ENGINEERING.

DEEP-WATER WHARF ON THE GAMBIA RIVER.

The method of deep-water wharf construction described below embodies a number of novelties, both in the scope and general conception of the design and also in the practical means employed to put it into execution. Before going into the details, however, some consideration may be given to the study of how, and to what extent, the changing conditions of the modern world affected this particular problem, and to the explanation of why it should be necessary for engineers to revise their ideas on the subject of wharf construction. An endeavour will then be made to correlate the novel features of design and of constructional method with the intrinsic requirements brought about by the changed circumstances mentioned.

The changes that particularly affect the building of wharves, jetties, docks and harbours are of two quite different sorts. There is first the purely technical change brought about by the increase in the size of ships; and, secondly, a group of changes due to economic causes which, taken together, have produced a marked scarcity in the supply of both materials and labour

For many years, the trade of the world was carried on by small steamers ranging from 1,000 to 10,000 tons deadweight. These ships rarely had a greater draught than 26 ft. when fully loaded, and many of them could be allowed to settle down comfortably at low tide on the mud or sand at the bottom of the berths where they lay. Because of their moderate size, however, it was comparatively easy to make wet docks for them to berth in, with the water maintained at one level by means of entrance locks so that they could remain continuously afloat at all states of the tide. All the engineering works involved in providing these basins and also in providing wharves and jetties in tidal waters were based, therefore, on ships of moderate draught, and the technique of construction was developed to suit the depth of water.

Modern ships, however, are much larger—the latest development of oil tankers, for example, shows a very great increase in size, up to 40,000 tons deadweight; and, owing to the great expense of making wet docks in which to berth them, the tendency is to revert to wharves and jetties in tidal water. Where the rise and fall of spring tides is, say, 20 ft., the draught of the ships to be catered for is, say, 35 ft., and the height of the wharf deck over the highest tide level is, perhaps, 5 ft. The addition of these figures gives a total height from sea or river bottom up to the deck level of the wharf of 60 ft. This is a formidable height, which to a large extent rules out timber as a constructional medium; if the wharf is supported upon or bounded by piles, driven the usual 25 ft. or so into the ground, a pile some 85 ft. long is needed. Such timbers are unobtainable except in a few special localities like Tasmania.

Reinforced-concrete piles are in little better case because, while it is perfectly practicable to cast piles of that length in concrete and to thicken them out to, say, 24 in. square so as to make them strong enough to bear lifting, the resulting product weighs well over 20 tons and becomes most difficult and expensive to handle and drive. It is still possible to build a modern piled wharf by using steel members, steel piles and steel bracings, but the drawback to naked steel structures is that they rust. It can be seen, therefore, that the building of the old-fashioned cheap lattice wharf structure on piles is not now as simple, and certainly not as satisfactory, a solution for berthing the big modern ships as it was for their smaller forerunners.

There are also changes brought about by economic scarcity and socialisation. Whereas, in the industrial conditions and social atmosphere of 50 years ago there always seemed to be any amount of material for sale, and any number of workmen anxious to get jobs, the tendency for some years past (and there is no indication of a change of trend) is for material to be scarce and for labour to be both difficult to obtain and, judged upon earlier standards, poor in quality.

The characteristics of labour in most countries to-day is that men, having been trained to read and write, do not want to engage in heavy physical exertion, do not want to work long hours unless paid at enhanced rates on the basis of overtime, are definitely disinclined to work in conditions of physical discomfort, danger or dirt, and are not, as a rule, individually possessed of very much skill in any department of handicraft. These characteristics, in conjunction with the scarcity and high cost of building materials, have a pronounced bearing in the field of harbour and dock engineering generally; because they mean that nearly all the time-honoured forms of more substantial construction, such as mass concrete or masonry walls built within cofferdams, or concrete blockwork walls built by divers on prepared beds in dredged channels, or monolith cylinder and compressed-air caisson foundations involving internal grabbing, pumping and hand excavation, have become fabulously expensive and even uncertain of accomplishment, owing to the difficulty of obtaining the right kind of men in sufficient numbers.

It is true that there are some alternative methods, such as the employment of hollow reinforced-concrete floatable units, built in a dock on shore and afterwards floated into position and founded in the wharf structure, methods which are sometimes useful in special cases. The method just mentioned was, for example, used with justification and did, in fact, effect an immense saving in cost and in time in the building of the sea forts that were sunk in the Thames and Mersey estuaries during the recent war,

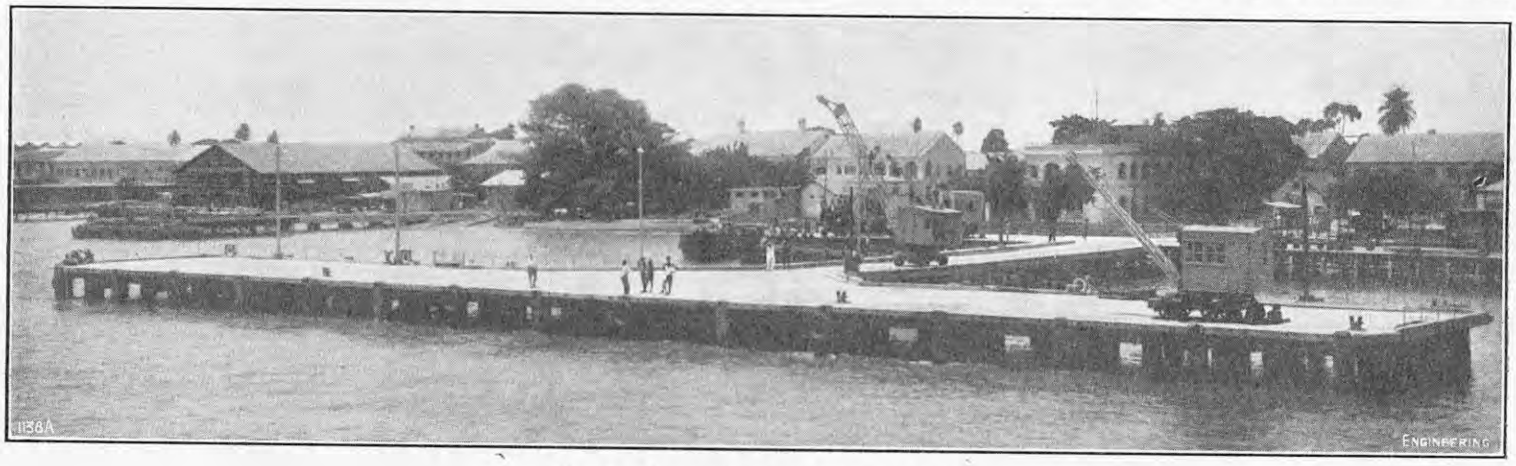
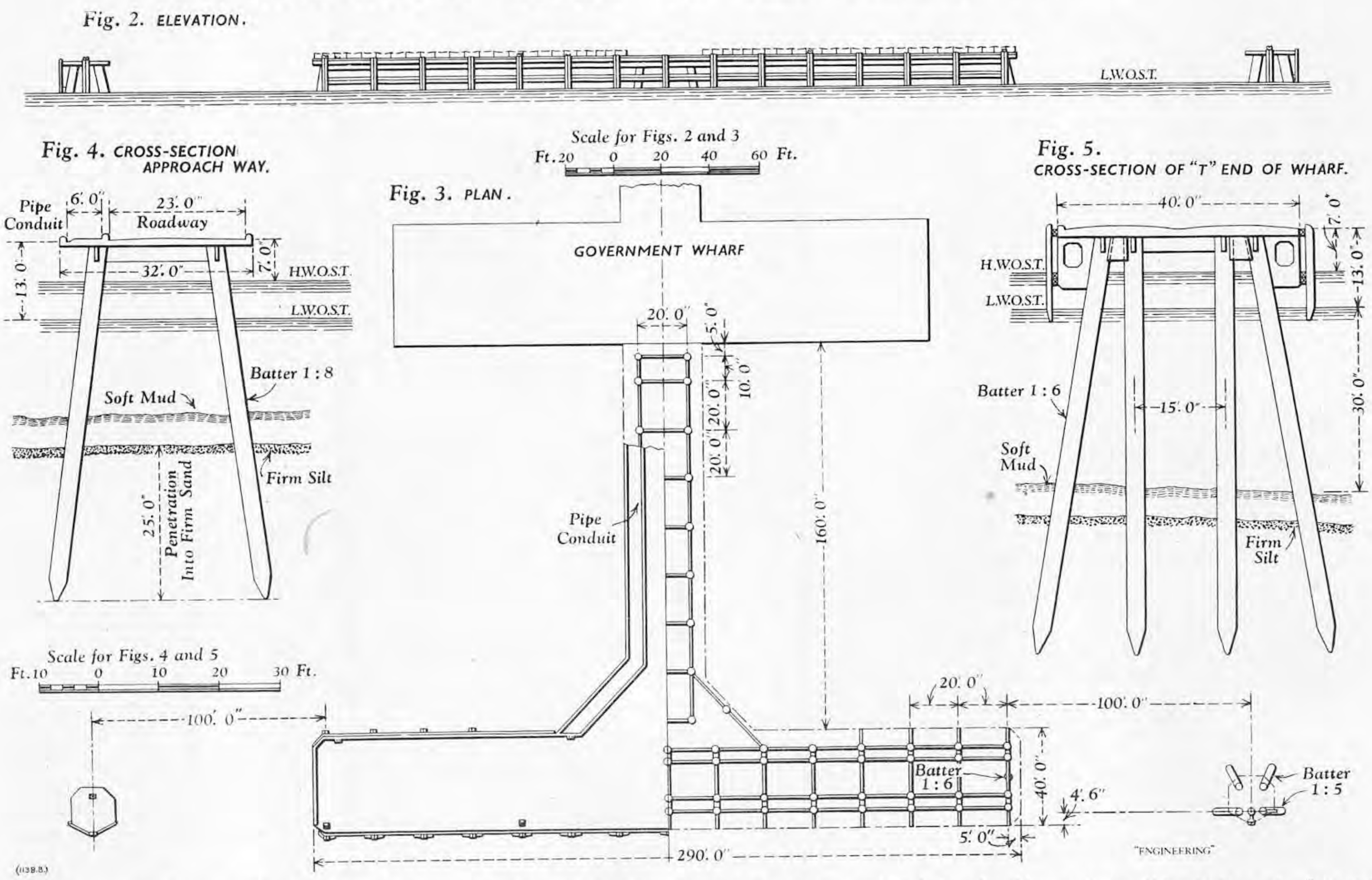


Fig. 1. Front of Completed Wharf.

DEEP-WATER WHARF ON THE GAMBIA RIVER.



and, of course, in the case of the Mulberry Harbour; but, however suitable this method was for war-time purposes, this does not hold for peace-time wharf construction, where the cost of the method is almost certain to prove as heavy as that of the more ancient and traditional of the massive construction methods.

Generally, therefore, the position brought about by the two kinds of changes taken together has been to render the construction of new dock works so costly as to act as a deterrent to future development, and, incidentally, to make the evolution of simpler and cheaper forms of construction well worth while. The designer seeking a new form of construction has to keep the changed circumstances clearly in view. He must design something which is sparing in the use of material, and in which every ounce of the material performs a necessary service. He must also design something which calls for as little as possible of the labour of the old kind of navvy and handicraftsman, and which can be made and erected by the new kind of men, who drive machines; and, of course, while mindful of these new circumstances, he must work within proper limits of safe stress and produce a structure which will require the minimum of maintenance.

The Gambia Colony.

The Gambia is the most northerly of the British West African territories and is also one of the oldest and the smallest of them. There is no large European community, and the Africans have not yet advanced very far in industrial development; but what the Europeans lack in numbers and resources they make up for in the useful faculty of knowing what they want and how to set about getting it, and what the Africans lack in industrial *savoir faire* they make up in natural artistry and craftsmanship. From the point of wharf construction, however, the site was a difficult one. There is no firm land in the vicinity of Bathurst, which lies at the mouth of a wide tropical river estuary. The subsoil, for a great depth, consists of very fine mud and silt, overlain in places with a layer of very fine sea-borne sand. The current in the river, where it flows past Bathurst, is fierce, and, though the water is normally fairly smooth, tornadoes are to be expected in their season. There are, moreover, no commercial workshops or stores of material in the neighbourhood; for instance, nowhere in the Colony was there any stone or gravel out of which to make good-quality concrete. Suitable stone had to be imported by sea.

