it would be interesting to see whether all the results fitted into a common pattern.

The general order of accuracy of the observations was significant. Much of the work was done at the National Physical Laboratory and particular care was taken to obtain consistent measurements. It was thought that those model results were correct within $\pm 0 \cdot 5$ per cent., and it would be valuable if the authors would give some indication of the standard of accuracy which they would attach to the ship measurements. In the course of the model experiments, the effect of tank boundary interference became evident, and a particular study had been made of that subject as a result of its being brought into prominence. In passing, it should be noted that there was no important boundary interference effect in the normal commercial-model test tank at Teddington.

Mr. R. W. L. Gawn, O.B.E., said that the upshot of the paper was a vindication of the methods which, more than 80 years ago, revolutionised naval architecture and had since played a dominant part in contributing to the propulsive efficiency of all classes of ship. Both the pioneer and his son steadfastly followed a policy of consistency in all their work, pending information which would make the outcome more clear. The paper showed that models could be too small, and, for different reasons, too large, and that there was still much to be learned concerning skin-friction resistance. The wisdom of the Froude's policy was endorsed, but the paper went much further by indicating the scope for refinements in prediction. The authors' table indicating the percentage excess of the ship resistance over the predictions from the models at various speeds, for the two hull conditions considered, showed that predictions from model hull-resistance tests and Froude's frictional coefficients agreed closely with the measured ship resistance for the smoothest hull surface tested at the high speeds for that ship, above 11 knots. Dr. Allan observed that the authors supported Schoenherr, but he (Mr. Gawn) wished to point out that, if the standard roughness coefficient of 0·0004 were applied to the Schoenherr frictional line, the predictions were about 3 per cent. greater than Froude's. He proposed to add to his remarks a table that he had prepared, which would bring that out. He thought that the text of the paper did not indicate sufficiently clearly the remarkable closeness between Froude and Schoenherr.

One interesting point was that the reliability of the prediction seemed to vary with speed. Speed trial analysis of warships indicated that the resistance deduced was less than that of the ship by an amount greater than the 5 per cent. error—not very much, but broadly that amount was constant over the speed range. It varied equally with Froude and Schoenherr. There seemed to be a better link-up, in that respect, with the Telfer prediction. However, there was certainly a problem here, and it emphasised the authors' plea for further information on larger ships. Generally the ships he had referred to were longer and faster than the Lucy Ashton; for example, the speed of 14 knots for the Lucy Ashton became, on Reynolds' number similarity, less than 5 knots for a 600-ft. ship. Similarly, the low speed of 5 knots for the Lucy Ashton was only about $1\frac{1}{2}$ knots for the longer ship. The wind resistance of the ship was relatively more pronounced at slow speeds, ranging from 10 to 20 per cent. of the measured resistance. The wind-resistance coefficient of the ship, as obtained from wind-tunnel tests, was about 1·26 in a head wind; generally speaking, that was about 50 per cent. greater than in most cases, and greater than any to which he could find any reference. There was no doubt that the experiments were done correctly; but he would like the authors to consider that matter, for, if the wind resistance had been exaggerated, the deduced water resistance would be correspondingly increased and a closer overall relation with model predictions would be obtained.

The trip wires increased the model resistance by as much as 2 per cent. in some conditions. Since the investigation proved that they were not necessary, it would appear appropriate to delete their effect from the correlation, and, to that small extent, the difference between prediction and measurement would be reduced. The authors had made a commendable approximation of the magnitude of the contribution of form effect to skin-friction resistance. He hoped that it would be followed up, but suggested that it could not be represented by a constant percentage addition, as it would vary with wave-making and, therefore, with speed. There was indirect evidence of that from speed-trial results for fast ships, and there was also very good theoretical confirmation in the paper which Mr. Guilloton presented to the Institution in 1952. The authors made special reference to the lessons learned on that subject from aerodynamic research, but, he thought, that remark did less than justice to naval architects; the work on aerodynamics was extremely valuable, but it did not take account of the complications arising from the free surface. On that problem, the Institution's *Transactions* for 1916 contained some detailed information by Dr. G. S. Baker for various ships. Much of it was in line, at low speed, with the 8 per cent. increment mentioned in the paper, but the fuller forms gave a bigger coefficient.

Professor Kenneth S. M. Davidson, of the Stevens Institute of Technology, in the United States, described the paper as "remarkable and important." Not since William Froude's time had there been so authoritative and complete a report on the relation between ship and model resistances. The outstanding fact was that, in the interval since Froude's time, no significant improvement had been made on his basic assumptions—not for want of trying, or because anyone had believed implicitly in those assumptions, but simply because the assumptions were obviously good to a first order of approximation and because to achieve a second order of approximation had proved to be very troublesome. In trying to achieve a second order of approximation, one of the most baffling problems had been to get reproducible experiments from which to start. Progress had been made in that direction in the past 20 years or so through recognition of the importance of avoiding partial laminar flow, in which connection the choice of the Lucy Ashton seemed to have been a peculiarly happy one. Apparently, the tests reported on the hull form of the vessel, with its fine ends, could be accepted with little question as to turbulence. On that happy basis, and taking for granted the method employed to correct for tank-wall effects, it was found that (with a minor reservation) all the models tested could be aligned in accordance with Froude's assumptions, on various consistent functions of the

Reynolds number, to within about 1 per cent. over the entire speed range. That was a significant result, and could only be construed as evidence in support of both the Froude assumptions and the Reynolds number concept for dealing with skin friction. Further, it presented the question whether there was any real need to consider possible refinements of either the Froude assumptions or the Reynolds number concept if 1 per cent. consistency could be obtained by present methods. He would not attempt to disclaim his own partiality for the Schoenherr line; he had yet to see any other line that, with continued experience, had stood up so well, and he was impressed by the fact that, in the authors' extrapolation diagram on the Schoenherr basis, the consistent alignment of the various models was also consistent with the Schoenherr line for planks. That again was supporting evidence for the Froude assumptions, because there were thus two forms involved, the Lucy Ashton form and the generalised plank form represented by the Schoenherr line; both conformed simultaneously with the assumptions.

It was important, however, to distinguish clearly between the two Froude assumptions. The first, that skin friction and wave-making were additive components of the total resistance, was one thing; the second, that the friction of the ship was equal to the friction of the "equivalent" plank, was another. If the second were questioned, while allowing the first to stand, it was easy to produce "modified" Schoenherr diagrams of the type given in the paper; but—which, he thought, was the real issue—the model tests alone were not good enough to permit a clear decision to be drawn upon the relative merits of the extrapolation diagram on the Schoenherr basis and the modified extrapolation diagram on that basis, given in the paper. To decide from the model tests alone would evidently require a consistency among the model tests of materially better than 1 per cent. Any performance expressed must rest, therefore, upon other considerations. He was not averse, on principle, to introducing other considerations; but he did object to the flat statement in the paper, regarding the modified Schoenherr expansion, that "there is little doubt that the real model friction is at that level" (8 per cent. above Schoenherr), because, however plausible, it rested almost wholly upon other considerations and he did not think that the evidence was good enough. He suggested also that the impulse for introducing the modified Schoenherr expansion in that instance was the vanishingly-small roughness intercepts for the full-scale ship at the lowest speeds. Admittedly, the modified expansion increased those intercepts, but it did not produce a uniform intercept over the whole speed range, nor, in fact, did it alter materially the trend of the variation of the intercept with speed.

At the opposite end of the range, the slightly higher resistance of the two smallest models at very low speeds obviously tended to support the idea that the Schoenherr line might be a little low, in the region of small Reynolds numbers. That idea had been in his mind for a long time, but he found conclusive evidence extremely difficult to obtain. The accumulated evidence on hand at the Experimental Towing Tank was being re-examined, and he hoped to make a further statement about it at the American Towing Tank Conference in May. Meanwhile, he was not much concerned because the smallest Lucy Ashton models, at their lowest speeds, were a little high with respect to the Schoenherr line. He noted also that the authors of the paper attached little weight to it. Nevertheless, he wanted to test, say, a 6-ft. model, to fit into the series. A satisfactory resolution of the friction and expansion problems was beginning to appear, and the present was a good time to make haste slowly. They ought not to expect anything in the nature of an ultimate resolution of those problems until the state of the art of model testing had been brought to a point where consistency among geosim model tests could be expected to within considerably better than 1 per cent. That lead to his main question: was there a practical need for such refinement? No doubt, the necessary refinement could be effected in due course, but only at considerable cost in time and effort—and there were many other problems demanding time and effort.

(*To be continued.*)

LABOUR NOTES.

British Railways conveyed more goods during the past winter than in any winter since the war and some classes of traffic provided record loads. In a review of winter freight operations, issued last Sunday, the Railway Executive states that this satisfactory working was achieved in spite of some of the worst weather for several years, including an exceptional amount of fog. The heavy traffic movement was assisted by the steady progress which has been made in the through working of trains, locomotives and crews, between the different Regions. This enabled many alternative routes to be developed which were not previously available. Other important contributing causes were the elimination of duplicate and overlapping services and the introduction of new standard equipment. Even more equipment would have been constructed and introduced had steel supplies permitted.

Prolonged periods of bad weather frequently made it necessary for railway staffs to undertake special week-end working and the Executive reports that the men performed these tasks "readily and with good heart." The co-operation of trade and industry in forward planning and in the quick turn-round of wagons was a major factor in the successful movement of traffic. From the week ended September 13, 1952, to the week ended March 28, 1953, deep-mined and opencast coal moved by rail amounted to 9,244,767 wagon loads, compared with 9,086,327 wagon loads during the corresponding period twelve months previously. Between September 7, 1952, and March 21, 1953, the conveyance of home-produced iron ore, one of the main divisions of traffic in post-war years, reached a level of 5,939,302 tons, compared with 5,482,233 tons during the corresponding period twelve months previously. During the week ended March 30 last, 338,395 wagons of coal were cleared from British collieries, the highest weekly total since 1949. The tonnage of iron and steel carried during the week ended September 27, 1952, was 235,919 tons, the highest figure on record for any one week.

The coming of the automatic factory in the not far-distant future was forecast by Mr. F. G. Woollard, a director of the Birmingham Aluminium Casting (1903) Company, Limited, in the course of an address, last Saturday, at a conference arranged by the British Institute of Management at Gleneagles, Perthshire. He said that the necessary technical equipment was already available, and considered that such factories, suitable for undertaking mass-production work, could be constructed as soon as they were considered to be economically desirable. In his view, automatic-factory methods should be adopted, in the main, to reduce costs, meet competition and increase production. There could be no doubt that, in the long run, the new production techniques would increase employment, but, in the early stages, there would be, inevitably, some displacement of personnel, with its consequent hardship. There would also be the problem of teaching new methods to "old hands."

Negotiations between the Transport and General Workers' Union and the Railway Executive are still in progress respecting the unions' claims for increased rates of pay for women, youths and boys employed in railway workshops. The union reports, however, that some improvement has been offered by the Executive on its original proposals and that a further meeting between representatives of the two sides is being arranged. The vexed question of rates of pay for the welding grades employed in railway workshops, which has caused so much difficulty in the past, is also reported to be steadily approaching a solution.

Very general agreement is reported to have been reached between engineering firms and the unions concerned for the substitution of a longer holiday at the time of the Coronation for the Whitsun week-end. The scheme has the approval of more than 80 per cent. of engineering plants in the South-West of England. The employees of these firms will work the normal hours during Whitsun, and will take, in lieu, a paid holiday from Friday evening, May 29, to Tuesday evening, June 2, and will resume work on Wednesday morning, June 3.

There was an unofficial strike of dockers employed at Tilbury during the early part of this week. The trouble began on account of the employment, at Tilbury, of 70 stevedores from the Millwall Docks. These men were sent to Tilbury on Thursday night last week because it was anticipated that the number of dockers there would be insufficient to cope with the available work. The Millwall stevedores were employed during the following day, but the expected shortage of labour did not arise, and several local dock employees were unable to obtain work at Tilbury and received only attendance money. When it was found last Saturday that men from another part of the Port of London were still being employed at Tilbury, some of the Tilbury employees came out on strike. The dispute, though unofficial, spread rapidly, and, by Monday last, nearly the entire labour force at Tilbury was idle, and work was stopped at 15 of the 16 ships in the docks; the exception being the vessel which the Millwall stevedores were engaged in unloading.