It may appear, therefore, that Bathurst was not altogether the ideal place at which to attempt to introduce a new form of wharf construction. What was wanted was a wharf lying conveniently close to the centre of the town on the one side, and to the deep navigable channel of the river on the other; a wharf where ocean-going ships could berth, and built well out in deep water, where the strength of the current and the lie of the land gave assurance against the risk of the berth silting up, and where the configuration of the coast could give shelter from large waves.

Description of Structure.

The structure, which is illustrated in Figs. 1 to 13, on pages 1 to 4, and Figs. 14 to 18, on Plate I, consists of a strong reinforced-concrete deck, shaped like a T, with the stem to the shore, and built in one piece without expansion joints. There is, however, an expansion joint where the bottom of the T joins the front of the old jetty on the shore line; that is to say, the new structure is not directly joined to the shore. The two reinforced-concrete dolphins on either side of the head of the T are of similar construction to the main jetty, but are quite independent of it. The reason for having dolphins was to give long ships something to nose up against when berthing, and something to tie up to, fore and aft. The funds available would not run to making the T head long enough to overlap the longer ships, so dolphin outriggers were employed as a cheaper alternative. The length of the T head which comes into contact with the midship section of the berthing vessel is 219 ft., which is adequate for landing passengers, and for discharging cargo from two holds at a time. The deck area is mainly for the use of road transport vehicles, but a small area is railed off and reserved for the support of oil mains and oil terminal connections.

The front of the T and the dolphins are fitted with short vertical timber fenders, 24 in. wide, and two lines of horizontal West African timber rubbing walings, flush with the fenders. Sufficient time has not yet elapsed to say whether, and to what extent, the pinkado timber from Sierra Leone can resist the attacks of the local teredo worm, but it appears to stand up moderately well against the rubbing of ships and lighters. For reasons of cost, it was impracticable to provide such luxuries as sprung fenders. The deck structure is supported upon caisson piles, the heads of which are linked together by precast reinforced-concrete beams. Steel stirrups connect the beams with the deck slab, of which they really form part.

The caisson piles are reinforced-concrete tubes 75 ft. long, 3 ft. in external diameter and 2 ft. 4 in. internal diameter, open at the top end, but closed at the bottom end by a heavy concrete point. The reinforcing steel is disposed in the tube as shown in Figs. 8 to 11, and is covered by precast concrete, 2 in. thick. Because these tubes were cast vertically in steel shutters and the reinforcement was made up in welded cages before being placed in the moulds, great accuracy of workmanship was achieved, the 2-in. external cover of concrete over the steel being well maintained. The concrete in each segment of caisson was cast in

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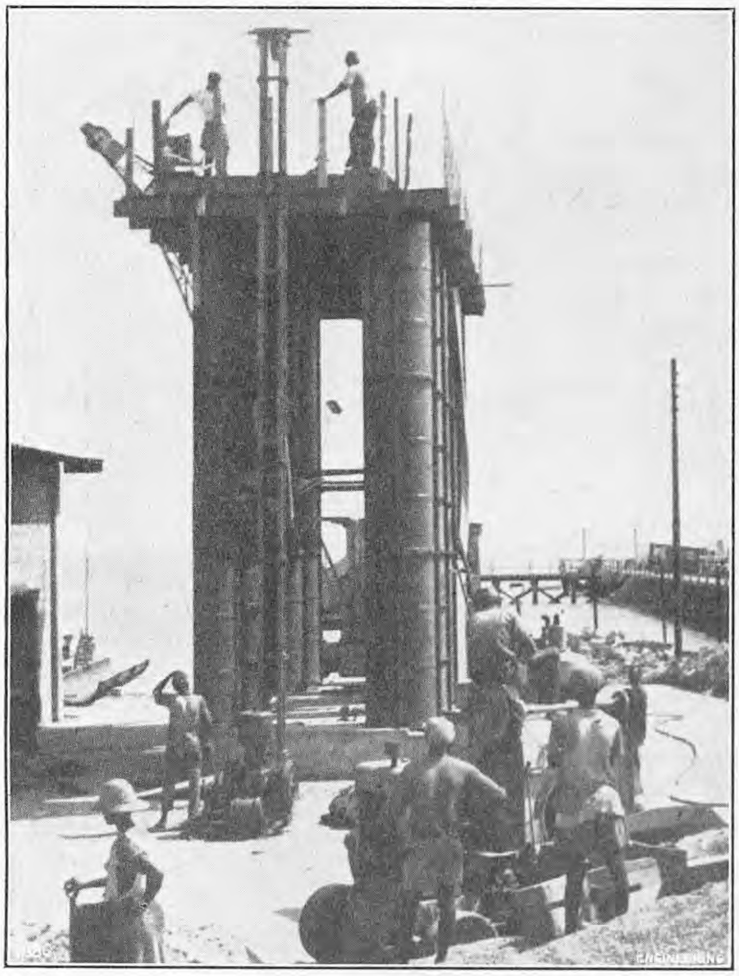

FIG. 6. CASTING RACK FOR PILES.

FIG. 7. FILLING CONCRETE PILE.

one piece without joints, and was of very high quality and perfectly watertight. As an added precaution against possible corrosion of the caisson piles, all that part of the shank which, in the finished structure, is left standing above sea bottom, and also the part between wind and water, was given two coats of heavy bituminous paint before being erected. It is too early to be able to say what happens to the part of the caisson pile which is deep under water, but the part just below low water mark is encrusted with small oysters and may thereby receive a measure of protection.

The caisson piles, some of which are vertical and others inclined at a slope of 1 in 6 or 1 in 8 to the vertical, are disposed so as to share the deck load, and so as to impart a greater lateral stability to the whole structure than they could have done if all had been vertical. The lower fender waling is carried by large reinforced-concrete precast brackets springing from the front row of caisson piles and bonded by reinforcement to the deck slab above.

The piles, beams and brackets were made of high-grade concrete, the coarse aggregate being imported by sea. The reinforced-concrete deck, which was cast *in situ*, was made of selected lumps of hard laterite, which were quarried and crushed in the Colony. Fine sand, originally sea-deposited and rather full of shell fragments, was used in the mix for want of better. The high-grade concrete, using imported aggregate, furnished crushing tests of 5,000 lb. to 6,000 lb. per square inch at 28 days. The laterite concrete in the deck slab gave 4,000 lb. to 5,000 lb. per square inch.

CONSTRUCTIONAL METHODS.

As may be surmised, every step in the constructional programme had to be thought out while the design was being made and afterwards each step had to be most carefully implemented by the contractor. Almost all of the plant and material had to be collected in the United Kingdom and sent out to Gambia by sea. That the operations eventually went through successfully was due to the careful and methodical way in which the contractors, Messrs. Caffin and Company, Limited, of 25, Craven-street, London, W.C.2, organised their supplies and prepared all the items of special plant, such as the cylindrical internal and external shutters, floats for the caisson piles, pitching and driving pontoons, mechanism, etc.

The method of forming the caisson piles, each 75 ft. in length, and weighing 13 tons, was to cast three lengths, each rather less than 25 ft. long, by pouring concrete into the mould formed by inside and outside steel cylindrical Guyrex shutters, standing vertically. The concrete was dropped 25 ft. to start with and was brought up the whole height of 25 ft. in about three hours, being tamped continuously with a long rod by a man at the top, and consolidated by a discreet application of vibration to the outside of the steel shutters. The concrete so produced by breaking some of the rules was of very good quality, perfectly free from voids, and finished with a smooth glass-like surface inside and out, and perfectly watertight.

After casting the three lengths and leaving the concrete in the shutters for long enough to prevent evaporation while setting was taking place, the three lengths were lifted and laid out horizontally, end to end, with the reinforcing bars overlapping; then the bars were welded together and the joint run with splice concrete. All the time, before and after splicing, the precast tubular casting was perfectly free to contract upon itself without creating any contraction cracks anywhere in the concrete. The completed pile was then rolled down an inclined slipway and a watertight iron plate was bolted on to the open end. When the pile entered the water, two light floats, made of pairs of drums, were manœuvred into position at either end of it, and were secured to it by light tackles fitted with quick-release Stenson clips. The pile was then towed round to the driving pontoon, which was built in the Colony, of West African hardwood, in the form of two pontoons jointed together. On the pontoons were mounted a boiler, a jet pump, a 5-ton Woodfield piling winch, and a light steel tower for lifting and pitching.

The floating caisson pile was then lifted by its head from the tower, and as it was always half in the water, only about half its weight came on the return block. As it was pitched, the weight of the pile carried it down several feet into the sea bottom. Its further penetration was assisted at first by means of the water jet alone. The jet was applied through a 2-in. pipe, external to the pile, which was recovered after use; but there was a short bent length of pipe permanently fixed to the point of the pile, and this, of course, was not recoverable. This bent part of the jet tube was carried down to terminate very near to the point of the pile. The best results were obtained by using the open pipe, without any nozzle contraction.

In those cases where the caisson pile was intended to stand at an inclination, pitching was performed vertically and the pile was jetted down for about 10 ft. in the vertical position. The top of the pile, which was roped to the pontoon tower, was then pulled over, to give the desired degree of inclination, by hauling the pontoon over bodily by means of the mooring ropes.

After the pile—either vertical or inclined, as the case might be—had been jetted down about 15 ft. below the sea bottom, its penetration by jetting

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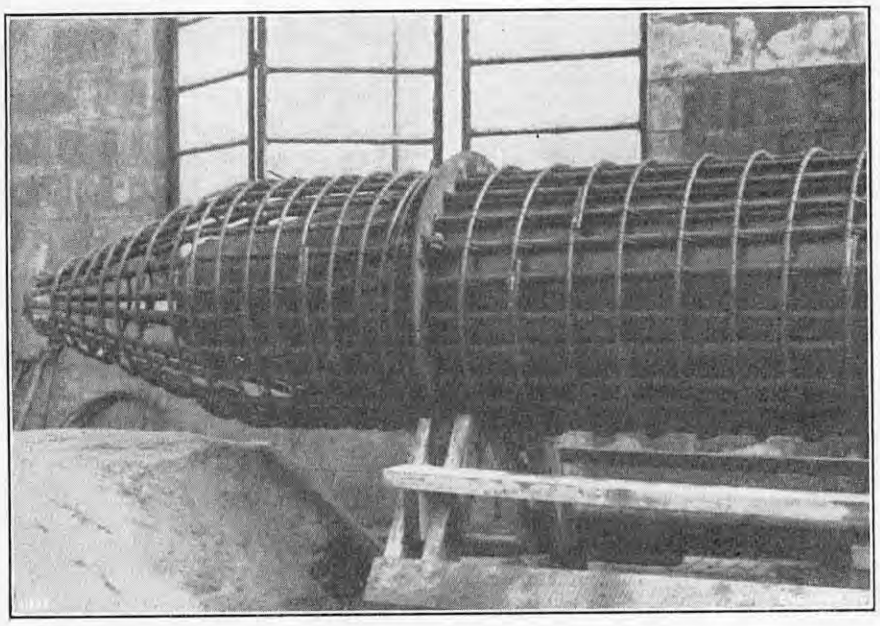


FIG. 8. REINFORCING BARS IN POINT OF PILE.

Fig. 9. DETAIL OF CYLINDER PILE.

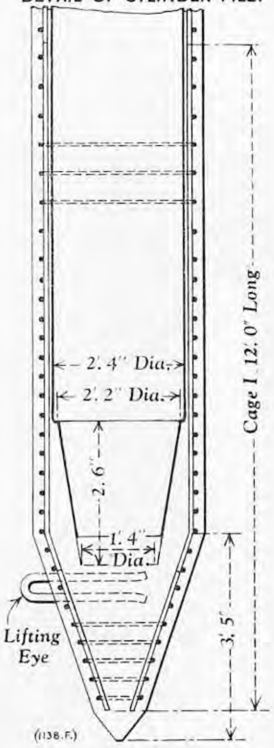


Fig. 10. DETAIL OF SPLICE.

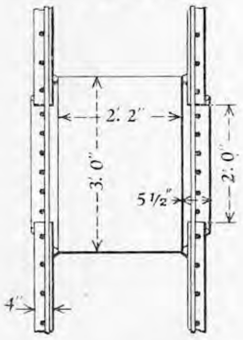


Fig. 11. CROSS-SECTION OF CYLINDER PILE.

Fig. 12. DETAIL OF T-HEAD DECK.

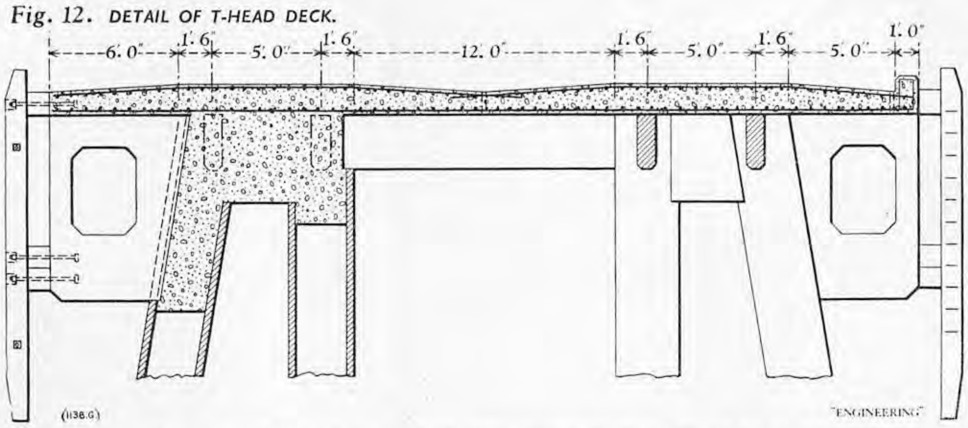
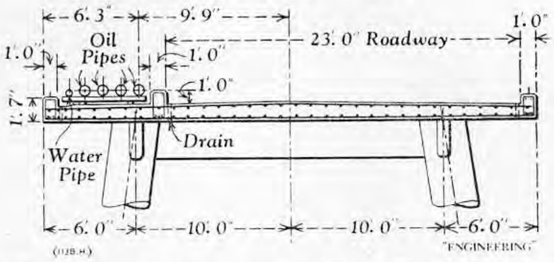


Fig. 13. PIPE CONDUIT AND ROADWAY.



alone became slow; so, at this stage, a steel cylindrical hammer, weighing 4 tons, which fitted very loosely inside the pile, was lowered into it by means of a driving rope from the tower, while the pile was filled to the top with water. By lifting and dropping the hammer, a gentle blow was then delivered upon the point of the caisson pile. The hammer was operating under the 70 ft. of water inside the pile shank and was guided by the inside of the concrete tube. It did not matter whether the drop given by the operator was large or small, because the velocity with which the hammer struck the pile base was regulated by the water surrounding the hammer; this prevented a higher striking velocity than about 8 ft. per second. The blow was not delivered directly upon the concrete base of the pile, but was cushioned by sand or stones previously deposited in a conical cavity left for that purpose in the concrete at the bottom of the shank.

By the impact of these gentle blows, aided by the lubricating and displacing effect of the water jet, it was found possible to drive a caisson pile to about 35 ft. below the sea bed in four hours or so. The last two or three feet of penetration were obtained by hammering alone, so as to avoid the creation by the water jet of undue disturbance of the stratum upon which the point should ultimately rest. The object of filling the pile with water before starting to drive was, first, to ensure that the hammer should work only under the velocity limitation imposed by the water, and, secondly, to obtain the benefit of the six or seven tons of water as an aid to penetration.

In this connection the objection might be raised that, in ordinary pile-driving practice, there would seem to be little or no advantage to be gained by increasing the weight of the pile. In this case, the pile weighed 13 tons and the hammer 4 tons, so that the ratio of the weights was a little over 3. There would seem, in normal practice, to be no advantage in increasing the weight of the pile by the addition of six tons of kentledge so as to make the total weight 19 tons, thereby raising the ratio to the admittedly less favourable figure of 5; but the case was not so simple as this. The water kentledge was not attached to the pile, so that the inertia of the water had no effect in damping the penetrating force of the blow at the moment of impact; but the weight of the water did come into play immediately after the moment of impact as a follow-through force, tending to improve the penetration primarily induced by impact. The whole question of the driving of piles by means of a hammer rising and falling in a tube of slightly larger cross-sectional area than the hammer, and filled with water, presents a number of interesting problems for those mathematically inclined. Certainly, the combination of jetting with under-water internal driving, though at variance with accepted methods, worked satisfactorily in this case and enabled these large caisson piles to be given a good penetration and left standing either vertically or at any desired inclination. Another respect in which established custom was flouted was in the non-attachment of the pile to the pile-driving frame. There was no rigid or sliding connection, only a flexible lateral control through the medium of rope tackles. This simplicity made it possible to drive piles raking in any direction, with equal facility.

After the caisson piles were founded they were not filled with concrete, the reason being the desire to avoid unnecessary weight. The tops of the piles were cut down and notched out after they had been driven, to form seatings into which to insert the precast beams and brackets. These castings had reinforcing bars left projecting from their ends so as to bond with the opposite bars when seated within the circle of the top of the pile, where they were concreted in. Stirrup bars also were left projecting from their upper edges, to be bent over the reinforcing bars of the deck slab and to bond securely with it when it was concreted *in situ*.

This design, and the unusual methods used in carrying it out, were planned in order to develop a form of construction more quickly and cheaply executed than the traditional forms, but equally effective for its purpose; and, now that it has been built, it is worth while to examine how far the result bears out the intentions.

Cost.—The structure as designed and built does achieve its purpose at small cost. The actual cost was about 100,000*l.*, which, having regard to the high cost of doing work at the present time, to the devaluation of sterling, and to the added difficulties and expense of working in West Africa, must be regarded as a low price to pay for a wharf capable of berthing a large cargo vessel. The design may be regarded, therefore, as having proved very cheap by modern standards.

Simplicity in Execution.—The work was carried out by a group of about eight European engineers and foremen, controlling a small force of not very efficient Africans. All of it was above water and it was performed in about 20 months, mainly by means of a few simple items of contractor's plant. One 5-ton mobile crane, one 5-ton piling winch with

DEEP-WATER WHARF ON THE GAMBIA RIVER.

(*For Description see Page* 1.)

FIG. 14. SINKING PILE WITH WATER JET.

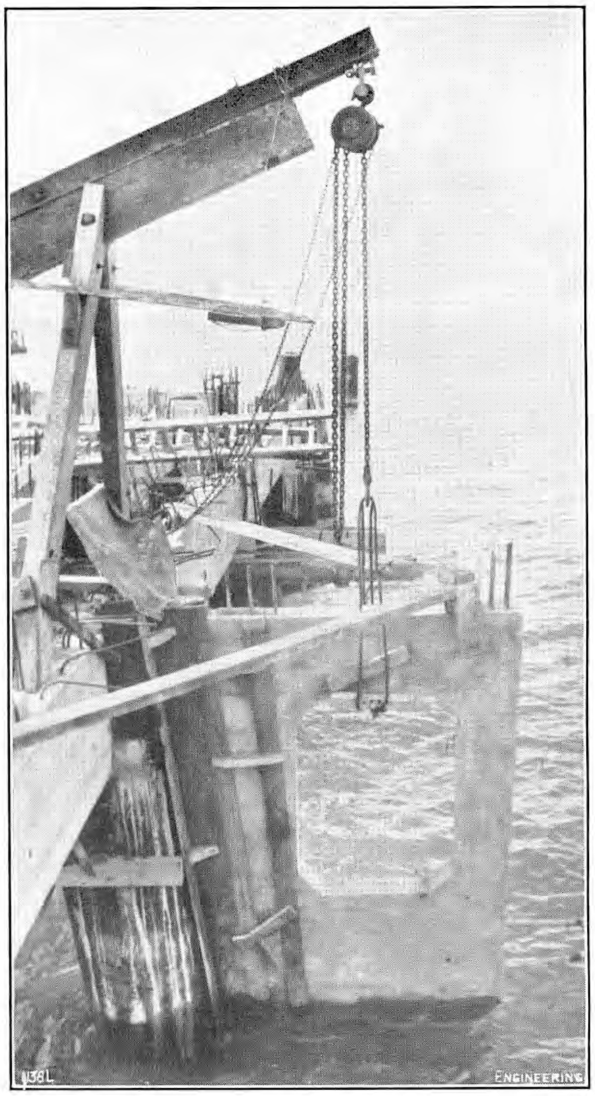


FIG. 16. FENDER BRACKET.

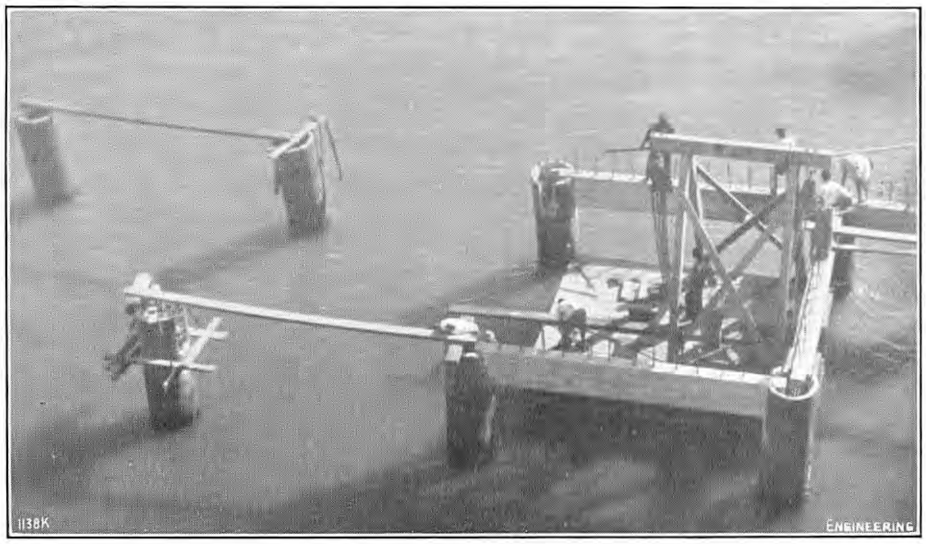


FIG. 15. PLACING PRECAST DECK-BEAMS.

FIG. 17. REINFORCEMENT OF DECK SLAB.

FIG. 18. CONSTRUCTION OF DECK.

(*To face page* 4.)

jet pump and boiler, mounted on a pontoon, and two small concrete mixers were the principal tools used.

Strength.—Considered as a floor for carrying loads, the reinforced-concrete deck system possesses adequate strength. Considered as a girder in a horizontal plane, capable of distributing lateral impacts throughout the whole structure, the monolithic reinforced-concrete deck, with its attached beams and curbs, possesses enormous strength; the monolithic character of the deck slab may, therefore, be looked upon as a key feature in this form of design. Considered as struts, the caisson piles, on account of their large moment of inertia, are capable of bearing a 50-ton load over the long unsupported length between the point of firm embedment in the sea bottom and deck level (in this case, 45 ft.) without the use of intermediate bracing; i.e., they combine strength and simplicity. Considered as foundations, the caisson piles have the merit of presenting an area of 7 sq. ft. to bottom resistance and about 350 sq. ft. of side surface to the frictional resistance of the strata penetrated; i.e., they are much more effective than concrete piles of equal weight.

Durability.—By making the caisson piles and the beams of high-grade concrete, and by forming and curing them in the precasting yard under ideal working conditions, it was possible to ensure that all those surfaces exposed to deterioration under water or between wind and water would present a minimum surface, of the shape and quality least likely to suffer damage. In other words, the caisson pile is about the most durable form of reinforced-concrete post or upright that can be conceived.

Flexibility and Expansion.—The principle of carrying the monolithic deck structure upon a number of caisson piles relies upon a certain measure of flexibility in the piles themselves. There are no interior expansion joints and the deck is free to expand and contract upon itself. The points of maximum movement are the two ends of the T head and the end of the approachway, where the lateral movement to be taken up by pile flexure is about one inch. Under the impact of ship collision, the whole structure can yield 2 in., thus providing a small, but very valuable, amount of spring. The incorporation of raking piles ensures, however, that the sway movement is definitely limited.

The wharf was built under the aegis of Mr. K. Wilson, M.I.C.E., the Director of Public Works in Gambia, and was commenced under the Governorship of Sir Andrew Wright, K.C.M.G. The opening ceremony was performed by the present Governor, Sir Percy Wyn Harris, C.M.G. The consulting engineers responsible for the design and the methods of construction were Messrs. Maunsell, Posford and Pavry, of Abbey House, Victoria-street, Westminster, S.W.1.