The men decided at a mass meeting last Monday to continue the strike, in spite of their union's advice to resume work. One of the difficulties in the way of a settlement was the "continuity rule" agreement, which operates throughout the Port of London and provides that once men have been allocated to a particular job, they remain with that ship until the task is completed. A further complication was that the Millwall men belong to the National Amalgamated Stevedores and Dockers, while the Tilbury men, both dockers and stevedores, belong to the Transport and General Workers' Union. However, at a meeting of representatives of the two sides on Tuesday, the N.A.S.D. agreed to waive their members' rights under the continuity rule. This enabled the Millwall stevedores to be withdrawn, and work was resumed on all vessels at Tilbury on the same day. The conciliatory action of the N.A.S.D. was well received, especially as it is understood that there is a surplus of manpower at Millwall Docks at the present time.

The court of inquiry set up by the Ministry of Labour to investigate the dispute at the Austin Motor Company's Longbridge works at Birmingham commenced its sittings in London on Tuesday last. The National Union of Vehicle Builders was represented by Mr. W. T. Wells, M.P., and the company by Sir Godfrey Russell Vick, Q.C. The chairman of the court, Sir John Forster, Q.C., invited Mr. Wells, as the representative of the side that had asked for the inquiry, to present the case for the union. Mr. Wells submitted that the shop steward over whom the dispute arose had been "selectively" dismissed and claimed that the company, by not re-engaging the man, had failed to honour its agreement not to take on new operatives from outside until redundant employees of the company had been absorbed.

Mr. Wells suggested that, in addition to the question of the shop steward's dismissal, the issues before the court were whether the firm had failed to fulfil an undertaking or agreement that new personnel would not be engaged until persons made redundant had been absorbed; whether the men were justified in stopping work after five months of fruitless negotiations; and whether the firm was justified in issuing notices, the effect of which was to dismiss any striker who had not returned to work by the subsequent Friday, March 27, and in not modifying that ultimatum in view of the union's offer to call off the strike by March 30 at the latest. Sir Godfrey submitted that another vital question for the court to consider was whether the union was seeking preferential treatment for the shop steward concerned. It was not disputed, he said, that all members of the union should have the same protection, but preferential treatment for a shop steward was something which no union had ever sought.

THE MEASUREMENT OF SURFACE FINISH BY PNEUMATIC GAUGING.*

By M. Graneek, B.Eng., A.M.I.E.E., and H. L. Wunsch, M.Eng., G.I.Mech.E.

While existing types of stylus recording instruments provide an overall assessment of surface quality, experience has shown that there is a need for a portable and inexpensive form of comparator, suitable for general use in engineering workshops and inspection rooms. For workshop control, increasing use is being made of sets of comparison specimen blocks, exhibiting various grades of texture, in which the specimen and the product are compared by sight or touch. This process of selection is entirely dependent on the personal judgment of the inspector, and many of the difficulties that arise in practice can be overcome by the provision of a simple type of comparator, giving a numerical assessment of the variations in finish. The present article describes the adoption, for this purpose, of two alternative designs of pneumatic comparator, recently developed for precision linear measurements.

The application of pneumatic gauging to the measurement of surface roughness was initially developed in France by Nicolau,† who, by making use of a standard type of Solex air-operated gauge, showed that the variations in surface texture can be registered as pressure changes on a water manometer. More recent applications of this basic technique, including the use of high-pressure air‡ and the design of pneumatic gauges§ with a good speed of response have led to the development of a robust comparator of high sensitivity which appears to bridge the gap between the more expensive instruments and the comparison-block method.

Details are given of a special design of measuring jet, suitable for the examination of both flat and cylindrical surfaces. Results obtained with the pneumatic comparator on a series of ground and turned surfaces, having different grades of finish, showed that a reasonably linear relation existed with the corresponding Centre-Line Average (C.L.A.) readings.‖

The basic principle of gauging with compressed air has been widely applied in engineering practice for many years for controlling the linear dimensions of machined components. Briefly, it consists in observing the resistance to the escape of air from a valve or jet, the delivery from which is controlled by the dimension of the component being measured. This technique has also been applied by Nicolau to assess the variations in surface texture of machined components, using a cylindrical design of measuring jet which receives air, at a pressure of about 1 lb. per square inch, from a Solex gauge. The jet is enclosed in a guard ring, which protrudes slightly beyond the outlet of the jet and contacts the surface under test.

Figs. 1 and 2, herewith, show enlarged views of the measuring head in contact with two surfaces, one finished by optical polishing and the other by diamond turning. When the measuring head is applied to the perfectly smooth surface, air escapes from the jet to atmosphere through the small holes drilled in the wall of the guard ring. On a rough surface, the rate of flow of air to atmosphere is increased, which causes a change in the water level in the Solex manometer. With the introduction of the high-pressure gauging system by General Motors-Holdens, of Australia, designed to operate off the shop air-line, the pressure changes corresponding to variations in surface texture can be registered directly on a standard type of scale and pointer instrument.

* Communication from the Mechanical Engineering Research Laboratory. Abridged.

† M. P. Nicolau, "Position du problème industriel des aberrations géometriques des surfaces." Conférences de la Société D'Encouragement pour L'Industrie Nationale, 1948.

‡ "Air-operated Gauges." *Production and Engineering Bulletin*, issued by the Ministry of Production. vol. 4, No. 28 (1945).

§ M. Graneek and J. C. Evans, "A Pneumatic Comparator of High Sensitivity." *Engineering*, vol. 172, page 414 (1951).

‖ *The Assessment of Surface Texture (Centre-Line Average Height Method).* British Standard 1134: 1950.

Details of Pneumatic Comparators.

Two alternative types of pneumatic comparator, recently developed for precision linear measurements of length, have been adapted at the National Physical Laboratory for assessing the variations in surface texture. Each unit is capable of high sensitivity with a good speed of response. Their working elements are briefly described below.

Piston-Type Comparator (National Physical Laboratory).—Referring to Fig. 3, herewith, the essential elements of this unit consist of a hollow piston which is a good sliding fit inside a cylinder of ½-in. bore. Compressed air, maintained at a constant pressure by a precision pressure-regulator, is supplied to the centre of the cylinder, whence it flows downward through the hollow piston to the

Fig. 1. MEASURING HEAD ON PROOF PLANE.

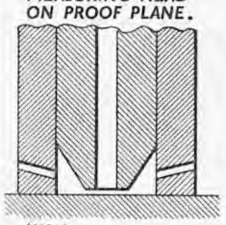


Fig. 2. MEASURING HEAD ON ROUGH SURFACE (DIAMOND TURNED).

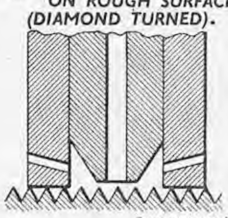
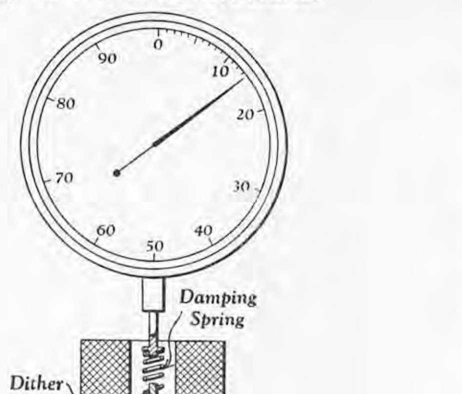


Fig. 3. PISTON-TYPE COMPARATOR.



control orifice. After flowing through the orifice, the air passes to the lower part of the cylinder and then, by means of a short length of small-bore flexible tubing, to the measuring head. As the escapement area at the measuring head varies according to the roughness of the surface, the corresponding change in the pressure underneath the spring-loaded piston results in a small displacement of the piston, which is indicated on a dial gauge. The effect of static friction between piston and cylinder is overcome by vibrating the piston over a small amplitude in an axial direction by means of the "dither coil," supplied with alternating current at mains frequency. Fig. 4, on page 506, is a general view of the prototype instrument. The air supply required for the comparator may be obtained from the normal shop line or from a small auxiliary compressor.

Diaphragm-Type Comparator (Sigma Instrument Company, Limited.).—An alternative design of comparator, using a flexible diaphragm in place of the piston, has been developed commercially. The details are shown diagrammatically in Fig. 5, on page 506. Air at constant pressure is passed to the outside of the diaphragm and then through the control orifice to the inside of the diaphragm and, finally, to the measuring head. The force corresponding to the differential pressure across the diaphragm is transmitted by the drag wire to the control spring. In operation, variations in escapement area at the measuring head thus produce movements of the drag wire, which are amplified by a mechanical lever system, and the final result is indicated by the angular movement of a pointer across a scale.

Design of Measuring Jet.

Basic Design Data.—The design of the measuring jet is based on the pneumatic principle, previously described elsewhere. The effective escapement areas M and C, and the corresponding air pressures, are related by the approximate formula $\left(\frac{M}{C}\right)^2 = \frac{P}{p} - \frac{p}{P}$, plotted in Fig. 6, on page 506, where P = constant supply pressure; p = the intermediate pressure between the control orifice and the measuring jet; M = the escapement area at the measuring jet; and C = the escapement area at the control orifice. (P and p are measured above atmospheric pressure.) For values of $\frac{p}{P}$ between 0·4 and 0·9, the characteristic curve relating $\frac{p}{P}$ and $\frac{M}{C}$ is approximately linear and can be represented by the equation

$$\frac{p}{P} = 1{\cdot}10 - 0{\cdot}50\frac{M}{C}.$$

These results have been based on a constant supply pressure P of 15 lb. per square inch, but they will serve for any value of P from 10 lb. to 20 lb. per square inch. This is demonstrated theoretically below. For a constant value of C, the above equation indicates that, within the range $\frac{M_{min.}}{C} = 0{\cdot}4$ and $\frac{M_{max.}}{C} = 1{\cdot}4$, the readings of the comparator will be approximately a linear function of the surface-roughness escapement areas. In addition, it will be seen that, when the measuring jet is applied to a perfectly smooth surface, e.g., an optical proof plane, there must be a minimum escapement area given by $\frac{M_{min.}}{C} = 0{\cdot}4$.

The characteristic curves referred to above can be derived as follows:

Assuming adiabatic expansion of the air passing through two orifices A_1 and A_2 and the pressures in the system to be as shown in Fig. 7, on page 506, then $P V^\gamma = K$, where K is a constant. The work done in expanding unit mass of air from pressure P_1 to P_2 is

$$U = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} K\,V^{-\gamma}\,dV,$$

$$= \frac{K}{\gamma - 1}\left[V_1^{1-\gamma} - V_2^{1-\gamma}\right],$$

Therefore

$$U = \frac{K^{\frac{1}{\gamma}}}{\gamma - 1}\left[P_1^{\frac{\gamma-1}{\gamma}} - P_2^{\frac{\gamma-1}{\gamma}}\right].$$

But $\gamma\,U = \frac{u^2}{2\,g}$, where u is the velocity of the air passing through the orifice; and $W = \frac{A_1\,u}{V_2}$, where W is the rate of mass flow. Therefore,

$$W^2 = \frac{A_1^2}{V_2^2}\,2\,g\,U\,\gamma,$$

$$= \gamma\,A_1^2\,2\,g\,K^{-\frac{2}{\gamma}}\,P_2^{\frac{2}{\gamma}}\left[\frac{K^{\frac{1}{\gamma}}}{\gamma - 1}\left(P_1^{\frac{\gamma-1}{\gamma}} - P_2^{\frac{\gamma-1}{\gamma}}\right)\right]$$

$$= \gamma\,A_1^2\,\frac{2\,g}{\gamma - 1}\,K^{-\frac{1}{\gamma}}\,P_2^{\frac{2}{\gamma}}\left[P_1^{\frac{\gamma-1}{\gamma}} - P_2^{\frac{\gamma-1}{\gamma}}\right]$$

MEASUREMENT OF SURFACE FINISH BY PNEUMATIC GAUGING.

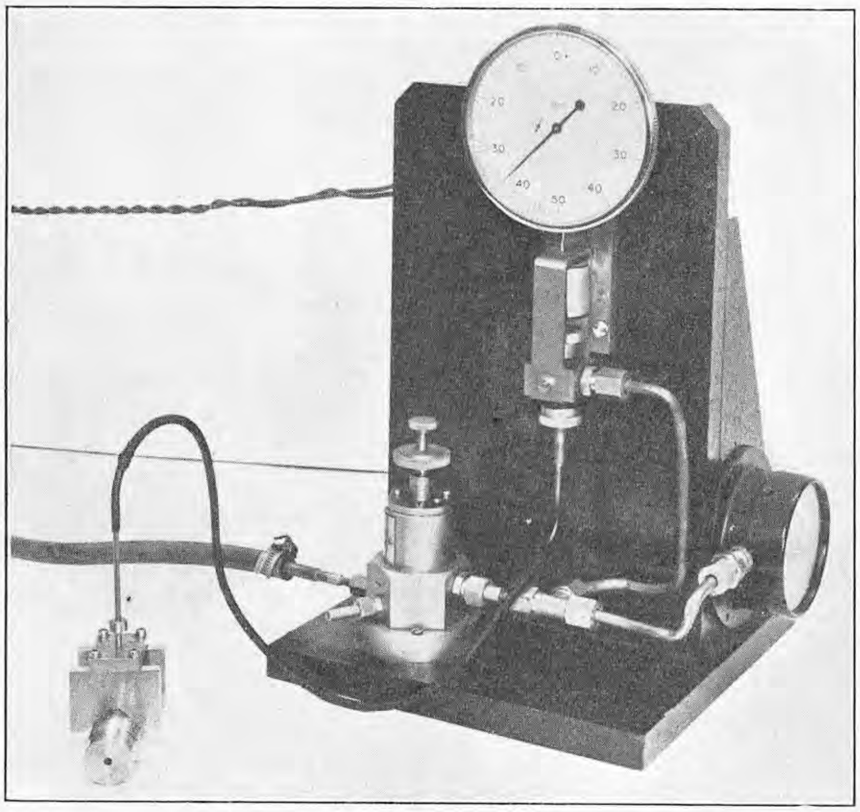
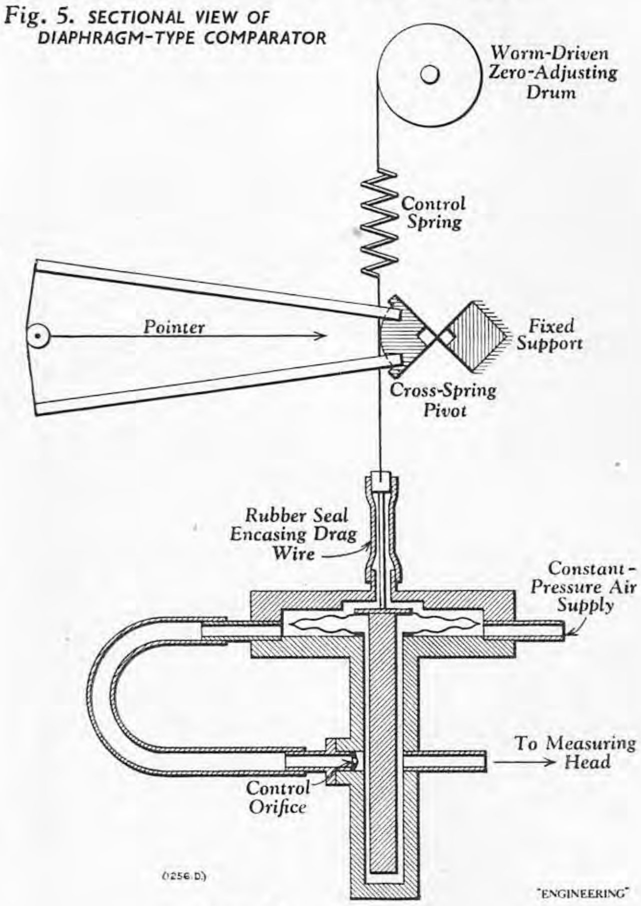


FIG. 4. PISTON-TYPE COMPARATOR.

Fig. 5. SECTIONAL VIEW OF DIAPHRAGM-TYPE COMPARATOR



Similarly, with reference to the second orifice,

$$W^2 = \gamma A_2{}^2 \frac{2g}{\gamma - 1} K^{-\frac{1}{\gamma}} P_3^{\frac{2}{\gamma}} [P_2{}^{\frac{\gamma-1}{\gamma}} - P_3{}^{\frac{\gamma-1}{\gamma}}],$$

$$\therefore \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{P_2}{P_3}\right)^{\frac{2}{\gamma}} \frac{(P_1{}^{\frac{\gamma-1}{\gamma}} - P_2{}^{\frac{\gamma-1}{\gamma}})}{(P_2{}^{\frac{\gamma-1}{\gamma}} - P_3{}^{\frac{\gamma-1}{\gamma}})}.$$

Using the nomenclature given above, $A_2 = M$, $A_1 = C$, $P_1 = P + \pi$, $P_2 = p + \pi$, and $P_3 = \pi$, where π is atmospheric pressure. Then,

$$\left(\frac{M}{C}\right)^2 = \left(\frac{p+\pi}{\pi}\right)^{\frac{2}{\gamma}} \left[\frac{(P+\pi)^{\frac{\gamma-1}{\gamma}} - (p+\pi)^{\frac{\gamma-1}{\gamma}}}{(p+\pi)^{\frac{\gamma-1}{\gamma}} - \pi^{\frac{\gamma-1}{\gamma}}}\right].$$

Fig. 8, herewith, shows the relationship between $\frac{M}{C}$ and $\frac{p}{P}$ as calculated from the above formula, assuming $\gamma = 1{\cdot}4$. The curves have been plotted for values of P = 10, 15 and 20 lb. per square inch. It can be seen that the result agrees closely with the result of the approximate formula

$$\left(\frac{M}{C}\right)^2 = \frac{P}{p} - \frac{p}{P}$$

shown in Fig. 6.

Circular Type of Jet.—The results of some preliminary tests, using a conventional type of circular measuring jet, showed that the N.P.L. design of comparator (Fig. 4) was capable of registering the variations in surface roughness on a series of ground and face-turned specimens having C.L.A. readings of approximately 4, 8, 16, 32 micro-inches, etc. This type of jet has, however, a restricted application, since it can only be applied to the examination of flat surfaces.

Slit Type of Jet.—The above disadvantage associated with the cylindrical jet can be avoided by using a slit-shaped jet. In addition, the readings obtained with the slit jet are directional in regard to the pattern of the surface-texture lay, and it is possible to obtain a direct comparison between them and the Centre-Line Average method of assessment. Figs. 9, 10 and 11, opposite, show a convenient type suitable for the examination of both flat and cylindrical surfaces. It consists of two steel plates

Fig. 6.

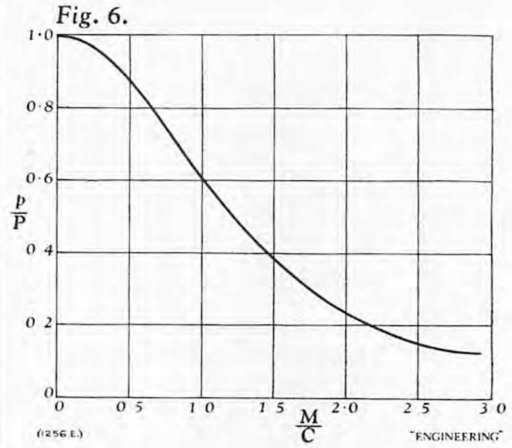
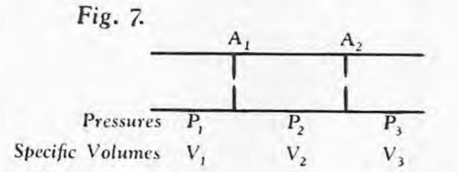


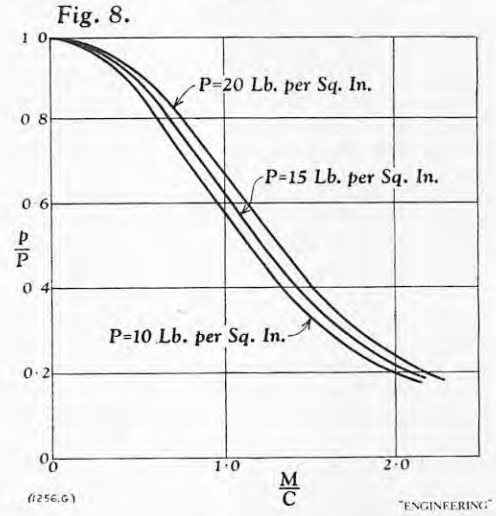
Fig. 7.



A and B, secured together. The lower surface C, which is hardened and lapped, forms the datum measuring plane. Air from the control orifice enters the unit via the flexible connection D and then flows to atmosphere through a narrow slit which is slightly offset from the datum plane by a small amount δ.

When the unit is applied to a perfectly smooth surface, the minimum escapement area of the jet $M_{min.}$ is equal to $2\,l\,\delta$, where l is the length of the slit. Thus, for flat surfaces, changes in the escapement area depend entirely on the spacing and depth of the surface irregularities. This simple relationship will also apply to the examination of cylindrical surfaces, provided that the error in escapement arising from cylinders of different diameter can be kept quite small. To achieve this, it is essential to use a narrow slit width. A suitable value can be determined as follows. Referring to Fig. 12, let $2\,x$ = the effective width of the slit, δ = the distance by which the slit is set back from

Fig. 8.



the datum surface, r = the radius of the specimen, and y = the effective escapement depth.

Then the error in escapement depth when comparing a flat surface with a cylinder radius $r = (y - \delta) \simeq \frac{x^2}{2\,r}$.

Thus, to reduce the error, x should be made as small as possible. In general, however, the measuring jet would be used for comparing the finish of specimens of similar radii. For ease of manufacture, the width of slit, $2x$, was made $0{\cdot}005$ in. and a slit length of $0{\cdot}1$ in. was selected since it is equal to one of the standard sampling lengths suggested for general use in B.S. 1134. The sensitivity of the comparator can be altered by appropriate changes in the dimension δ and the diameter of the control orifice. Using a value of δ equal to $0{\cdot}0018$ in., the results of some preliminary tests with the diaphragm-type comparator showed that the linear response of the comparator covered variations in surface finish from about 2 to 150 micro-inches (C.L.A. reading).

To facilitate the measurement of cylindrical specimens, the jet is located centrally in the V-block fixture, illustrated in Figs. 13 and 14, opposite, which ensures accurate alignment of the measuring slit in relation to the cylinder axis. It consists of two side register plates, rigidly secured to a bridge

MEASUREMENT OF SURFACE FINISH BY PNEUMATIC GAUGING.

GENERAL VIEW OF JET

Fig. 9.

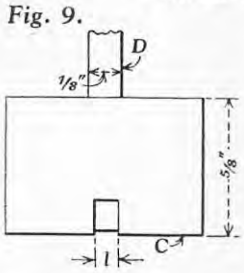


Fig. 10.

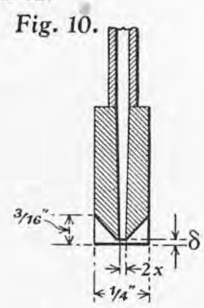


Fig. 11.

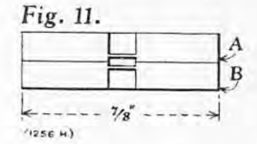
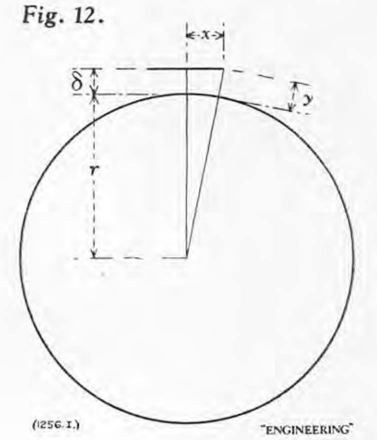


Fig. 12.