ROLLS-ROYCE "AVON" JET ENGINE TO BE PRODUCED IN SWEDEN.—An agreement has been signed between Rolls-Royce Ltd., Derby, and the Royal Swedish Air Board for the manufacture of Avon jet engines in Sweden by Svenska Flygmotor A.B., Trollhätton. Some complete engines will initially be exported from the United Kingdom, and until Swedish manufacturing facilities are established, engine parts will also be supplied. Sweden's most recent fighter aeroplane, the J-32 Lansen, which is undergoing flight trials, is powered by a Rolls-Royce Avon engine.

PREMIUMS FOR TECHNICAL WRITING ON RADIO.—The Radio Industry Council offer awards of 25 guineas, up to an average of six a year, to non-professional writers of technical articles on radio published during the year in journals that can be purchased by the public. The panel of judges will shortly be considering their verdict. Writers who wish to be considered should submit published articles (five copies if possible), with a declaration that they are not paid a salary for writing and that their income from articles or book royalties does not amount to 25 per cent. of their total income, to the secretary of the Council, 29, Russell-square, London, W.C.1.

LITERATURE.

Vibration and Shock Isolation.

By C. E. CREDE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6·50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52*s*. net.]

THE problem of isolating the effects of vibration and shock is of increasing importance to engineers, and the proper instruction of the beginner in the essential aspects of the matter is invaluable to him, whatever the branch in which he eventually specialises. Broadly, the aim is the practical one of designing a resilient mounting so that the energy of vibration may be temporarily stored, and subsequently released in its entirety, but out of phase with the source of the disturbance. In certain instances, however, the effectiveness of the isolator may be increased by the dissipation of energy through damping, though this is a secondary consideration in its function. Mr. Crede, starting from this point, expounds the subject in a manner that is evidently based on a long experience in the development and application of these devices for commercial and military purposes.

Of the six chapters in the book, the first deals with the nature of vibratory motion and the dynamics of rigid bodies, and so brings the subject into close relation with the theory of vibrations. In the next two chapters, the author considers, in turn, applications in the case of vibration and shock by classifying the conditions to be satisfied into appropriate categories. Thus, in Chapter 2, the approach to a solution depends on whether the objectionable characteristic arises from the unbalanced forces and couples or from the amplitude of vibration produced by them. Although the ultimate aims and tests of effectiveness are different in these two cases, the principle of design is the same, namely, mounting the equipment upon resilient supports in such a manner that the natural frequency of vibration of the modified system is substantially lower than the frequency of the vibration to be isolated. Several points of practical importance merit attention at various stages of the work; for example, the process of decoupling the natural modes of vibration, by the method indicated in the final section of this chapter. Likewise, in Chapter 3, the treatment of shock is divided into four main classes. On the one hand, there is the case of a motion through shock which results in a displacement that may be either greater or less than the maximum admissible deflection of the isolator. On the other hand, there is the case of a force through shock which results in a displacement that may be either greater or less than the maximum admissible deflection of the isolator. Numerous applications are discussed in the text, including the methods of protection against damage to delicate apparatus during transport by road and rail.

The further consideration and exemplification of the effects of vibration and shock, in Chapter 4, brings under review the theory of isolating devices that are distinguished by a non-linear relation between the force and the deflection, and touches upon the isolation of sound by means of resilient supports. In his discussion of the physical properties of the resilient materials available for the purpose, in the next chapter, Mr. Crede provides new and useful data on the characteristics of natural and synthetic rubbers, and a certain amount of information on other materials, like felt, cork, and sponge rubber. The book, with its numerous footnote references to further sources of information, covers the subject in commendable detail, the final chapter containing an instructive summary of the remedial measures to be adopted in particular types of machines and structures, such as, for instance, prime movers, looms, forging hammers, railroads, aircraft, and military and naval equipment.

Wind-Tunnel Technique.

By R. C. PANKHURST and D. W. HOLDER. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 57*s*. 6*d*. net.]

DR. PANKHURST and Mr. Holder have accomplished with conspicuous success a piece of work which many of their predecessors engaged on experimental aerodynamics must have felt the urge to undertake, only, perhaps, to be daunted by the formidable extent of the labour involved. A wind tunnel is essentially scientific research equipment, and every experiment for which it is used embodies at least some degree of originality and, correspondingly, some individualities of technique that are an inherent feature of the investigation. Since many thousands of wind-tunnel researches have been carried out and described during the past 40 years, a comprehensive survey of the available information is itself a task only less arduous than that of selecting, classifying and lucidly presenting the best of it.

For the exercise of these critical functions, the authors are qualified by being themselves engaged on wind-tunnel research in the Aerodynamics Division of the National Physical Laboratory. They appreciate, consequently, that the aerodynamic and structural design and development of a wind tunnel are technical features of the first importance, and they give an excellent account of the relevant theory and practice for tunnels ranging from the simple atmospheric-pressure types to those employing compressed air or achieving supersonic speeds. Succeeding chapters deal with the numerous methods of constructing and rigging experimental models, measuring the forces and moments upon them or the distribution of pressures and velocities round them, correcting for tunnel interference effects, and eventually reducing the experimental observations and presenting the results. Techniques and apparatus for visualising fluid motion are instructively treated, and a great variety of gauges and instruments, used in research with both high-speed and low-speed tunnels, are described, with details of their characteristic behaviour. The authors emphasise the value of such auxiliary equipment in a lengthy account of special measurements concerned with the phenomena of turbulence and aero-elasticity, the stability and control of aircraft, and the performance of airscrews.

The not-unexpected inclusion, in a work largely derived from reports of aeronautical research, of a description of a whirling arm and an account of "analogy" methods of studying fluid motion which, strictly, lie outside the scope of wind-tunnel technology, exemplifies how especially useful this book should be to new workers in the field of experimental aerodynamics. It will supplement admirably what has to be learned, less systematically and completely, from the experienced senior staffs in the laboratories of Government establishments or aircraft companies. Wind tunnels have many applications, however, to non-aeronautical engineering problems, and the often isolated industrial research worker with no colleagues to teach him may justly feel that the authors' meagre reference to wind-tunnel experiments on vehicles, buildings and fans not only does less than justice to the importance of this class of work, but discloses nothing about the techniques peculiar to it. If this deficiency can be rectified in a future edition it will undoubtedly enlarge the value of a book that, as it is, can be commended to experimental aerodynamicians everywhere.

PRICE CONTROL OF METALS RELAXED.—The Minister of Supply (Mr. Duncan Sandys) has made an Order removing from price control unwrought brass and scrap of gilding metal, cupro-nickel and brass. This is made possible by the improved supplies of these metals. Secondary copper and copper scrap remain subject to price control for the time being. The Order—The Copper, Zinc, etc. Prices (No. 6) Order, 1952—came into operation on December 31.

AGRICULTURAL TRACTOR PERFORMANCE.

Fig. 1.

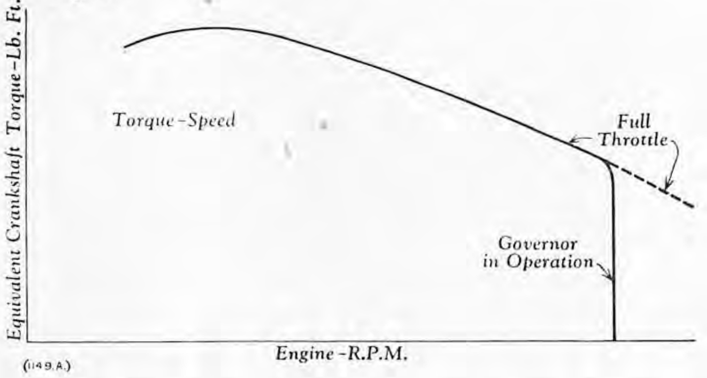
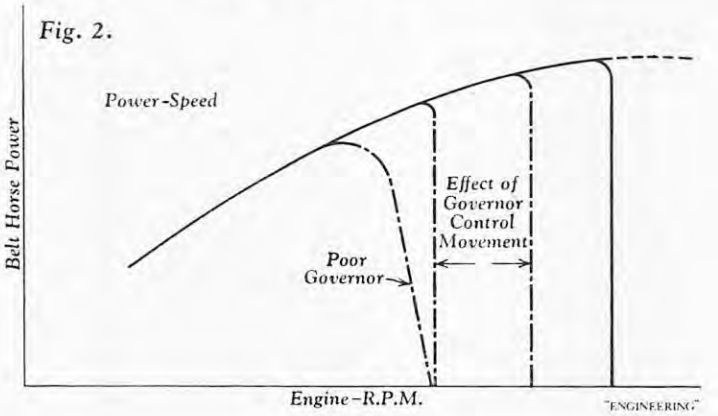


Fig. 2.



THE ELEMENTS OF AGRICULTURAL TRACTOR PERFORMANCE.

By P. H. Southwell.

The purpose of an agricultural tractor is to supply power for farm operations. It consists essentially of an internal-combustion engine supplying power to components by means of which torque is converted into a straight-line pull, so that a proportion of the power at the engine flywheel is made available as tractive power. Any tractor design may be divided into three main parts, namely, the engine, the transmission and the ground drive components. The two main types of tractor are based on two types of ground drive component, i.e., on two methods of obtaining adhesion with the ground, and are correspondingly known as wheeled tractors and tracklaying tractors. Although this article is primarily concerned with agricultural machines, it applies also, in some instances, to industrial tractors used for civil engineering work.

In addition to the provision of power at a drawbar for hauling field implements, the modern agricultural tractor also supplies power at a belt pulley for driving stationary machinery, at a power take-off shaft for driving the mechanisms of field machinery, and to a hydraulic pump for controlling equipment mounted on the tractor frame. These additions to the major purpose have been dictated by the agricultural requirements of a mobile farm power unit, as opposed to a mere replacement for animal draught power. It follows that both the engineer and the operating agriculturalist are concerned with the evaluation of any tractor design, because both engineering efficiency and practical working features are involved. Discussion is confined here to the engineering aspect, but it will be appreciated that agricultural considerations must be a strong influence on the scope and methods of performance testing.

Performance Testing.

Agricultural performance tests throughout the world are divided into two sections, namely, the belt or power take-off performance and the drawbar performance. Obviously, the overall efficiency can be derived most readily by measuring both engine power and drawbar power, but, since operators are only interested in the power provided for farm work, the measurement of engine power most commonly comprises a test of performance when driving a dynamometer through a belt from the tractor pulley or through appropriate shafting from the power take-off. Engine brake horse-power can then be estimated. Because of the variation in work losses in flat belts, the measurement of torque and power at the take-off shaft (a comparatively recent innovation) may come to be preferred in future years in order to facilitate comparison between different tractors. For the same reason, drawbar performance needs to be measured on a good and more or less standard surface; drawbar performance is, of course, always dependent upon surface conditions. It is desirable, therefore, that the variation in performance of any particular tractor with soil conditions should be investigated, but it is not desirable that the only results available to operators should be those obtained on an "ideal" surface, which is largely artificial and non-practical. The best course is to make measurements on a range of ground conditions which includes the "ideal."

The two major tractor-testing stations are at the University of Nebraska in the United States and at the National Institute of Agricultural Engineering in England. The N.I.A.E. makes tests over a range of ground conditions and presents the results in the form of graphs from which the salient figures are quoted; it also carries out the British Standard test for agricultural tractors (B.S. 1744 : 1951) which is comparable with the Nebraska type of test, though performance curves are obtained. The Nebraska station carries out drawbar tests on one surface only and presents results in the form of individual readings. Performance curves are used as a basis in this article.

Engine Characteristics.

A tractor engine is fitted with a variable-speed governor to avoid the constant manual adjustments necessitated by fluctuations in load; Figs. 1 and 2 show engine performance curves which are ideal in some respects. Movement of the governor control from the maximum setting will reduce not only the maximum power output, but also the speed difference between maximum torque and maximum power. This speed difference and the relation between maximum torque and the torque at maximum power are significant, as will be shown later. It follows that the lower the speed at which maximum torque is developed the better, because the speed difference depends upon the governor setting. In point of fact, tractor-engine designers can tend to concentrate upon a maximum volumetric efficiency at the low-speed end of the range, since full-throttle performance in the upper part of the range is not so important as it is in some other applications of internal-combustion engines.