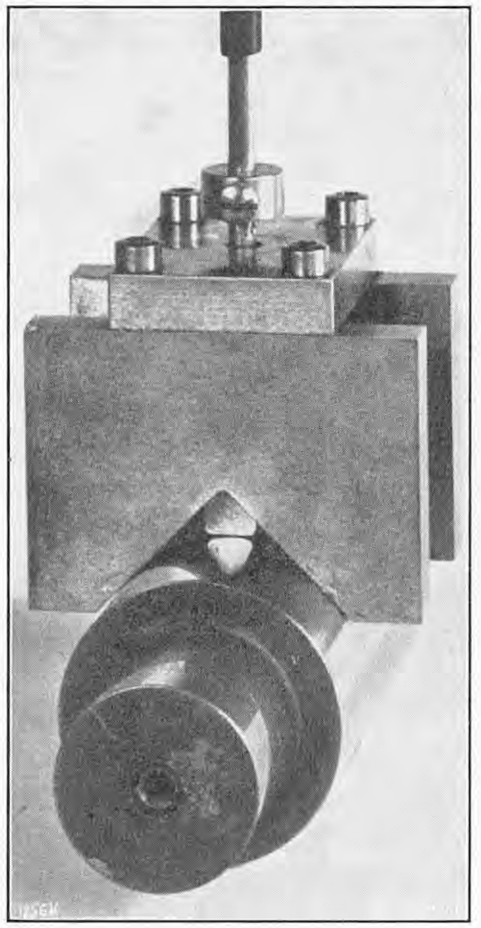


FIG. 13. V-BLOCK FOR ALIGNING JET.

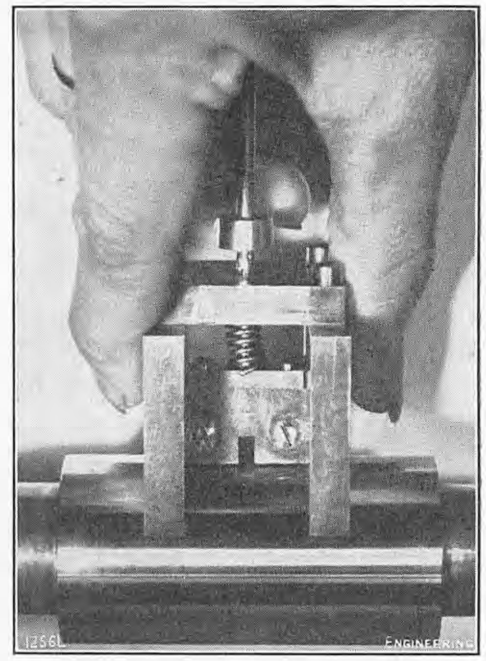


FIG. 14. PLACING V-BLOCK.

Fig. 15. RELATION BETWEEN AIR-GAUGE READING AND CENTRE-LINE AVERAGE ROUGHNESS VALUE FOR GROUND SURFACES.

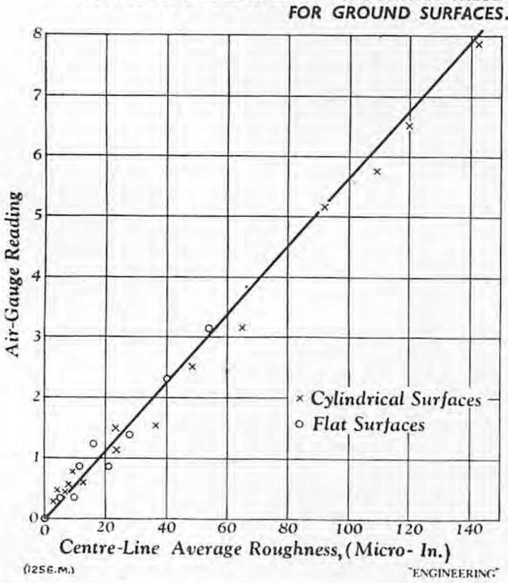
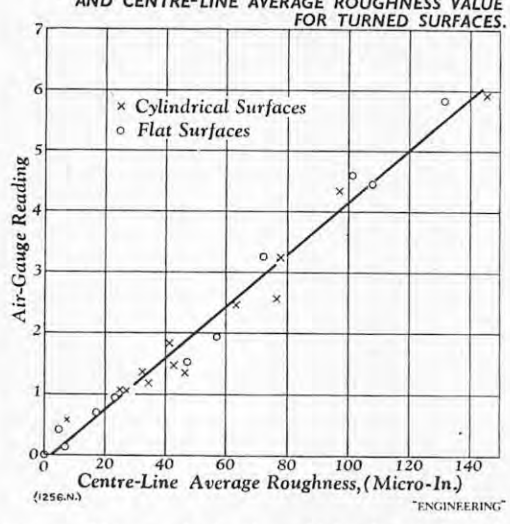


Fig. 16. RELATION BETWEEN AIR-GAUGE READING AND CENTRE-LINE AVERAGE ROUGHNESS VALUE FOR TURNED SURFACES.



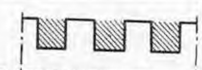
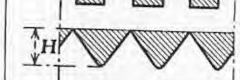
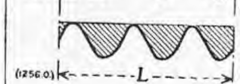
piece through which the air inlet pipe passes. The jet is an easy sliding fit in parallel grooves machined in each side plate and its movement relative to the V block is controlled by a light compression spring.

MEASUREMENT OF FLAT AND CYLINDRICAL SPECIMENS.

Theoretical Considerations.—In common with other accepted methods of surface-finish assessment, such as the C.L.A. and the R.M.S., the pneumatic readings give little if any indication of the shape of the profile, and profiles very different in form may have the same number. Each method can, however, give a useful indication of the change in surface texture on components produced by the same machining process and, consequently, finds a ready application in engineering production.

The Table herewith gives the relative values of the pneumatic escapement areas and C.L.A. values, determined theoretically for a number of surfaces having square, triangular and sinusoidal waveforms. This analysis, in which A = twice the shaded area of each waveform shown in the Table, since air escapes from both sides of the slit jet; H = the total height of the waves; and L = the sampling length, i.e., 0·1 in. for the present investigation, shows that the ratio $\frac{A}{h}$ is independent of both the pitch of the waves and of their total height. It varies for different theoretical waveforms, however, but, for any number of components produced by the same machining process, the ratio $\frac{A}{h}$ should be constant. The above analysis shows that, for general use, the two methods of assessment can be readily related by a simple conversion factor.

Practical Results.—The results of the air-gauge readings and Talysurf meter readings (C.L.A.) obtained on a series of ground and turned surfaces are graphically represented in Figs. 15 and 16, respectively, where each plotted point represents the mean of ten readings. For each machining process, representing both flat and cylindrical specimens, diameter 1 in., it will be seen that a reasonably linear relation exists between the two methods of assessment. The straight-line graphs have been fitted by the principle of least squares.

Waveform.	Pneumatic Escapement Area A.	C.L.A. Index Value, h.	Ratio $\frac{A}{h}$
	HL	$\frac{H}{2}$	2L
 H	HL	$\frac{H}{4}$	4L
 (1256 O) L	HL	$\frac{H}{\pi}$	πL

The deviation of some of the plotted points from each straight line is partly due to large local variations in surface roughness which were found to exist on several of the specimens. A further contributory cause is the presence of surface waviness or secondary texture in the specimens, as distinct from the primary texture arising from the cutting action of the tool or grinding wheel. The difference in gradient between the two graphs is associated with the change in form of the surface irregularities, which depend on the method of machining and shape of the cutting tool, and the results tend to confirm the theoretical observations referred to above.

THE LATE MR. F. P. BEST.—We regret to record the death of Mr. Frank Powell Best, technical manager of the Marconi International Marine Communication Co., Ltd., and of the Marconi Sounding Device Co., Ltd., which occurred in London on Thursday, March 26, at the age of 52. Mr. Best was born at St. Helens, Lancashire, and educated at Prescot Grammar School. He subsequently studied electrical engineering at Cambridge and Liverpool and gained the Alan Broley prize at the former and the David Rew scholarship at the latter university. He joined the Radio Communication Co., Ltd., in 1924, and transferred to the Marconi International Marine Communication Co. on the amalgamation of the two concerns. He became assistant technical manager in 1929 and deputy technical manager three years later. In 1934 he joined Marconi's Wireless Telegraph Co., with whom he was engaged in the development of equipment for marine use. Five years later, while still holding this position, he returned to the Marine Company as technical manager, and in 1940 he was also appointed to a similar position with the Marconi Sounding Device Co. Ltd. He was elected an associate member of the Institution of Electrical Engineers in 1927.

PRESTRESSED-CONCRETE BEAMS FOR RAILWAY STATION ROOF.

Fig. 1. HALF ELEVATION OF PRESTRESSED-CONCRETE ROOF BEAM AND CROSS-SECTION ON AWNING.

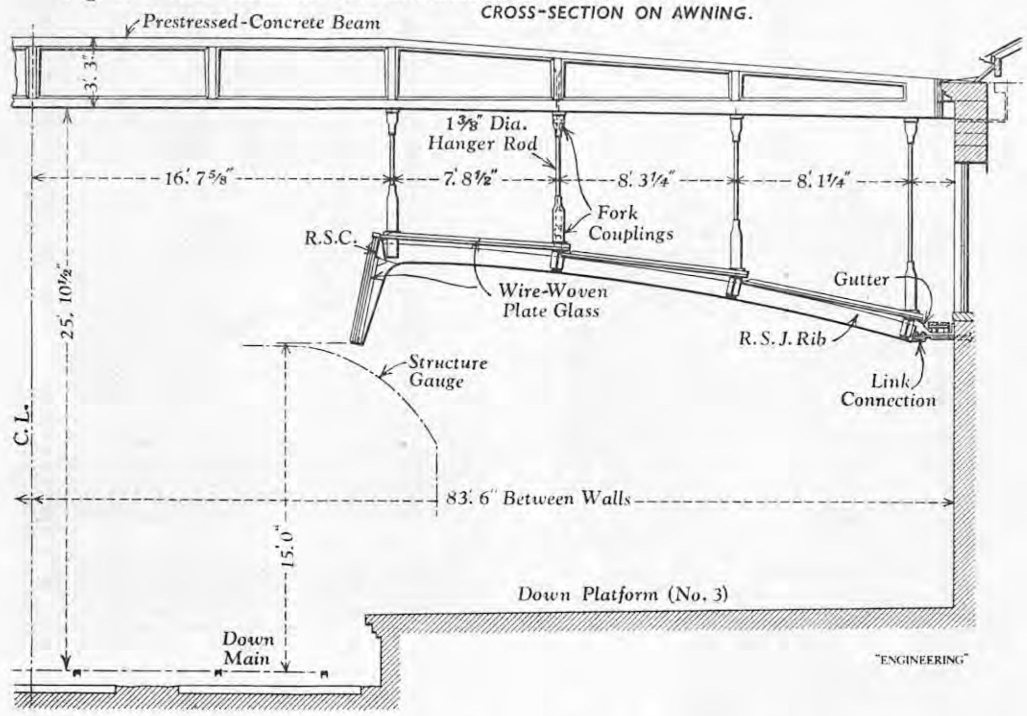


Fig. 2. SECTION AT MID-SPAN OF ROOF BEAM.

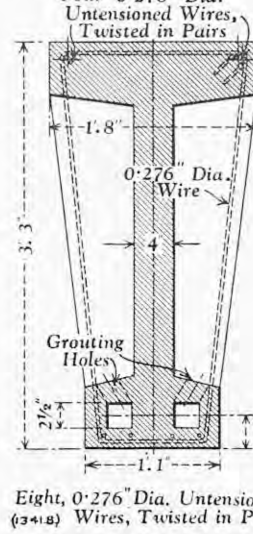
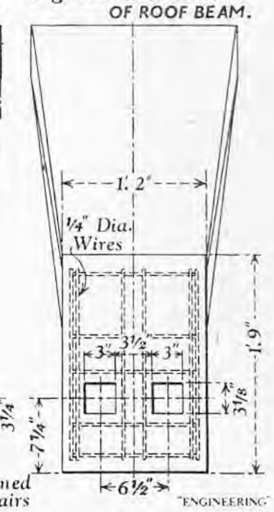


Fig. 3. END ELEVATION OF ROOF BEAM.



PROPOSED CAR PARKS IN INNER LONDON.

THE Ministry of Transport has recently issued the "Report of the Working Party on Car Parking in the Inner Area of London"* which contains much interesting information on the numbers of cars parked at different hours of the day, and the various spaces which could be used for the purpose, given, of course, the funds necessary to adapt such spaces without unduly reducing their amenities or detracting from their aesthetic value as architectural features. The Inner Area of London taken into consideration in the report, is of about 7¼ square miles, and consists of the City of London, the Metropolitan Borough of Holborn, and parts of the City of Westminster, the Metropolitan Boroughs of Chelsea, Finsbury, St. Marylebone, Shoreditch and Stepney; the total length of classified roads in the area is 76 miles, and of unclassified roads, about 170 miles.