In view of the fact that a tractor engine is operated at part load for the greater portion of its working life, the shape of its specific consumption-load curve is important. The direct-injection Diesel engine has an advantage in this respect, because it not only gives the lowest minimum specific consumption but also the flattest specific consumption-load curve. The governor setting will, however, affect the shape of this curve: the higher the governed speed, the higher the specific consumption at part loads. The governor setting and the performance of the governor affect the maximum power input to the tractor transmission, the speed relationship between maximum engine power and maximum crankshaft torque, and the shape of the specific consumption-load curve. Assuming a certain maximum no-load engine speed, a poor governor characteristic results in an effective power loss, as indicated in Fig. 2. A good governor for an agricultural tractor engine should give a maximum of about 100 r.p.m. difference in speed at no-load and maximum power; if it gives much more than this—and the rate of wear of governor components must be considered—it is of very limited value.

Drawbar Performance.

In practical terms, the important factors in drawbar performance are the capabilities of the tractor as regards size of implement (load) and rate of work (power). Though power is proportional to drawbar pull multiplied by forward speed, the speed and pull are individually significant; for example, the maximum pull in each gear is a very important factor and the number of speeds at which any one pull can be obtained has a strong influence on operational fuel consumption. At the higher forward speeds, engine power is the limitation to maximum pull and maximum drawbar horse-power, because of the greater engine loading and the power loss due to rolling resistance of the tractor. At the lower speeds (higher pulls), slip of the ground drive components is most often the limitation; it is desirable, in fact, that this should always be the case in the lowest gear so as to safeguard the transmission components, the engine crankshaft and also the implement against overloading.

These two interrelated factors, slip and rolling resistance, are the major influences affecting drawbar performance. The maximum drawbar horse-power in any gear depends upon the relative influence of slip and rolling resistance, according to the forward speed and drawbar load. The absolute maximum drawbar horse-power will be obtained in the gear giving the optimum arrangement of the two, but both factors are dependent upon the soil condition and the type of ground drive.

Adhesion between tractor components and the ground may be obtained by either of two means, namely, by what is virtually surface friction and by penetration. A pneumatic-tyred wheel derives adhesion mainly by virtue of a low contact area, but a high ground contact pressure; penetration by tread bars may be considered secondary. On the other hand, a track derives adhesion mainly by penetration and placing the soil in shear behind each penetrating lug or grouser, the most important function of the track plates being to carry the weight of the tractor and thus locally to increase the shear strength of a soil having low cohesion properties.

Drawbar horse power-pull curves and the corresponding slip-pull curves for a hypothetical tractor with four forward gears are shown in Fig. 3,

AGRICULTURAL TRACTOR PERFORMANCE.

Fig. 3. VARIATION OF DRAWBAR PERFORMANCE.

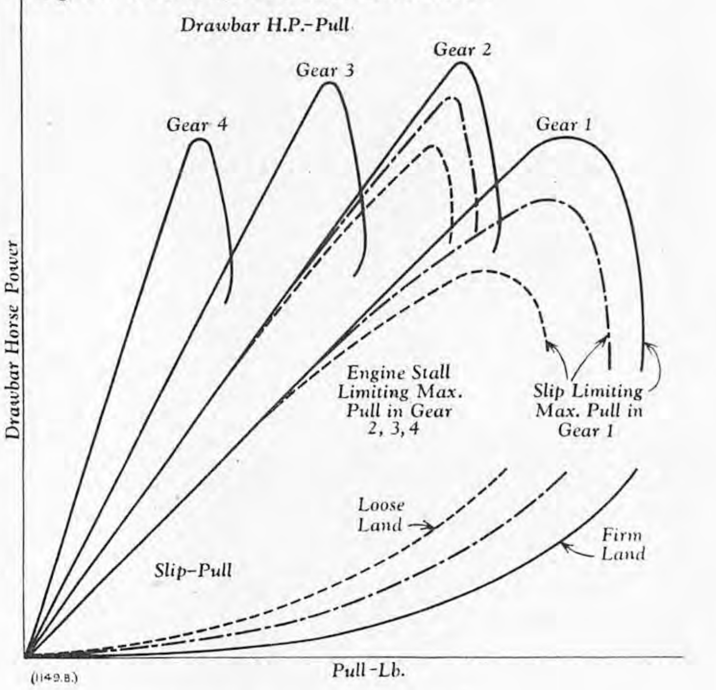


Fig. 4. INFLUENCE OF TORQUE-SPEED CURVE SHAPE.

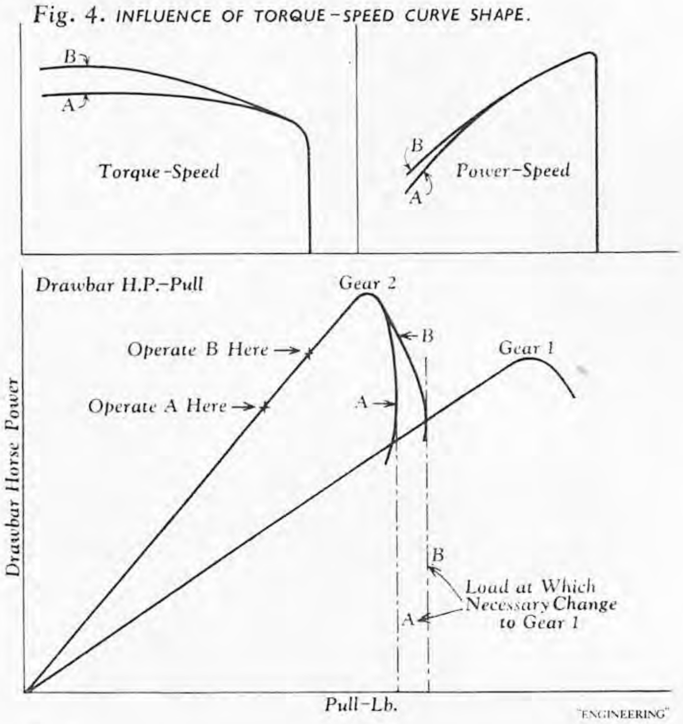
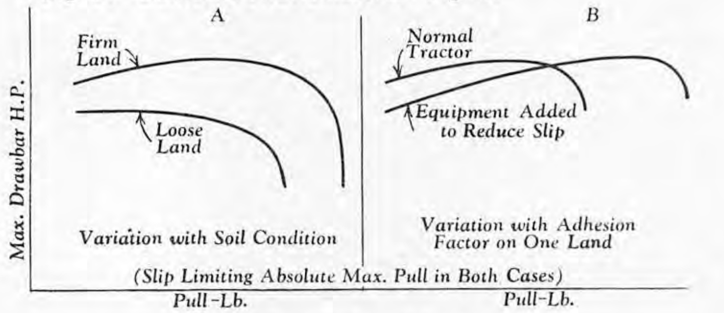


Fig. 5. DRAWBAR POWER ENVELOPES. Fig. 6.



AVAILABILITY OF POWER AND PULL. (Engine Stall Limitation in all Gears)

Fig. 7. Fig. 8.

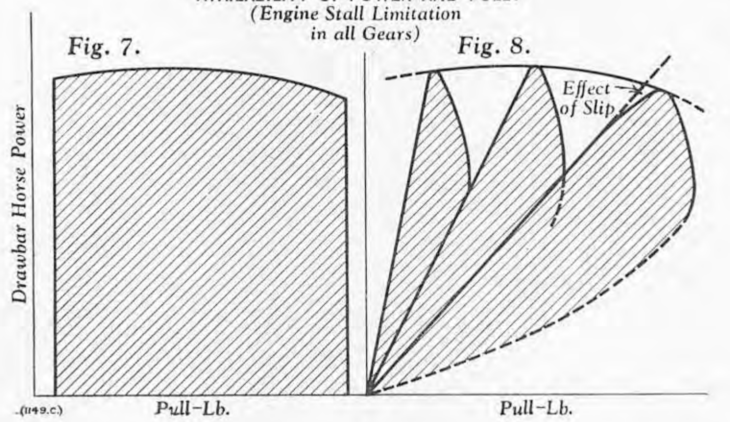
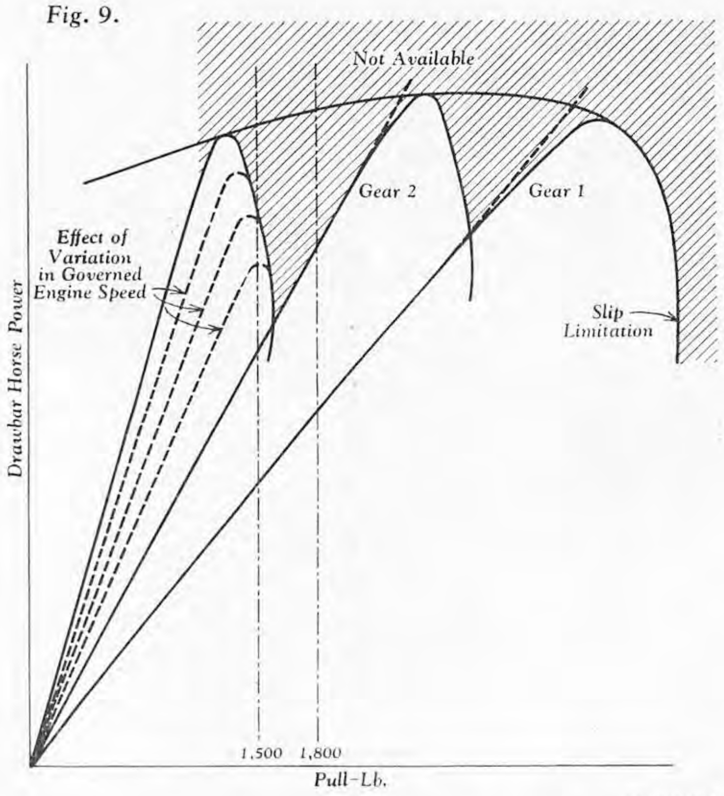


Fig. 9.



opposite. An indication is also given of the variation in performance according to surface conditions which may be expected in the two lowest gears, and it will be noted that both slip and rolling resistance increase as the cohesion of the soil decreases. If there were no slip (i.e., if the adhesion factor were 1) throughout the range of pull on any one land, then maximum power would be obtained in first gear because of the lower power loss due to rolling resistance. On the firm surface, the absolute maximum power is obtained in second gear, and engine stall is the factor limiting maximum pull in the three highest gears. The shape of the curve beyond maximum power in these gears reflects the shape of the engine torque-speed curve and the maximum pull represents maximum crankshaft torque.

Drawbar performance is comparable with engine performance, in that the latter is modified by slip and rolling resistance; the ultimate limitations to maximum drawbar horse-power, maximum pull and specific field fuel consumption are the maximum engine brake horse-power, the maximum crankshaft torque and the specific brake fuel consumption, respectively. The slope of the portion of each drawbar horse power-pull curve between no-load and maximum power is determined by the over-all gear ratio together with the engine governor setting and performance, but the most important engine characteristic is the shape of the torque-speed curve.

The performance of two tractors having the same maximum power and between which the only difference is in the shape of the engine torque-speed curve, is illustrated in Fig. 4. The torque-speed curve is flat with tractor A, but is well peaked in the case of tractor B; this gives rise to the drawbar horse power-pull curves shown. If it be assumed that the tractor is to be operated in the region of maximum power, i.e., efficiently, in second gear, the differences of torque and speed between maximum power and maximum torque represent a reserve. Now tractor load conditions in agricultural practice are variable, and it will be seen that the drawbar load can temporarily increase more with engine B than with engine A before it is necessary to select a lower gear. Once a lower gear is selected, the engine loading is reduced and the engine is operated less efficiently; the specific fuel consumption-load curve rises sharply with decreased load. Hence, with engine A the normal tractor load must be chosen so that the engine is operating at a mean of, say, 75 per cent. of maximum power, whereas engine B can be operated at a mean of, say, 90 per cent. of maximum power without undue risk of frequent gear-changing.

OPERATIONAL FUEL CONSUMPTION.

The importance of the engine torque-speed curve is much reduced if an infinitely-variable gear ratio between engine and wheels is available; but the fewer the gear ratios provided in a mechanical transmission, the more important the torque-speed curve shape becomes if a low operational fuel consumption is to be achieved. To obtain the maximum fuel economy with a prime-mover, such as a tractor, having both variable gear ratio and variable governor setting, it follows that the correct operating procedure is to select a high gear and then to close the manual governor control in order to get the required travelling speed. The engine is thus operated near to the full-throttle curve and savings in fuel consumption of the order of 20 to 25 per cent. may be achieved by this method, given suitable engine torque-speed characteristics.

Slip and Rolling Resistance.