After considering various suggestions the conclusion arrived at is that "the only satisfactory solution of the problem would be the provision of a great many more garages, some of them under certain London squares." In addition to the provision of underground and multi-storied garages, however, the introduction of parking meters together with "a new and balanced system of waiting regulations" is also recommended. The report accordingly recommends that a start should be made with the construction of four underground garages to be located under Grosvenor-square, Cavendish-square, Berkeley-square and St. James's-square, since the survey showed that, at any time, about 2,900 cars are parked for a period exceeding two hours within a distance of a quarter of a mile from these squares. These four underground "Square Parks" would accommodate 1,820 cars, leaving a balance of about 1,000 cars for which multi-storied garages would be required to be constructed in the same neighbourhood. The construction of the four underground "Square Parks" was estimated, at 1951 prices, to entail an expenditure of 1¾*l.* million. The type of construction illustrated in the report presents no engineering difficulty, but involves a great deal of excavation. After completion of the structural part of these schemes, the amenities of the squares in the form of lawns and paths would be reinstated at their present levels, leaving only the entrance and exit ramps as a source of possible offence.

* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

NEW ROOF AT VICTORIA STATION, SHEFFIELD.

THE roof at Victoria Station, Sheffield, on the Eastern Region, British Railways, is being replaced by a new permanent covering which embodies precast prestressed-concrete beams spanning 83 ft. 6 in. between existing platform walls and carrying fully-glazed awnings of light-weight construction. An elevation showing half the span of the beams and a cross-section through the awning is shown in Fig. 1, herewith, and the two detailed drawings, Figs. 2 and 3, show a section of the beam at mid-span and an end elevation, respectively. The first stage of the erection was carried out during Sunday, March 22, when nine of the 16 beams to be erected were put into their final position.

The original roof spanning the main-line platforms was constructed during the period 1850 to 1880 and additional wind bracing was added in 1912. This roof was partly covered by glass and partly by boarding and slates; a lantern light was located along the central ridge. The principal members of the roof were 33 trusses of cast and wrought iron, at 12 ft. 6 in. centres, that were supported on the brick walls extending along the back of the platforms, thus giving a high-level roof over the platforms and tracks without intermediate column support. During the 1939-45 war, the station was subjected to blast from several high-explosive bombs which fell in the area, and in September, 1951, four of the original trusses, at the western end of the station, collapsed due to a concealed fracture in the cast-iron ridge-piece of one of the trusses concerned. As a result of an investigation, it was decided to dismantle the entire structure and to erect temporary awnings until such time as a new permanent roof could be constructed.

As previously mentioned, the design adopted for the new permanent roof comprises roof beams supporting light-weight glazed awnings, an arrangement which has the general advantage of ease of maintenance and also retains the beneficial feature of the original roof in that the platforms are free from supporting columns. The precast-concrete roof beams have an overall length of 87 ft. 9 in. with a rise of 4 in. at the centre; they are 21 in. deep at the ends and 39 in. at mid-span, and each weighs approximately 12½ tons. The beams are prestressed by twin cables, each comprising 16 wires 0·276 in. in diameter, threaded into the square holes shown in Fig. 2, tensioned by the Magnel-Blaton process and finally grouted in. Screwed sockets have been cast into the beams to receive the steel suspension rods that carry the awnings. The beams are being made near to the site so that they can be readily trolleyed to a point below their final position and then slung into place during short possessions of the track. When in position, the beams will generally be at 25-ft. centres, that is, on every second bearing pad of the original trusses. When the lines are operated electrically, the overhead equipment will also be suspended from these beams.

The steel framework of the awnings is clearly shown in Fig. 1, and comprises curved ribs welded from 9 in. by 4 in. rolled-steel joists, purlins consisting of 12 in. by 5 in. R.S. joists at about 8 ft. 3 in. centres, and the fascia stringers. The fascia, which is 5 ft. deep and has a front batter of 1 in 5, has a continuous bottom stringer formed by a 4 in. by 3 in. by ⅜ in. angle and a corresponding upper member of a 12 in. by 3½ in. channel that is stiffened along its lower leg by a 4½ in. by 1½ in. by $\frac{5}{16}$ in. bent plate. The fascia is strengthened by three intermediate frames in each 25-ft. bay. All connections, steel to steel, are welded. A parcels bridge, spanning both the platforms and the tracks, divides each awning into two sections of approximately 211 ft. and 177 ft.; the two centre ribs in each section of the awning are built into the wall and, in order that any movement due to expansion shall take place towards both ends of the section, the heels of the remaining ribs are linked to 3 in. by 3 in. by ⅜ in. T-pieces built into the wall. The galvanised-steel gutters are supported by T-pieces welded to the innermost purlin. The awning, including the fascia, is completely covered by glazing of ¼-in. thick rough-rolled plate glass strengthened by an embedded wire mesh; extruded aluminium-alloy glazing bars which are bolted to the steel framework have been used to hold the glass in position. Each of the curved ribs is suspended directly below a prestressed beam by four hangers made from 1⅜-in. diameter rods that are screwed into the sockets in the beams above. A turnbuckle in each hanger enables its length to be adjusted and any longitudinal movement of the awning, due to temperature changes, is taken up by forked couplings at both ends of the hangers, which are protected from the atmosphere by non-corrodible sheaths.

The design of the new roof was made under the supervision of Mr. J. I. Campbell, M.I.C.E., the Civil Engineer to the Eastern Region of British Railways, and the contract, including the fabrication of the prestressed beams, was let to Samuel Butler and Company, Limited, Stanningley, near Leeds.

DEVELOPMENT IN ELECTRICAL INSULATING MATERIALS: ERRATUM.—We regret that errors occurred in our report of the paper read by Mr. R. T. Rushalls at the Symposium on Electrical Insulating Materials, which appears on page 437 of the issue of April 3. In line 61 "moist oil-soaked pressboard" should read "moisture-free oil-soaked pressboard," while in line 69 "of up to 40 per cent." should read "up to 4 per cent."

STEAM TURBINE RESEARCH DEVELOPMENT.

(*Concluded from page* 459.)

The Second Session: Discussion.

Dr. R. W. Bailey took the chair for the discussion on the second session's papers, which was opened by Dr. J. F. Shannon. Referring to the method, described by Dr. Kantorowicz, of developing the wave-speed curves in a turbine disc, Dr. Shannon suggested that it was not suitable for such high loads. He recommended an easier method of analysis, in which the ordinates were the cyles per second and the abscissae were the numbers of nodal diameters (discs). This provided a natural arrangement which could be analysed in order. He suggested that the author should rearrange his results on the lines which were being adopted by all other workers, and thought that this would help the investigation.

Mr. P. J. Pollock, M.A., referring to Mr. Terrell's paper, observed that he had taken the temperature gradient across the cylinder wall as being the major cause of distortion; but a temperature gradient in the axial direction could also produce severe plastic strain, especially where the diameter varied appreciably along the axis. In the case of a cylindrical shell, if the temperature distribution was assumed to be uniform through the wall, but to vary linearly along the axis, no appreciable stress would be produced away from the ends; but if the ends were constrained in any way, high stresses could occur there. In 1926, some experiments were carried out on the heating of a turbine cylinder end. The cylinder was set up on end and heated by means of gas rings to a maximum temperature of 400 deg. C. at the high-pressure end. The heating was quite slow, taking about two hours to get to the full temperature. After cooling down, the cylinder was unbolted and measurements of the distortion showed that there was an increase of about 0·015 in. on the vertical diameter of 46 in. and a decrease of about 0·02 in. on the horizontal diameter, and a gap on the inside of the flange varying from 0·010 in. to 0·018 in. Those heating and cooling cycles were repeated a number of times and they showed that the distortions due to the subsequent heatings were quite small compared with the first one. In fact, after three cycles, a steady state had practically been reached and no further appreciable distortion took place. Considering a flat plate heated from one side and constrained to remain plane: if the plate were free, it would assume a spherical shape, whence it could be seen that the stress required to bend it flat again would be the same in both directions. The question then arose, how did the variation of Young's modulus, E, with temperature affected the result? The formula given in Appendix I of Mr. Terrell's paper appeared to treat E as constant. In the case of an axial temperature gradient, the error introduced by assuming E to be constant for the purposes of integration did not appear to be very large, not being more than about 10 per cent. at the most; but in the case of a gradient across the wall the error might be considerably greater. Had the author made any estimate of the influence of a varying elastic modulus on the stress produced?

Dr. N. P. Allen said that, as the temperatures in the machines rose, the problems of materials got progressively more serious. Mr. Terrell's paper, on the thermal distortion of turbine casings, illustrated a general point of some importance, which was that the problems of design could often be eased by improvements in materials, and, likewise, improvements of design could ease materials problems. There was always a materials aspect and a design aspect. Mr. Terrell had given a series of numbers which represented the susceptibility of a material to distortion, on heating essentially. It was interesting to see how great the variations were. If they did represent the susceptibility of the material to distortion, the figures showed that a great deal could be done, by suitable choice of material, to reduce the distortion problem. One conclusion that seemed to be obvious was that, as in raising the temperature it was necessary to go to oxidation-resistant materials, it was desirable to make the most of the critical 10 per cent. chromium steel, which was good in that respect, before going on to the austenitic steel. The figures for the 12 per cent. chromium-molybdenum-vanadium steel were disappointing in the high maximum permissible stress quoted. To some extent, they were on the lower coefficient of expansion. That was rather important because it was due to the admixture in the steel of a certain amount of chromium, and the chromium had a lower coefficient of expansion than iron. That seemed to be a direction in which to move. Were those figures really relating to the properties of castings, such as might be used in a turbine casing, or were they typical of forged steel materials of that kind? The steel was customarily heat-treated to get the properties quoted in the paper, and it might be that they were not so easily obtained in a casting as in a small forged part. If the figures were indeed the properties of a casting, it seemed that a great easing of the thermal distortion difficulty might be obtained; but if the properties were merely those of a typical material of that kind, it must be concluded that, while the improvements were possible, they had not yet been achieved.

Dr. Brown had spoken of his success in running a turbine on the worst fuel that he could possibly find. That was a triumph on which he was to be congratulated. On the other hand, did engineers generally realise the burdens that they put on their materials by choosing the worst possible fuels? Such fuels were cheap, no doubt, but, in general, the maximum temperature at which a material could be expected to work was lowered by the action of corrosive materials in the products of combustion of the fuel. The heat-resistant materials would normally work quite satisfactorily at temperatures up to 1,000 deg. C. if the atmosphere was free from corrosive agents, but they would break down quickly at 700 deg. C. if the fuel was corrosive.

Mr. P. D. Morris said that he was more closely associated with turbines which flew than those which were afloat, but some of the fundamental problems were the same, even though the solutions were influenced by the particular conditions of service. Furthermore, he believed that the gas turbine would become a powerful competitor to the steam turbine, and that, when the marine gas turbine was ultimately developed, it would have many closer resemblances in general construction to its flying ancestor than were yet apparent. Dr. Brown had referred to the Pametrada research in the use of the very high cycle temperature of 2,000 deg. F. The use of such temperatures must lead to a vast reduction in engine sizes, and the relative stabilisation of casing temperatures must result in a simpler construction, which would reduce thermal expansion and distortion troubles. The paper by Mr. Terrell on the thermal distortion of turbine casings was a most interesting contribution on a subject which had not received much attention in the literature. Experience at the National Gas Turbine Establishment bore out much of his philosophy. One method of reducing thermal distortion in a split casing which had been tried, was to divide the casing axially into a number of sections to get split sections on the horizontal and vertical axes, respectively, so that the distortions through heating and cooling in adjacent sections of the barrel opposed each other. The stresses involved were thus relatively small. Another method, adopted on an experimental turbine at the N.G.T.E., was the use of a double casing in which the outer, of robust construction, had a number of internal passages which could be heated or cooled by a small subsidiary low-pressure air supply. The temperature and the thermal expansion of the outer casing could be controlled and stabilised. The inner casing was of light segmental construction, supported from the outer casing. Such an arrangement allowed the clearances to be controlled by adjusting the temperature of the outer casing. The complexity of construction might make it unattractive for marine use, but it appeared to embody a principle, the development of which was still possible. There was still scope, also, for research into the use of blade shrouding to obtain a smaller leakage loss for a given mechanical clearance.

Mr. D. G. Ainley, B.Sc., suggested that Dr. Brown had not sufficiently emphasised the value which accrued to the design and research staff at Pametrada when troubles arose on the test bed, troubles which might occur in units other than those of their own design. Nor had he touched adequately upon the close co-operation existing between the Association and the member firms, whereby the staff became intimately aware of production difficulties and defects arising on sea trials and on service. Owners were usually very co-operative, and it was as natural to take the superintendent to the research station as it was to take him to the drawing office. Assisting in this feed-back of knowledge were the various committees, and the Board regulating research, drawn from the industry and representative authorities. This progressive experience was rapidly causing Pametrada to become possibly the greatest authority on marine-turbine design. Referring to Fig. 91, showing types of gear failure, Mr. Ainley thought that it might suggest that shaved gears were liable, in normal circumstances, to deteriorate in the manner shown. He asked whether the author would add an illustration of the teeth and the nature of contact before the test commenced, and also a critical description of the method employed in shaving of the teeth. There were good grounds for believing that the surfaces had been damaged by work-hardening, with the system of shaving adopted.

Mr. F. Dollin, B.Sc. (Eng.), thought that Mr. Terrell had produced a valuable analysis, but objected to the introduction of yet another name—the "T*w* number"*—to their repertoire. As stated in the paper, it was not uniquely a property of the material. It involved two extraneous factors —the thickness of the piece and the ability of the working substance to put heat into it; but if a standard value of the wall thickness *d* and a standard value of the surface heat-transfer coefficient *h* were taken, what remained would be uniquely the property of the material; and if one particular substance were then selected for the norm and the value for every substance were divided by the value for that norm, the result would again be uniquely the property of the material. The term "thermal susceptibility" had been used. Why not use that?

Mr. J. H. Dale said that Mr. Terrell's T*w* number seemed to make a contribution to a variable of which there had previously been no true criterion. Mr. Terrell must have overcome a great problem in getting so many running hours out of the Pametrada gas turbine, with austenitic casings 1¾ in. thick. Why were they so thick? On pressure grounds, surely ½ in. was enough. Suspension must be the only outside influence, and, in this connection, the lighter the casing the better, because there was less weight to carry. Thermal distortion was worse with a heavier casing. Mr. Dale said that he had been associated with the design of a marine gas-turbine of 6,000 h.p. with a specific weight of 5 lb. per brake horse-power. The maximum pressure was 275 lb. per square inch absolute, which was lower than the higher of the steam turbines. They ran with rather large tip clearances of 0·025 in., but they wanted to run from cold to maximum power within four minutes —which they had succeeded in doing. There had been some problems with thermal distortion, but they had been overcome. The turbines, of the two-stage type, had no longitudinal joints, but only circumferential joints, which made the job much easier. The casings were only ⅜ in. thick, so that the thermal distortion problems were greatly eased. The nozzles were flexible through the outer turbine casings, reducing the danger of distortion in those members. They tried to reduce the rate of heating of the outer casing by putting in a very thin heat shield, which reduced the radiation from the hot part of the turbine to the casing. In spite of these precautions to slow down the heating of the turbine casing, however, they had a flange outside the high-pressure turbine with a working temperature of 800 deg. F. Seventy-five per cent. of the temperature rise took place in eight minutes from starting up. The maximum temperature was

* Mr. Basil J. Terrell, in his paper, described the Terrell-Walker, or T*w*, number as "a figure . . . . directly proportional to the temperature change that can be suddenly applied to a hot medium flowing through the cylinder without causing the latter to exceed the elastic limit of its material in any place."—Ed., E.

reached 30 minutes after starting. Speaking of difficulties with spigots, Mr. Dale said they had tried to maintain concentricity, but if the casing heated more quickly than the other part, crushing was likely to occur beyond the elastic limit. When unbolting, there was no trouble, but on re-assembly it was found that there was no concentricity left, because the spigot then had a clearance of 0·003 in. to 0·005 in. They had cut off the spigots, therefore, and used a radial dowel which fitted into the flange, running into a radial slot, so that on re-assembly there was true concentricity. There had been trouble also with bolts going through the flanges, because they were liable to stay colder than the flange.

The chairman (Dr. R. W. Bailey) said that he had had a great deal of experience with the problem of thermal distortion. Many turbine cylinders had been heated and the distortions measured. In several cases, there had been thermal distortion on the first heating; in other words, the material went through the elastic limit somewhere on normal heating up, or under conditions not as intense as those of normal heating up. So long as there was no overheating, repeated heating did not make any difference. Dr. Bailey then showed, by slides, diagrams of three successive heatings of a turbine cylinder. The maximum temperature was about 400 deg. F. Efforts were made to go about 100 deg. F. higher than the maximum steam temperature at the top of the cylinder. Thermocouples were placed in various parts of the cylinder. After the third treatment, the cylinder was unbolted and the measurements were taken. The distortion was about 0·015 in. on the diameter, measured in any two directions. In the case of the second heating, there was a slight increase in one or two of the readings, but it was quite small—perhaps 0·002 in. The elasticity did not change much with temperature. If the parts were bolted up and movement was restricted, when there was a rise in temperature the elastic strain would remain constant, since the horizontal area was constrained, and the plastic strain would change in accordance with the temperature reached. If the elastic strain at a temperature of 300 deg. C. was high, an increase in temperature would bring about plastic strain. If the temperature was raised to its maximum and it was uniform, the strain was taken off. If the cylinder were brought up to uniform temperature, right up through the thicknesses of the parts, the effect was reversed. The walls would be reduced in diameter with uniform temperature, whether it was uniform temperature to working temperature or uniform temperature to atmospheric temperature. What mattered was how far away the elastic limit was when the strain was applied by a thermal increase.

Dr. J. F. Shannon said that an austenitic cylinder on a gas turbine which had been running for many hours had been giving trouble and was opened up. A movement of $\frac{1}{8}$ in. was recorded on the inside, and a liner was put in all the way round. That layout had run for some 2,800 hours, and, when the turbine was opened up, the movement inwards was hardly measurable.

Mr. Terrell, replying to the discussion, said that Mr. Dollin complained that his principle brought thickness into the heating calculation. Mr. Dollin was correct, but at the same time it was a ratio which could be compared with what happened in mild steel. He did not agree with Mr. Dollin's remarks about the comparative expense of casings. Dr. Allen had asked if the materials cited were typical. They were the only materials that it had been possible to obtain. Everyone seemed to have made comprehensive investigations into the properties of forged and rolled materials, but little seemed to have been done in respect of cast materials. He was grateful to Mr. Ainley for his remarks. There had been criticism of the use in the gas turbine of $1\frac{3}{4}$-in. casings. Their use was due to external influences in another form, the foundrymen having said that it would be almost impossible to cast the casing properly if it was made any thinner.

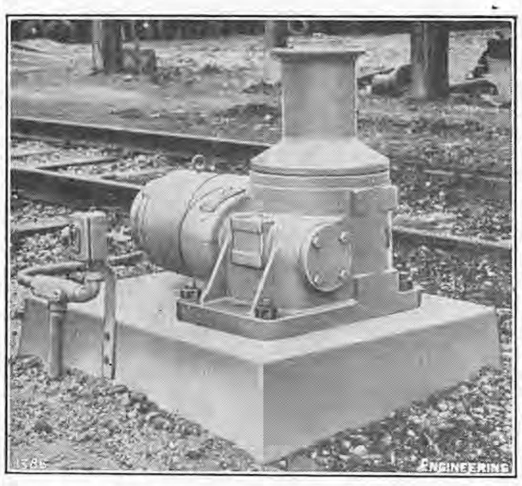
Dr. Kantorowicz, replying to Dr. Shannon, said that Dr. Shannon had plotted the speed of the rotor in revolutions per second at the bottom of the diagram and the frequency at the side. In principle, that was no different from plotting the frequency at the bottom and the speed of the rotor at the side.

Dr. T. W. F. Brown, referring to high-temperature turbines, said, for the cycle of the 3,500-h.p. gas turbine, they needed something like 60 lb. of air per horse-power per hour, whereas, with the high-temperature gas turbine, the corresponding figure was 20 lb. Thus they achieved an automatic weight reduction without any change in the type of design. He was certainly not in favour of extremely heavy and bulky designs unless there was a reason for them, but he thought that there might be a half-way house between adapted machinery, developed for the propulsion of aircraft, and the more orthodox marine types.

AN ELECTRIC CAPSTAN.

THE "Lo-hed" electric capstan shown in the accompanying illustration was exhibited at the recent Factory Equipment Exhibition by the Taylor Stoker Company, Limited, 189/191, Drummond-street, London, N.W.1. It has a starting pull of 5,000 lb. and a normal pull of 3,300 lb.; when the load is moving its normal speed is 45 ft. per minute. The design is based on a similar machine which has been in use for a few years in the United States and is made by an associated company.

The barrel of this capstan, which is made in a close-grained cast iron, has a smooth machined finish. It is mounted on a vertical steel shaft which is driven by a 5-h.p. 1,500 r.p.m. totally-enclosed squirrel-cage type motor with a high starting torque, through a steel pinion and spur gear, driving a steel worm and wormwheel. The



wormwheel has a bronze rim and cast-iron hub. The gears are totally enclosed by a cast-iron box and run in an oil bath. The bearings on the barrel shaft are bronze and on the worm shaft ball and roller bearings are fitted.

When used on railways, the capstan should be located so that the hauling rope is practically parallel to the track upon which the wagons are to be moved. Before hauling a wagon along a straight track, rough calculations can be made to ascertain the pull required, allowing a pull of 35 lb. for each ton to be moved, and additional allowances may have to be made for the poor condition of the track and wagon bearings. On an incline a further 20 lb. pull per ton for each per cent. rise of track level should be allowed, and on curves additional equipment in the form of guide rollers is necessary, and the pull must again be increased. An advantage claimed for this capstan is that it has no obstructions on the barrel and allows free handling of the rope from any angle; furthermore, the rope is not limited to a single direction as in the case of the horizontal barrel. The machine can also be made with ratings other than those mentioned.

SUBMARINE CABLE FACTORY IN SINGAPORE.—The new submarine cable factory and depot of Cable and Wireless Ltd., at Bukit Chermin, Singapore, is to begin production early this month. It will replace an old factory which was opened in 1887, and will be capable of manufacturing between 800 and 900 nautical miles of submarine cable per annum. The works include a jetty for servicing the cable ships Stanley Angwin and Retriever which are normally based on Singapore.

LAUNCHES AND TRIAL TRIPS.

M.S. "NORDEPIC."—Single-screw trawler, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the St. Andrew's Steam Fishing Co., Ltd., Hull. Main dimensions: 105 ft. by 23 ft. 6 in. by 11 ft. 6 in. Diesel engine developing 450 b.h.p. at 310 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester, 11. Launch, March 17.

S.S. "LISIEUX."—Twin-screw cross-channel vessel, accommodating up to 1,450 passengers, built by Les Forges et Chantiers de la Méditerranée, Le Havre, for the Société Nationale des Chemins de fer Français, Paris, principally for service between Newhaven and Dieppe. Main dimensions: 308 ft. 4 in. between perpendiculars by 45 ft. by 24 ft. to "B" deck; loaded displacement, 2,221 tons on a draught of 10 ft. 6 in. Two sets of marine steam turbines with simple-reduction bi-helical gears, developing 22,000 h.p. at 400 r.p.m., constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Speed, 24 knots. Maiden voyage, March 24.

M.S. "RIPLEY."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the Thomasson Shipping Co., Ltd., London, E.C.3 (Managers: Stephens, Sutton, Ltd., Newcastle-upon-Tyne). Main dimensions: 435 ft. between perpendiculars by 58 ft. 9 in. by 38 ft. to shelter deck; deadweight capacity, 10,310 tons on a mean summer draught of 25 ft. 11 in. Swan Hunter-Doxford four-cylinder combined-stroke oil engine, developing 3,300 b.h.p. at 108 r.p.m. in service, constructed by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne. Speed, 12 knots. Trial trip, March 26.

M.S. "MARICOPA."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for Thorvald Berg, Tonsberg, Norway. Main dimensions: 490 ft. between perpendiculars by 69 ft. 6 in. by 40 ft. 6 in.; deadweight capacity, 17,440 tons on a summer draught of 30 ft. $11\frac{1}{2}$ in. Five-cylinder opposed-piston oil engine, constructed by William Doxford and Sons, Ltd., Sunderland. Speed, $13\frac{3}{4}$ knots. Trial trip, March 27 and 28.