With pneumatic tyres, the adhesion factor can be most easily increased by the addition of weight; with a track-laying tractor it can be improved by an increase in the number or area of penetrating grousers. Much depends on the land conditions and it is dangerous to generalise, but the overriding point is that any measures to decrease slip will result in an increase in rolling resistance.

The influence of slip on drawbar performance will be most obvious in the lower gears, whereas the effect of rolling resistance will be most obvious in the higher gears. This is best illustrated by drawing "envelopes" round the maximum drawbar horse-powers obtained in the various gears. For example, Fig. 5, on page 7, shows drawbar power envelopes which may be obtained on a good and on an intermediate soil condition with the same tractor; on the intermediate land, slip has increased more than rolling resistance to give the result shown. The effect of employing some means of increasing adhesion is shown in Fig. 6, on page 7: rolling resistance has increased, but slip has been much reduced.

The significance of these two interrelated factors is dependent in practice on the type of work for which a tractor is mainly designed. For example, the importance of rolling resistance is diminished in the case of a tractor which is totally engaged in heavy slow-speed haulage work, but this is not so in the case of a general-purpose wheeled tractor. With the latter type of machine, which is predominant in agriculture at the present time, easy interchange of ground drive equipment is required so that something can be done towards promoting a high operational efficiency over the working life. For high-speed work at light loads, the tractor weight should be reduced to a minimum; for low-speed work at high drawbar loads, the weight needs to be increased to a maximum and/or accessories to effect penetration can be fitted. Alternatively, the pneumatic tyres may be replaced by steel wheels or half-tracks.

Speed Availability.

A tractor is theoretically capable of developing any power or exerting any pull below its drawbar horse-power envelope; such an envelope for a hypothetical tractor at maximum engine governor setting on a good surface is represented in Fig. 7, on page 7. In the absence of infinitely-variable gear ratios, however, the availability of power and pull at different speeds is determined by the gear ratios in the change-speed mechanism. There are thus certain non-available areas beneath the envelope, as shown in Fig. 8, but the greater the number of gears and the more peaked the shape of the engine torque-speed curve, the smaller these areas are.

The number of speeds at which any one pull can be obtained is important on two counts. Firstly, as regards fuel economy and the selection of the highest gear and lowest governed engine speed to derive efficient engine loading, bearing in mind that, owing to variable conditions, it is unwise to anticipate prolonged operation beyond maximum power in any gear. Secondly, as regards agricultural requirements and rate of work; that is, operation at the highest speed suitable for a particular job and compatible with the drawbar load applied by the implement in use. A further point in this connection is that, whenever a tractor is operating a field machine with mechanism driven from the power take-off shaft, a constant engine speed is required. In this case, therefore, variation of forward speed cannot be obtained by alteration of the governor setting, but only by gear selection; the choice of rate of work is then solely dependent upon the number of gear ratios available.

The conclusion is, therefore, that the smaller the increments of tractor forward speed within the desired speed range which are permitted by the transmission design, the greater the chance of a high operational efficiency. The question of fuel economy and the effect of variation in governed engine speed is illustrated in Fig. 9, on page 7, for a hypothetical tractor with which slip of the ground drive components is the limiting factor in first gear. It will be seen that it is possible to operate at a pull of, say, 1,500 lb. in gears 1, 2 and 3, but that a pull of 1,800 lb. can only be derived in two gears because there are insufficient ratios. Lower pulls can obviously be obtained at a wider variety of speeds because both methods of deriving a required speed (gear selection and alteration of governor setting) can be employed.

Design Factors.

To reduce the unavailable areas beneath the envelope as much as possible when the number of gear ratios is limited, it is necessary to have equidistant spacing of the maximum power points along the envelope; this is not the same as equidistant spacing between the gear slopes. It must be remembered, however, that the shape of the envelope with any one tractor design will vary with the type of surface. It is desirable, therefore, to minimise the variation in envelope shape over the normal range of ground conditions and to use a mean shape for gearbox design purposes. To design solely for high performance on good or ideal conditions is misleading because a very different envelope shape will be derived on the most frequently encountered conditions. This point is particularly applicable in the case of wheeled tractors when too great a proportion of the rear-axle weight, desirable for high performance on firm conditions, is built into the machine; this cannot be removed for operations on less firm soils, with which a greater contact area or penetration would be of more value in the lower gears, and the resultant high rolling resistance considerably reduces the drawbar power in the higher gears.

It follows that, in view of the diverse conditions and the requirements of operation and of the number of variables affecting agricultural tractor performance, there are two main essentials in design. They are a good basic design, giving a high efficiency over the range of drawbar pull on good surface conditions; and provision, with wheeled tractors, for the easy attachment of accessories, alterations in weight, etc., in order to maintain the performance and the drawbar power envelope shape, as far as possible, over the range of soil conditions on which the tractor will be required to operate. The performance value of any particular basic design must therefore be judged by the overall efficiency, the shape of the torque-speed curve, the shape of the drawbar power envelope on mean conditions, the number of gear ratios provided, and their spacing along the drawbar power envelope.

The Royal Society.—The following have been elected officers of the Royal Society for the current year: as President, Dr. E. D. Adrian, O.M.; as treasurer and vice-president, Sir Thomas Merton; as secretaries and vice-presidents, Sir Edward Salisbury, C.B.E., and Sir David Brunt; and as foreign secretary, Sir Cyril Hinshelwood.

LAUNCHES AND TRIAL TRIPS.

M.S. "Thistledowne."—Single-screw cargo vessel, built by Joseph L. Thompson & Sons, Ltd., Sunderland, for the Albyn Line, Ltd., Sunderland. Main dimensions: 420 ft. between perpendiculars by 59 ft. 6 in. by 38 ft.; deadweight capacity, about 10,000 tons on a draught of 26 ft. Four-cylinder opposed-piston oil engine, constructed by William Doxford & Sons, Ltd., Sunderland. Speed in service, 13 knots. Launch, October 22.

M.S. "Duffield."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Hunting & Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 506 ft. overall by 67 ft. by 36 ft. 3 in.; deadweight capacity, 14,890 tons on a draught of 28 ft. 9½ in. Hawthorn-Doxford four-cylinder two-stroke oil engine, developing 4,450 b.h.p. at 112 r.p.m. in service, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Service speed, about 13 knots. Trial trip, October 24.

M.S. "Burutu Palm."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the West African trade of the Palm Line Ltd., London, E.C.4. Main dimensions: 425 ft. between perpendiculars by 57 ft. 9 in. by 37 ft. 2 in. to shelter deck; deadweight capacity, about 8,516 tons on a summer draught of 23 ft. 9½ in. N.E.M.-Doxford four-cylinder airless-injection opposed-piston oil engine, developing 3,000 b.h.p. at 122 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Trial trip, October 28.

M.S. "Hembo."—Single-screw tug, built by Philip and Son, Ltd., Dartmouth, for the Union Lighterage Co., Ltd., London, E.C.3. Main dimensions: 75 ft. between perpendiculars by 20 ft. by 10 ft. 6 in. Seven-cylinder marine Diesel engine, developing 520 s.h.p. at 430 r.p.m., constructed by Ruston and Hornsby, Ltd., Lincoln. Launch, October 31.

M.S. "Brier Rose."—Single-screw coaster, built by John Lewis and Sons, Ltd., Aberdeen, for Hughes-Holden Shipping Limited, Swansea. Main dimensions: 170 ft. between perpendiculars by 30 ft. by 16 ft. 3 in. to quarter deck; deadweight capacity, about 800 tons. Diesel engine, developing 600 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by the shipbuilders. Launch, November 4.

M.S. "Cymric."—Twin-screw refrigerated-cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the Shaw Savill and Albion Co., Ltd., London, E.C.3. Second vessel of two. Main dimensions: 512 ft. overall by 69 ft. by 41 ft. 6 in. to shelter deck; gross tonnage, about 10,800. Two single-acting two-stroke opposed-piston Diesel engines. Launch, November 5.

M.S. "Cedric."—Twin-screw refrigerated-cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for Shaw Savill and Albion Co., Ltd., London, E.C.3. Main dimensions: 481 ft. between perpendiculars by 69 ft. by 41 ft. 6 in. to shelter deck; gross tonnage, about 10,800. Two six-cylinder single-acting two-stroke opposed-piston Diesel engines. Trial trip, November 6 to 8.

M.S. "Obuasi."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for Elder Dempster Lines, Ltd., Liverpool. Second vessel of a series of three. Main dimensions: 415 ft. between perpendiculars by 60 ft. by 34 ft. to shelter deck; gross tonnage, about 5,600. Harland-B. and W. five-cylinder two-stroke single-acting opposed-piston Diesel engine. Trial trip, November 11 and 12.

M.S. "Caltex Calcutta."—Single-screw oil tanker, built and engined by William Doxford & Sons, Ltd., Sunderland, for Overseas Tankship (U.K.), Ltd., London, W.1 Last vessel of a series of four for these owners. Main dimensions: 490 ft. overall by 61 ft. 9 in. by 36 ft. 3 in.; deadweight capacity, 12,300 tons on a draught of 28 ft. 2½ in. Doxford five-cylinder opposed-piston balanced oil engine, developing 5,150 b.h.p. at 108 r.p.m., and a speed of about 13¾ knots. Trial trip, November 12.

S.S. "Caltex Liverpool."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the Overseas Tankship (U.K.), Ltd., London, W.1. Main dimensions: 544 ft. 4 in. by 70 ft. by 39 ft. 9 in. to upper deck; deadweight capacity, 17,250 tons. Double-reduction geared steam turbines, developing a maximum of 8,200 s.h.p., and two Yarrow marine boilers. Speed, 15 knots. Trial trip, November 12 and 13.

S.S. "Lady Charrington."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for Charrington, Gardner, Locket (London), Ltd., London, E.C.3. Main dimensions: 270 ft. by 41 ft. by 19 ft. 6 in.; deadweight capacity, about 2,900 tons on a summer draught of 18 ft. Direct-acting triple-expansion engine, developing 850 i.h.p. at 80 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland, and two forced-draught coal-burning boilers. Service speed, 10 knots. Trial trip, November 14.

TWO RAILWAY ACCIDENT REPORTS.

Two railway accidents on which Colonel D. McMullen, an inspecting officer of railways, has reported* to the Minister of Transport are attributed by him to, in one case, a split pin which was allowed to remain in poor condition, and, in the other, to a split pin which was subjected to shear in service owing to an unsatisfactory feature of design. In the latter case, he considers that ineffective examination and an accumulation of dirt may have contributed to the failure.

In the first-mentioned accident, which is the subject of the title of the report, the front end of a brake rod on a tender became detached from the forked arm on the brake shaft to which it is normally connected by a round pin. After bouncing on the sleepers and ballast between the rails for a distance of over two miles, the brake rod struck the stretcher bar of some facing points. The closed switch of the points was wrenched open and the second engine (the train was double-headed), together with the following coaches, were derailed. The train was travelling at about 55 m.p.h. and 34 persons were injured. Colonel McMullen concludes that the pin can only have come adrift because the split pin had dropped out. The split pin was not found, but clearly it was defective. Moreover, the mark of wear on the round pin, due to friction between it and the bush in which it was fitted, was found to extend half-way over the split-pin hole—thus confirming that the split pin was not well maintained. "The complete absence of telescoping in the leading coaches," Colonel McMullen adds, "can probably be attributed to the Buckeye couplings with which they were fitted; these are now standard in the British Railways design of main-line coach. Another feature of this coach is the greatly strengthened welded underframe, which, in this accident, withstood the very considerable shock exceptionally well."

In an appendix to the report, Colonel McMullen gives details of the other accident, which occurred on October 25, 1952, near Crewkerne, between Yeovil and Axminster, on the Southern Region main line. It was caused by an unsatisfactory feature of design in the tender of a "Merchant Navy" class engine. The upper pin on which a brake hanger was suspended was fixed in the tender framing in such a way that the split pin holding it was liable to be subjected to shear. The pin hole in the brake hanger was bushed, but as there was no means of lubricating it friction occurred between the pin and the bush. Consequently, whenever the brake was applied, there was a tendency for the pin to turn, and as the sole method of holding the pin consisted of a split pin which, unfortunately, was fitted in a hole in the brake-hanger bracket, the split pin was subjected to shear. As a result of this accident and another of a similar character, longer top pins, secured by split pins outside the bracket, have been fitted to all tenders of this type. The report mentions that leakages of oil from the valve-gear sumps of "Merchant Navy" engines cause dirt to accumulate more rapidly on the under-gear than on other engines.