M.S. "CITY OF YORK."—Twin-screw liner, with accommodation for 106 passengers and cargo, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for Ellerman Lines, Ltd., London, E.C.3. Third vessel of an order for four. Main dimensions: 500 ft. between perpendiculars by 71 ft. by 41 ft. to upper deck; deadweight capacity, about 11,300 tons on a draught of 28 ft. 6 in.; gross tonnage, about 13,360; displacement, 19,640 tons. Two Hawthorn-Doxford six-cylinder opposed-piston heavy-oil engines, developing a total of 12,650 b.h.p. at 115 r.p.m., constructed by R. and W. Hawthorn, Leslie and Co., Ltd., Newcastle-upon-Tyne. Service speed, $16\frac{1}{2}$ knots, fully loaded. Launch, March 30.

S.S. "LEDA."—Twin-screw mail boat, carrying 119 first-class and 384 tourist-class passengers, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Det Bergenske Dampskibsselskab, Bergen, Norway. Main dimensions: 410 ft. between perpendiculars by 57 ft. by 30 ft. to upper deck; gross tonnage, 6,670; cargo-carrying capacity, 75,630 cub. ft.; deadweight capacity, 1,970 tons on a draught of 20 ft. Two sets of geared turbines with double-reduction double-helical gearing, developing 13,000 s.h.p. at 150 r.p.m. in service, and two Babcock and Wilcox boilers; turbines and boilers constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, $21\frac{1}{2}$ knots. Trial trip, March 31.

M.S. "AMBERLEY."—Single-screw cargo vessel, built by the Grangemouth Dockyard Co., Ltd., Grangemouth, for Stephenson Clarke, Ltd., London, E.C.3. Main dimensions: 249 ft. by 38 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,400 tons on a draught of 17 ft. Eight-cylinder Diesel engine, developing 1,500 b.h.p. at 300 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Launch, March 31.

M.S. "JUANITA."—Single-screw oil tanker, built by the Nakskov Shipyard, Ltd., Nakskov, Denmark, for Rederiet J. M. Ugland, Grimstad, Norway. Main dimensions: 510 ft. $2\frac{1}{2}$ in. overall by 65 ft. 9 in. by 36 ft. 3 in. to main deck; deadweight capacity, about 15,650 tons on a draught of 29 ft. $1\frac{1}{4}$ in.; oil-tank capacity, 730,000 cub. ft. Seven-cylinder two-stroke oil engine, developing 6,850 i.h.p. and a service speed of 14 knots, constructed by Burmeister & Wain, Ltd., Copenhagen, Denmark. Trial trip, March 31.

M.S. "BURMAH SAPPHIRE."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Burmah Oil Company (Tankers), Ltd., London, E.C.2. Main dimensions: 409 ft. 6 in. between perpendiculars by 56 ft. by 31 ft. 3 in.; deadweight capacity, about 8,510 tons on a draught of 25 ft. $2\frac{1}{4}$ in.; gross tonnage, 6,290; oil-tank capacity, 401,260 cub. ft. Wallsend-Doxford four-cylinder two-stroke opposed-piston oil engine, developing a maximum of 3,500 b.h.p. at 109 r.p.m., and designed to operate on heavy furnace fuel. Engine constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 12 knots. Launch, April 1.

DEVELOPMENTS IN ELECTRICAL INSULATING MATERIALS.

(*Continued from page* 469.)

GENERAL PROPERTIES AND CURRENT PROBLEMS.

AT the meeting on Wednesday afternoon, March 18, the chair was taken by Dr. S. Whitehead, and Dr. R. W. Sillars reported on general properties and current problems. He gave a general summary of the eight papers presented, of which five aimed at assessing definite aspects of usefulness of certain organic insulants, two gave general data on the properties of ceramic insulants, together with background information about their manufacture, and one included similar general information on rubber-sheathed cables.

A paper entitled "The Properties of Some of the Newer Laminated Plastic Insulating Materials" was presented by Messrs. A. N. Hawthorn and S. W. Messent. Tests, which are not yet complete, on the effect of various conditions on the properties of some of the more recently developed insulating materials were described and the conclusion was reached that none possessed all the attributes desired for an insulating board or sheet. Varying the proportions of resin to fillers altered the properties of the laminations with other than paper bases, but the most suitable combinations might not have been achieved. The cellulose-filled laminates were at present the most widely used and were comparatively straightforward to produce, owing to the chemical and physical structure of the fibres, which were readily melted by most synthetic resins. Cellulose fibres, however, absorbed moisture with consequent dilation and were lacking in thermal stability. The acetylated cotton fabric fillers produced laminates which maintained a high insulation in tropical conditions. They also had much better electrical characteristics than the conventional cotton fabric laminates, although at the expense of the mechanical properties.

In general, the glass-fabric-filled laminates possessed good mechanical properties and thermal stability, but suffered a serious deterioration of electrical characteristics in humid conditions. This was probably due to inadequate "wetting" of the glass fibre, with consequent lack of bonding, by the resin. Recently, methods of sizing the glass fabric had been evolved using compounds which replaced the surface hydroxyls of the fibre by organic groups, thus facilitating "wetting" by resins. The silicone resin-bonded glass fabric laminate had most of the requirements of an insulating board with the exception of its poor behaviour in humid conditions. The amino-resin bonded glass laminate represented an attempt to improve upon the electrical characteristics obtained with a straight melamine formaldehyde resin. The inclusion of the urea-formaldehyde resin plasticiser led to an unusual pattern of behaviour during some of the long duration tests. Only the silicone and amino-resins conferred resistance to tracking.

Although tests on the phenolic-resin bonded glass laminate were incomplete, it did not appear to have any advantage over the silicone or amino-bonded glass materials. Of the synthetic fibre-filled laminates, the two Terylene laminates had good electrical properties, but poor mechanical characteristics. Their low electric strength might be due to a chemical combination of resin and filler, since it was known that some phenols reacted with Terylene under certain conditions. An improvement in mechanical strength was very desirable and would appear to require the use of a different type of resin bond. The nylon laminates had better mechanical strength, but inferior electrical properties. The only material which withstood a temperature of 200 deg. C. satisfactorily for any length of time was the silicone resin-bonded glass laminate. All the other materials withstood a temperature of 100 deg. C., reasonably well, but 150 deg. C. was too high, except perhaps for short time exposures in the case of nylon and glass-filled laminates. Exposure to high humidity for long periods did not cause appreciable thickness swelling, except in the case of the paper-filled laminates.

A paper by Mr. H. R. Heap on "Recent Developments in Testing of Impregnating Varnishes" described a method in which a standard test coil, impregnated with the varnish by a standard procedure, was used, the idea being to simplify procedure and to achieve more practical and useful results than those obtainable at present. The test coil consisted of six layers of 0·038 in. diameter double cotton-covered wire wound on a ½-in. diameter metal mandrel which was fitted with synthetic-resin bonded paper sheet flanges. Both ends of each layer were secured by inserting them through saw cuts in the flange and six such layers were wound independently, alternate layers being traversed in opposite directions.

In order to assess the quality of a varnish accurately, it was necessary to know the method of application, the equipment to be impregnated and the conditions under which it would be used. Tests had therefore been developed relating to certain basic properties, including penetration, drying time, ageing, filling efficiency, moisture resistance, tank stability and effect on enamel wire; information was also given on how the standard coil could be used to select a varnish for a particular application.

INSULATION OF ROTATING ELECTRICAL MACHINERY.

A paper on "Insulation of Rotating Electrical Machinery" was presented by Mr. E. Jones, who discussed the use of the new materials which had become available during the past 25 years and indicated their advantages and disadvantages. Electrical glass fibres were introduced about 1937 and were now available in thicknesses from 3 to 11 mils. as tapes woven from continuous-filament yarns. They had a much higher resistivity than the ordinary grade of woven asbestos and were not affected to any serious extent by damp conditions. Their higher tensile strength made it possible to apply coil insulation much more tightly, with consequent improvement in coil ratings and insulation space factors. Tracking was completely eliminated. Cloths woven from glass yarns had also proved useful for several applications. Glass tapes had, however, certain drawbacks. Armature or stator coils were susceptible to abrasion by the edges of the slots, although this could be reduced by special varnishing treatment. Thin varnished glass tapes were also sensitive to damage by small particles of copper and other foreign matter. Braided glass sleevings were useful for insulating commutator, stator-coil and solenoid-coil leads, as they were not seriously affected by heat. Glass fibre cords and twine were strong in tension even at high temperatures and under damp conditions, but they had a long elongation, so that when used for binding were apt to be tight or slack. Successful laminated glass cloth boards could be made using either a phenolic or metamine resin bond, but although strong mechanically had indifferent electrical properties. Glass-textile wire coverings were available and papers containing at least 70 per cent. of glass fibres had been produced.

In 1940, an improved type of asbestos tape was made with very much better electrical performance than the older types so that it could be used for 3,000-volt direct-current windings. It was also equal in robustness and abrasion resistance, although its tensile strength was somewhat lower. This could be improved by replacing the cotton fibres, which were necessary to increase the yarn strength, by glass, Terylene or nylon. Asbestos sleevings were little employed on rotating machines as the minimum wall thickness was too great for many purposes, although cords and ropes had certain uses. Synthetic resin bonded asbestos woven cloth was of interest, owing to its mechanical strength and resistance to heat. Laminates incorporating coarse cloth had poor electrical properties, but high tensile, compression and impact strengths and were also resistant to abrasion. They were useful where mechanical strength at temperatures up to 150 deg. C. was required. Synthetic bonded laminates of fine asbestos cloth could, however, be stressed continuously at up to 40 volts per mil for laminate thicknesses of ⅛ in. or less. Synthetic resin bonded asbestos paper laminates were of considerable value when a heat resisting material of reasonable dielectric properties was required, as their mechanical strength was good. A high purity asbestos paper reinforced with glass fibres was now available and had a high tensile strength and resistance to tearing. It had a high short-time electric strength and could replace mica in certain cases. Its long-time electric strength, however, was not high. Ordinary qualities of asbestos paper, treated with resin or vulcanised rubber, were used to an appreciable extent in machines.

The most important development, which had taken place in the field of cotton tapes and cloths during the last 20 years, had been the development of esterified or acetylated cotton. Nylon had not been used extensively in machines owing to supply difficulties and cost, but it had a number of compensating technical advantages, such as appreciable elasticity, great mechanical strength and good dielectric properties. Phenolic resin-bonded nylon cloth was particularly satisfactory for punching into small accurate shapes, especially when hot. Textiles produced from polymers of ethylene glycol terephthalate (Terylene) had some outstanding properties, notably resistance to high temperatures, and probably offered a serious challenge to glass and asbestos.

The advent of synthetic resin enamelled round wires some 12 years ago initiated many changes in the manufacture of rotating machines by providing improved resistance to abrasion and solvents. The oil-modified synthetic resin varnishes, which became available in 1938, had proved to be of considerable value, owing to their superior bonding characteristics, through-hardening properties and resistance to moisture. Great interest was also being taken in the polyester and ethoxyline (epoxide) resins, which had been used for several years in the aircraft industry for manufacturing radomes and various structural parts. Synthetic-resin-impregnated compressed laminated wood had proved of marked value in the construction of the windings of large machines. The introduction of silicone materials caused much interest in the electrical engineering world, owing to their good performance at high temperatures; and it seemed certain that they would have a very wide use in the future. A wide range of silicone insulation varnishes was being produced and silicone elastometers were being used with glass textiles for the insulation of traction-motor field coils. The fluorcarbon polymers, produced some years ago in the United States, were finding considerable application because of their phenomenal resistance to heat. Polytetrafluorethylene, for instance, had a high tensile strength and resistance to tearing. Its short-time electric strength was very high, although unfortunately it was very sensitive to electrical discharges. The mechanical stress must be low if plastic flow were not to take place. Polychlortrifluorethylene has similar properties to polytetrafluorethylene, but its resistance to heat was inferior, making it much easier to mould and extrude.

(*To be continued.*)

"OLYMPUS CANBERRA" AIRCRAFT.—The Bristol Aeroplane Co., Ltd., Filton, Bristol, have announced that a Canberra aircraft which is serving as a flying testbed for two Bristol Olympus jet engines has attained heights of over 60,000 ft. during normal development work. The Company are considering the possibility of an attempt on the official international height record for aeroplanes, provided that it can be made without interfering with the main development programme. (The present record is 59,446 ft., attained in 1948 by a modified de Havilland Vampire aircraft.) The Olympus engine, which was briefly described on page 13 of our 174th volume (1952), is known to develop a static thrust of 9,750 lb.

JUNIOR INSTITUTION OF ENGINEERS: MAUDSLAY SCHOLARSHIP.—Through the generosity of the Maudslay Society, the Junior Institution of Engineers are enabled to offer the fifth Maudslay scholarship, amounting to 150*l*. for one year, to young engineers to assist them in their education and training. Those eligible must be engineers, or training to be engineers, mainly interested in mechanical engineering, and not more than 25 years of age. If not already members of the Institution, the selected candidate will be required to apply for membership and be duly elected. In suitable cases, the scholarship may be extended for a further one or two years. Applications should be made before July 31 to the secretary, Junior Institution of Engineers, 39, Victoria-street, London, S.W.1, from whom further particulars may be obtained.

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.

Circular Dies for Thread Rolling.—A new specification, B.S. No. 1947, gives dimensional details and tolerances for the circular form of die, known as the thread roll, used for the production of screw threads by the rolling process. The publication constitutes one of two complementary specifications, the other, B.S. No. 1946, relating to dies of flat form. In the present specification are set out definitions and manufacturing tolerances on the main dimensions and on the thread form, the latter being based on the provisions of B.S. No. 84 for Whitworth threads, B.S. No. 93 for B.A. threads, and B.S. No. 1580 for Unified threads. An appendix contains, in addition to notes on the thread-rolling production process, some indication of the faults which may occur, particularly those concerned with the diameter of the blanks for the components to be threaded. [Price 4*s.*, postage included.]

Aluminium Filler Alloys for Brazing.—A new specification, B.S. No. 1942, dealing with aluminium filler alloys for brazing, is complementary to two other specifications, namely, B.S. No. 1723, entitled "Brazing," and B.S. No. 1845, relating to filler alloys for brazing (and comprising silver solders and brazing solders). The new publication is concerned with four types of aluminium alloys. These materials are suitable for brazing alloys complying with the series of specifications for aluminium and light alloys dealt with in B.S. Nos. 1470 to 1477 and 1490. Chemical compositions and limits of impurities are specified and the approximate melting ranges are given for information only. [Price 2*s.*, postage included.]

Copper-Rich Alloy Rods, Sections and Forgings.—Two new specifications relating to copper-alloy rods, sections and forgings for general engineering purposes have now been issued. The first, B.S. No. 1948, covers copper—3 per cent.-silicon alloy materials and the second, B.S. No. 1949, 60 : 40 brass. Each publication specifies requirements for forgings and for rods and sections having a diameter, or width across the flats, of not less than $\frac{1}{16}$ in. Tables of tolerances on round, square and hexagon rods are included. [Price 3*s.* each, postage included.]

TRADE PUBLICATIONS.

Rust-Removing and Passivating Agent.—Basol Ltd., Basol House, 16, Bolton-street, Piccadilly, London, W.1, have sent us a pamphlet giving particulars of Basol-Fepar, which contains phosphoric acid and is described as a rust converter, rust remover, rust destroyer and passivator. It is stated that no washing off is necessary after the de-rusting treatment. Both the immersion and the brushing-on methods may be employed.

Aluminium-Bronze Die Castings.—A pamphlet, entitled "The Properties of Aluminium-Bronze Diecastings" has reached us from Fry's Diecastings Ltd., Midland Works, Brierley Hill-road, Wordsley, near Stourbridge. It contains brief illustrated particulars of these alloys, including physical and mechanical properties, wear and corrosion resistance, the finishing processes advocated, design considerations, and the soldering and welding processes recommended.

Meehanite Metal.—A "buyer's guide" recently produced by them for the International Meehanite Metal Co., Ltd., 66, Victoria-street, London, S.W.1, has come to hand from Taylor Advertising Ltd., 115, Gower-street, London, W.C.1. The guide contains lists of all the foundries licensed to operate the Meehanite-metal process both in this country and overseas. Copies are obtainable from the International Meehanite Metal Company.

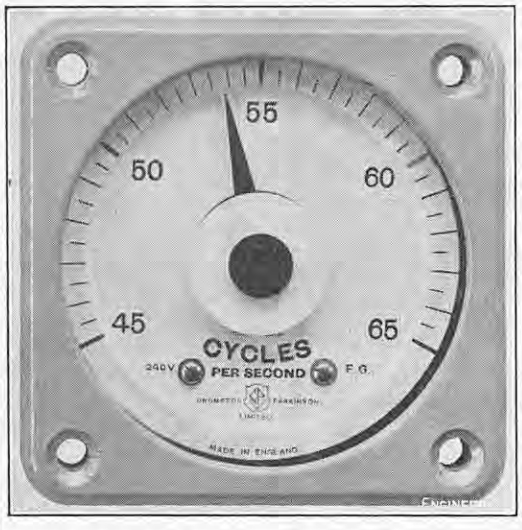
Industrial Electric Furnaces.—Examples of their bale-out, hooded, tilting and die-casting furnaces, solder and tinning baths, and automatic temperature-control equipments are given in a folder issued by Funditor Ltd., 3, Woodbridge-street, London, E.C.1.

Induction Motors.—Details of the induction motors made by them for outputs up to 80 h.p. are given in a pamphlet received from the Brush Electrical Engineering Co., Ltd., Loughborough.

Zinc.—The 10th number of the "Zinc Bulletin" may be obtained from the Zinc Development Association, Lincoln House, Turl-street, Oxford. This stresses the points that zinc supplies are now adequate to meet all requirements, and that all restrictions on the use of the metal have been removed. Among the subjects dealt with in the "Bulletin" are zinc-alloy die-castings, zinc glazes and the adoption of hot-dip galvanised coatings at Abbey Works, Margam.

BRIDGE-NETWORK UNIT FOR FREQUENCY INDICATION.

Messrs. Crompton Parkinson, Limited, Aldwych, London, W.C.2, have developed a bridge-network unit which enables any size of centre-zero moving-coil instrument with a range 500-0-500 microamperes to be used as a frequency indicator. The network circuit consists of resistors, condensers and inductances arranged in a frequency-sensitive bridge with half-wave rectifiers to give the unidirectional output necessary to operate the instrument. The network is balanced so that no current flows through the instrument at a predetermined value of frequency. If the applied frequency differs from the predetermined value, a unidirectional current passes which is proportional to the difference in a plus or minus direction and the



pointer takes up a position to indicate the frequency. It is claimed that the new circuit is practically immune from error caused by abnormal wave forms and therefore gives greater accuracy than rectified bridge circuits with a calibration which is true for only one wave form at one voltage.

The instruments used in conjunction with the bridge network unit, illustrated herewith, comply with the British Standard requirements that errors should be not more than 1 per cent. of the mean value, and that with a variation of $\pm$ 10 per cent. from the rated voltage, the change in indication shall not exceed 1 per cent. The bridge network is contained in a separate box measuring about 7 in. by 5 in. by 4 in. deep. The unit is standardised for 45 to 65, 46 to 54, and 56 to 64 cycles at the present time, and can be used on any voltage within the 100 to 120 and 200 to 240 volt bands.

The instruments are available in all the usual patterns; the $3\frac{1}{2}$-in. circular scale shockproof type has been approved by the Admiralty.

Duty-Free Entry of Machinery.—The committee appointed to consider whether it is in the national interest to provide for the duty-free admission of machinery into the United Kingdom would welcome evidence in writing from interested persons or organisations. This should be addressed to the joint secretaries, Board of Trade, Room 3135, Horse Guards-avenue, London, S.W.1, before Friday, May 15. Information to the effect that such evidence will be submitted should, however, be given at once.

Cargo-Loading System for Aircraft: Erratum.—We have been requested by the Straits Air Freight Express, Ltd., Dominion Buildings, Mercer-street, Wellington C.I., New Zealand, to correct a statement in the opening paragraph of an article on "Cargo-Loading System for Aircraft," which appeared on page 804 of our 174th volume (December 19, 1952). The Cargon system was not, as stated, developed by engineers of New Zealand Railways, but by Straits Air Freight Express, Ltd., who submitted the system when tendering for the New Zealand Railways rail-air contract. The airborne Cargons are owned by Straits Air Freight Express, Ltd., and under the terms of the contract the New Zealand Railways Department manufactured the traverser loading docks.

BOOKS RECEIVED.

Dynasty of Iron Founders. The Darbys and Coalbrookdale. By Dr. Arthur Raistrick. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 30*s.* net.]

United States National Bureau of Standards. Miscellaneous Publication 207. *Annual Report*, 1952. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

United States Coast and Geodetic Survey. Annual Report of the Director of the Coast and Geodetic Survey for the Fiscal Year Ended June 30, 1952. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 35 cents.]

Forty-Seventh Annual Report of the Rand Water Board to His Excellency the Governor-General. Financial Year ended 31st March, 1952. The Secretary, Rand Water Board, P.O. Box 1127, Johannesburg, South Africa.

British Iron and Steel Federation. Annual Report, 1952. Offices of the Federation, Steel House, Tothill-street, Westminster, London, S.W.1. [Price 2*s.* 6*d.*]

Definitions and Formulae for Students. Automobile Engineering. By H. Kerr Thomas. Second edition by Staton Abbey. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 1*s.*]

Servicing Guide to British Motor Vehicles. Vol. 2. *Cars, Commercial Vehicles and Tractors.* By J. N. McHattie. Trader Publishing Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 2 guineas.]

Power Cables: Their Design and Installation. By C. C. Barnes. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 35*s.* net.]

Proceedings of the Institute of British Foundrymen. Vol. XLV. 1952. Edited by G. Lambert. Institute of British Foundrymen, Saint John-street Chambers, Deansgate, Manchester, 3.

CONTRACTS.

Leyland Motors, Ltd., Leyland, Lancashire, have received an order valued at over 100,000*l.* for Diesel vehicles for operation in the Middle East. The order comprises 39 vehicles specially equipped for constructional work. They consist of 20 Comet "90" cruiser-weight lorries with all-steel platform bodies, designed for end tipping; 15 six-wheel Super-Hippo haulage vehicles with steel platform bodies; and four Super-Hippo six-wheel heavy-duty tractors. Among other contracts is an order for 56 of the firm's Titan double-deck omnibus chassis placed by the Sheffield Transport Department.

Heenan and Froude, Ltd., Worcester, have received an order from Hubert Davies & Co., Ltd., for six water coolers for installation in a new power station in course of construction at Walvis Bay, South West Africa. Another order, received from F. Perkins, Ltd., Peterborough, is for two electric dynamometers. One is a high-speed machine of small capacity and the other is of 180 b.h.p. A third order is from the Aviation Division of the Goodyear Tyre and Rubber Co., Ltd. This involves the design and construction of a large testing plant for proving aircraft wheels, tyres and brakes at the Goodyear factory, Wallasey, Cheshire.

The Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, have secured a contract to build a bulk-cargo motorship of the Australian Interstate type for Australian Steamships Pty., Ltd. (Howard Smith Ltd., managers), Sydney, New South Wales. The vessel will have an overall length of 356 ft., a carrying capacity of 5,500 tons, and a speed of 12 knots. Her propelling machinery will consist of a three-cylinder 2,300-b.h.p. Ailsa-Doxford Diesel engine and she will be built at the Aberdeen yard of Hall, Russell & Co., Ltd.

Westland Aircraft Ltd., Yeovil, Somerset, have received an order from the Ministry of Supply for a number of Dragonfly S.51-type helicopters to be supplied to Yugoslavia under the Mutual Defence Assistance Programme. The order has been placed with the Ministry of Supply by the United States Air Forces in Europe and the helicopters are being built in this country under licence. They will be powered by Pratt & Whitney engines supplied by the United States Government.

G. & J. Weir, Ltd., Cathcart, Glasgow, S.4, have received an order from the Anglo-Iranian Oil Co., Ltd., for evaporating and distilling plant for their new refinery at Aden, to provide more than 1,700 tons of fresh water daily from sea water. The order, placed through George Wimpey & Co., Ltd., is for three of the firm's triple-effect evaporating and distilling plants, each capable of producing 134,000 Imperial gallons of distilled water a day, the total output being not less than 400,000 gallons each 24 hours, if required. It is expected that the work of erection at Aden will commence early in 1954.