HYDRO-ELECTRIC CONFERENCE.—The Société Hydrotechnique de France, 199, Rue de Grenelle, Paris (7e), are to publish the contributions presented at the Deuxièmes Journées de l'Hydraulique, held at Grenoble, from June 25 to 29, 1952, and also the discussions to which these contributions gave rise. The publication will take the form of a special number of the journal *La Houille Blanche*, entitled, "Transports Hydraulique et Décantation des Matériaux Solides," these being the subjects of the conference. Paper-covered copies, price 1,600 francs, may be obtained on application to *La Houille Blanche*, Boîte Postale 41, Grenoble, France. The price to members of the Société Hydrotechnique, to members of its technical committee, and to those who attended the Conference, is 1,200 francs.

* *Ministry of Transport—Railway Accidents. Report on the Derailment which occurred on 18th April, 1952, at Blea Moor between Dent and Ribblehead in the London Midland Region, British Railways.* H.M. Stationery Office. [Price 6*d*. net.]

THE ENGINEERING OUTLOOK.

I.—RETROSPECT AND PROSPECT.

THE engineering industries appear to have reached, towards the end of 1952, a position in their post-war development in which they are finding it increasingly difficult to sell their products. The output of most sections fell heavily during the third quarter of the year, to a level substantially below that of the third quarter of 1951 and the very high average of the last three years, and this despite a marked improvement in the supply of materials. The falls in output, which have taken place so far mainly in industries with a short manufacturing cycle, range from 5 to 25 per cent. It is general knowledge in the industry, as some chairmen have already stated in their reports to shareholders, that most companies, even those with three to four years' orders on their books, are finding the inflow of orders inadequate to maintain production at a profitable level. This applies particularly to orders from overseas, where the fall in demand has been accentuated by import restrictions on the part of some Governments, and where competition from other countries has become very keen. There is also a widespread fear of cancellations if the general world economic situation should deteriorate further.

There is no doubt that the situation is potentially serious, but it is not one in which manufacturers must await the inevitable and depend on hope that it may not be as bad as they expect. Yet there is little evidence so far that managements are meeting the challenge with the energy and the imagination that it requires. For some 15 years there has been no sales problem, and most sales organisations consequently need overhauling. Moreover, during the past eight years, industry has become used to leaning on the stick of Government control and to determining policy in accordance with Government directives. High taxation has made it more difficult to increase efficiency, and the wide fluctuations in raw material prices, in some cases, have had a similar discouraging effect. Abroad, the actions of importing Governments have made the development of markets a risky business. It is understandable, therefore, that so many engineering managements should feel that the degree of control they exercise over their own companies' prospects is frustratingly small.

NEED FOR CONCERTED ACTION WITH WHITEHALL.

The analysis of the many complex factors which affect the prospects of the engineering industry results in the broad conclusion that acute pessimism is not justified; but the situation requires vigorous and urgent action, both by the Government and by individual managements, based on a wide understanding of the problems that have to be faced. The next year is likely to be a much more severe test of industry-Government co-operation than at any time since the war, and the co-operation will have to be based on goodwill and understanding rather than on controls and directives. Post-war attempts have shown that the Government cannot easily influence the course of world trade, and therefore are unable to determine precisely the engineering industry's export policy. Experience has also proved fairly conclusively that controls do not instil drive and energy in industrial enterprise. With a very high level of taxation, profitability has not been the prime mover that it was before the war, and nothing has taken its place; there has been, therefore, a marked lack of enterprise which has been hidden by the fact that the world was hungry for British engineering products.

In any case, the greater availability of most engineering materials has greatly weakened the effectiveness of the Ministry of Supply's allocation system. The change to a buyer's market almost everywhere has made it exceedingly difficult for any company to concentrate on "hard currency" areas, and, therefore, Whitehall directives have become less effective. Unless the Government and the industry work with a common purpose, however, it is unlikely that exports will be maintained even at their present level, and there is a danger that unless their efforts are synchronised, they will fail. For example, if the Government secured a "liberalisation" of trade, but British engineering products were substantially more expensive than German or American products, or were marketed less effectively, no increase in trade would result. Another example is that of a company setting up, at considerable expense, a sales organisation in Australia or New Zealand, only to find that the Government concerned had decided to exclude the product to save currency or to avoid inflation.

This article sketches the basic problems that the metal-using industries are likely to have to face during the next few years. Some are basic to the whole economy, such as those relating to international trade and movements of capital, but others arise from the rapid and extensive development of the metal-using industries since the war and the circumstances in which this development took place. The country's fundamental task is to earn its living, balance its international payments, and stabilise its economy on an enduring pattern. Unless this is done, Lancashire, Birmingham, and other great industrial areas will be filled with the empty shells of factories as Cornwall is with derelict tin mines. From the point of view of the metal-using industries, one problem is to secure trading conditions under which efficient companies can reap the full advantages from low costs, inventiveness and marketing drive. The other problem is to raise the average efficiency of those industries to that of the best companies in them, who have proved many times that they can compete successfully against the best from America and Europe.

THE IMPACT OF FREER TRADE.

Freer trade and freer currencies are a prerequisite of an increasing volume of world trade, and were accepted as desirable objectives at the Commonwealth Conference in December. There is also a large measure of agreement on this among the member countries of the North Atlantic Treaty Organisation. Sir Oliver Franks, the retiring Ambassador to the United States, said at a Pilgrims' dinner given in his honour in London on December 16, "It is no use thinking that some one policy alone will prove a panacea. Some have wondered whether a great increase in Imperial preference might give the answer. This is a dream. Times have changed in the 20 years since the Ottawa Conference and with them the terms of trade and the position of the primary producer. Most members of the Commonwealth do not support the view." Sir Oliver went on to say that, though the capital development of the Commonwealth was a major and constructive issue, it would take too long to serve as a solution to present problems. The challenge to British engineering, therefore, is to become competitive in world markets without the same degree of help that has been received since 1932 from preferential tariffs, and since the war from the dollar shortage. Unless the industry and the nation as a whole do better in world markets and increase total exports—which will mean a large increase in the exports of metal products—there will have to be economies and a reduction in the standard of living.

There is clearly no easy road ahead, and the only quick returns which can be expected must come from improvements in methods of production and more flexibility in the industrial outlook. Is British industry, for example, making the things for which there is a rising demand or is it striving vainly to sell outmoded or obsolete products? Commenting on the ways still open to the British people in their efforts to earn their living unaided, Sir Oliver Franks said, "We cannot just cut away at defence and our overseas commitments till we feel comfortable. That means the decline of our political influence and power, which would soon cause economic weakening. We cannot aim to reduce exports; by them we earn the means to work and live. To cut the investment programme, except by most careful and selective pruning, is to sell our own future short."

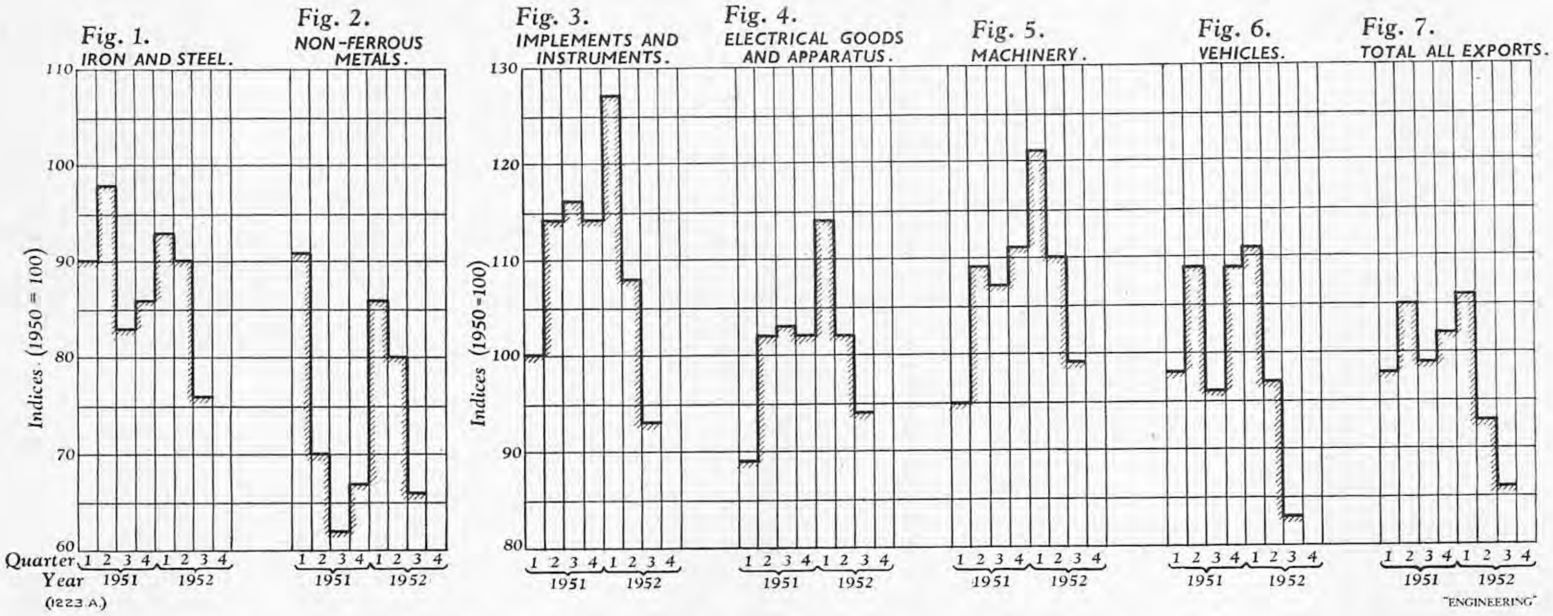
EXPANSION AND EXPORTS.

To determine whether or not the metal-using industries can possibly expand their exports, it is helpful to examine the circumstances in which their output has nearly doubled, compared with pre-war and has risen by more than 50 per cent. since 1946. This considerable expansion has taken place in face of serious shortages of materials, and despite restrictions on sales to the home market. The bulk of the increase has gone to overseas markets and engineering exports have risen, as a proportion of total United Kingdom exports, from 27 per cent. in 1938 to 39 per cent. in 1951 and 42½ per cent. in the first nine months of 1952. The value of exports of metal manufacturers is shown in Table I, herewith, taken from the *Report on Overseas Trade*; and Figs. 1 to 7 show the fluctuations in the volume of exports of each main category of metals and metal products.

These exports have been built up during eight years of boom, when the demand in every country industrial productivity increased by about 6 per cent. per annum. This rate has not been maintained in 1951 and 1952, but only because of the fall in demand for textiles and other consumer goods, which began in 1951 and has made it difficult to work machinery to capacity in these industries. In the metal industries there is no evidence of a diminution in the rate of increasing productivity.

These gains in productivity, however, can be accounted for to a large extent by more efficient use of the existing factors of production, labour, raw materials, etc. It has been estimated, for example, that while the tonnage output of the steel-using industries has increased 49 per cent. between 1946 and 1951, the consumption of steel increased by only 33 per cent. Greater use of trade improved as a result of the slump in the prices of imported raw materials. By the end of 1952, the emphasis of Government policy had changed somewhat. Official opinion now appears to have accepted the view (despite its being at variance with the American official view) that there is little immediate likelihood of the "cold" war flaring up into universal conflict, and that, while great importance still attaches to the need for carrying through the re-armament programmes, some reduction in the speed of its execution can be accepted where this seems expedient in the light of economic circumstances. From the point of view of the British economy, this is of the utmost importance, since it means that any further deterioration of the balance of payments will be met by cutting

FIGS. No. 1 TO No. 7 UNITED KINGDOM VOLUME OF EXPORTS OF METAL GOODS.



was inflationary. There were few attempts by the British Government to give engineering companies a lead as to what they should make, and the production of traditional lines went ahead as fast as possible. The scarcity of materials was used, by allocating authorities, to determine the proportion of output to be exported and, in some cases, the destinations of exports. The result was that very large quantities of traditional products were exported, in many cases, because more up-to-date designs made by the United States, Germany and other countries, which are now conducting export drives, were not then available. Some of the largest British markets, such as Australia, India, and New Zealand, have attempted during the inflation to build up manufacturing industries at the expense of their agriculture and primary industries, which, as a result, have tended to go short of labour. It is now clear that they will have to reverse, or at least to halt, this kind of development. Another important point is that several of the British metal manufacturing industries are exporting half or more of their total output, a proportion held to be much too high to sustain. To some extent, therefore, the development of engineering exports has been unsound and major changes are inevitable.

Plant for British Industry.

Home investment in plant and machinery in the United Kingdom has never been on a really adequate scale since the war. About one-fifth of the national product has been devoted annually to capital investment. This is certainly higher than the average for the decade before the war, but over the whole of that period, and even in the most prosperous year (1937), the national stock of capital was not being properly maintained. In the United States, the total investment per head has been twice as high as in the United Kingdom and investment in the plant and machinery for manufacturing has been relatively higher still. Manufacturing industry in the United Kingdom in 1951 received only about half of the total estimated home output of plant and machinery of 735*l*. million.

In each of the three years from 1948 to 1950,

TABLE I.—United Kingdom: Value of Exports of Metal Manufactures. (£1,000,000.)

—	1938.	1950.	1951.	1951.			1952.			Change in Jan.-Sept. 1952, compared with 1951, Per Cent.
				1st Qr.	2nd Qr.	3rd Qr.	1st Qr.	2nd Qr.	3rd Qr.	
Iron and steel, and manufactures thereof	44·6	156·1	159·6	37·3	41·8	38·2	47·7	48·5	41·8	+ 15
Non-ferrous metals, and manufactures thereof	12·3	76·9	70·5	21·2	17·0	15·3	22·5	20·8	17·3	+ 15
Cutlery, implements, instruments, etc.	9·0	45·2	62·7	13·3	16·0	16·5	19·0	16·3	14·2	+ 5
Electrical goods and apparatus	13·4	83·9	96·6	20·0	24·2	25·9	30·2	27·3	25·5	+ 14
Machinery	57·9	319·1	363·1	78·9	92·1	94·0	112·9	105·9	97·6	+ 16
Vehicles	44·6	405·0	480·3	105·3	124·9	116·2	138·9	123·1	106·4	+ 2

work-study methods, and more extensive use of mechanical handling, have increased the productivity of labour. All this has been achieved despite a slow but steady deterioration in the total stock of capital equipment. Those industries which have expanded rapidly, like the production of motor vehicles and office machinery, have, of course, an up-to-date stock of capital equipment, but these are exceptional. The old-established industries are in the worst situation: in cotton textiles, for example, despite a generous subsidy, the rate of replacement of worn-out and obsolescent machinery has been much less than is desirable. The Treasury have long been well aware of the danger to productivity and manufacturing costs which must result from the deterioration of industrial equipment; nevertheless, in view of the overriding importance which was attached to maintaining the re-armament programme at a time when the balance of foreign payments was rapidly worsening, it was decided at the beginning of 1952 to meet the situation by cutting home investment in order to make more engineering equipment available for export.

Official planning, however, did not foresee the slump in demand for British engineering exports, and, as a result of the inability to sell abroad, the home market absorbed more capital equipment in 1952 than had been intended. The foreign balance, moreover, became more favourable as the terms of armaments rather than by cutting the supplies of tools and equipment urgently needed by British industry.

The Need for More Investment.

It is, however, one thing to make more plant and equipment available to British industry and quite another to ensure that it will be absorbed. Manufacturers in the United Kingdom can legitimately claim that present fiscal policy acts as a serious deterrent to capital investment. Depreciation allowances based on the purchase price of plant which may have been installed upwards of 20 years ago bear no relation to the cost of replacement; onerous taxes are levied on profits ploughed back to reserves; and the initial allowances, which at least permitted manufacturers to write off much of the value of new equipment in the first few years of its operation, were discontinued in April.

The Government's financial policy, moreover, which has raised the cost of borrowing and made bankers closely critical of applications for advances, was expressly designed to limit home investment. A revision of this policy in favour of capital goods now seems overdue. The only argument which can be produced in favour of its continuance is that it prevents wasteful highly speculative investment. There is little danger of much investment of this kind taking place under current trading conditions.

At a time of falling markets at home and abroad, it is essential that enterprise should not be restricted through inadequate fixed and working capital. It has been true to say, perhaps, that the principal defect of monetary policy in the century to 1932 was the maintenance of a high bank rate long after the need for it had disappeared. Cyclical slumps which might have been avoided by a quick reversal of bank-rate policy were thus intensified.

Easier credit conditions and bigger tax relief would not of themselves stimulate a high level of home investment; much would depend upon the degree of confidence which the British manufacturer felt in the future demand for his product. In declining industries, like cotton textiles, it is not surprising if he tends to be cautious about his money outlays—even though his only chance of surviving and competing successfully in world markets depends on his having up-to-date machinery. Some branches of the metal-using industries, notably those making more traditional types of machinery and equipment, are not much more happily placed. Caution in these industries derives simply from the march of history and technological change, and in them new investment should take the form of replacing a large quantity of outmoded machinery with a few modern efficient units. Over much of British industry, and the engineering industry in particular, caution and lack of confidence are not structural, but are the consequence mainly of marketing difficulties, due, in many cases, to factors beyond the control of the manufacturers and of the British Government. The Government, however, by diplomatic skill, example and leadership, can do much to influence the course of trade and stimulate manufacturers to overcome their difficulties.

RISING OBSOLESCENCE OF MACHINE TOOLS.

Deliveries of machine tools provide some key to the extent to which the engineering industries have been failing to maintain their stock of capital equipment. In no post-war year up to 1951 did the home market absorb more than 30,000 machine tools. In 1952, exceptional imports and increased deliveries of British-built machine tools for re-armament have somewhat distorted the picture, but deliveries for normal engineering purposes have certainly not exceeded 30,000. The stock of machine tools in the country, however, is estimated at about 900,000, which, on a very conservative basis, would indicate a replacement demand of 45,000 per annum. On this basis, the level of replacement since the war has only been about two-thirds of the minimum required to maintain the stock.

Re-equipment cannot be discussed in a separate context from manpower; while the rate at which machinery is replaced varies according to market expectations from year to year, and is influenced by the other factors mentioned above, basically the quantity of machinery employed, and the frequency with which obsolescent machinery is discarded for more advanced equipment, depend on the type and quantity of labour available, but, above all, on the level of wages. The work of the Anglo-American Council on Productivity has emphasised that high productivity in the United States is due to no small extent to the constant pressure of the American unions for higher wages. Such a stimulus has not been provided in the United Kingdom; the Trades Union Congress, if not always the individual unions, have considered it their duty in the public interest to limit claims for higher wages as far as possible. The engineering unions have secured important wage increases in recent years, but the amounts which have been awarded and accepted have not been out of keeping with the national policy of restraint. In 1952, after negotiation, an award of 7*s.* 4*d.* a week was accepted, though the initial demand was for 2*l.* a week.

In the present critical state of the United Kingdom's economy, it would be unwise to advocate the type of unrestricted wage bargaining which prevails in the United States. The absence of this incentive, however, quickly gives rise to the danger that, in contrast to the United States, where speedy adoption of technical advances permits both a higher standard of living and reduced production costs, industry in the United Kingdom will continue to retain its outmoded machinery and to maintain itself in a competitive world only at the expense of the standard of living of the workpeople.

The output of the engineering industry has increased rapidly since 1948; as will be seen from Fig. 8, herewith, in the first quarter of 1952 it was at a rate 38 per cent. higher than in 1948. The general set-back in the export markets, however, resulted in a fall in production in the second quarter of 1952. In shipbuilding, engineering and electrical goods, this was less severe than for the industry as a whole, but in the vehicle industry it was very pronounced. The variations in some of the principal markets are indicated in Table II, which, like Table I, is taken from the *Report on Overseas Trade*. As has been argued above, increased consumption of plant and machinery in the home market is desirable and could partly restore the level of engineering production. The industry will not, however, achieve maximum production unless it can expand its exports.

(*To be continued.*)

FIGS. No. 8 TO No. 11 UNITED KINGDOM INDEX OF INDUSTRIAL PRODUCTION.

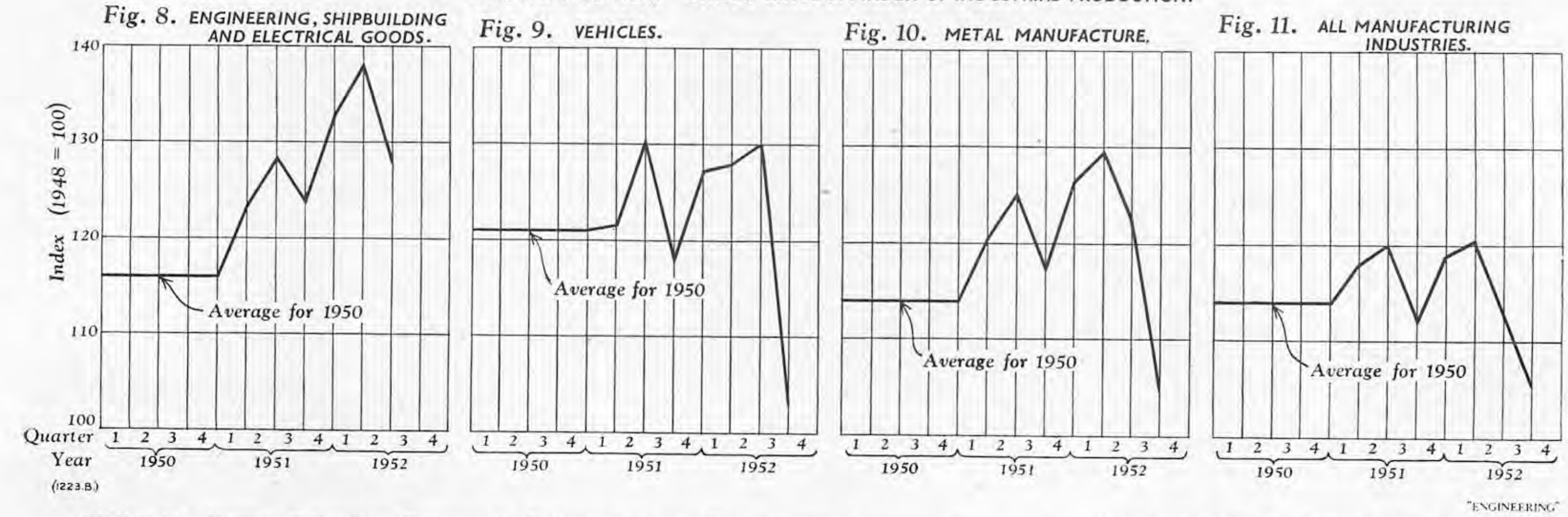


TABLE II.—UNITED KINGDOM: EXPORTS OF PRODUCTS OF THE ENGINEERING INDUSTRY TO SELECTED AREAS. (£1,000: Monthly Averages.)

—	1951, January to September.			1952, January to September.		
	Electrical Goods.	Machinery.	Vehicles.	Electrical Goods.	Machinery.	Vehicles.
United States	129	587	1,056	97	751	1,546
Canada	182	1,053	2,042	253	1,378	1,593
Other American-account countries	105	644	903	229	799	865
Non-dollar Western Hemisphere countries	494	1,904	2,171	403	2,285	2,188
Sterling members of Commonwealth	2,982	10,941	12,540	3,730	12,903	12,195
Australia	912	3,970	6,490	797	4,070	4,988
Union of South Africa	710	2,584	1,720	832	2,887	1,676
Others	1,360	4,387	4,330	2,101	5,946	5,531
Colonies	1,132	2,672	4,469	1,356	3,626	5,132
Iraq, Burma and Jordan	111	310	262	—	—	—
Non-sterling O.E.E.C. countries	1,407	6,498	10,354	1,650	7,842	10,744
O.E.E.C. possessions	71	542	676	90	828	951
Irish Republic and Iceland	381	906	963	311	959	836
Eastern Europe	165	1,115	663	233	1,011	1,416

RELAXATION OF ELECTRICAL WIRING REGULATIONS.

IN a recent report on "Economy of Building Materials," which was prepared by an Inter-Departmental Committee appointed by the Minister of Works, it was suggested that the War Emergency Regulations for the Electrical Equipment of Buildings of the Institution of Electrical Engineers might be reinstated with a view to effecting economies in the use of copper during the present stringency. As a result of a review by the Wiring Regulations Committee of the Institution, however, it was, found that the situation was no longer the same as in 1942, when the War Emergency Regulations were issued, since modifications had been introduced, which enabled cable economies to be achieved. It was also considered undesirable to permit any general increase in the maximum voltage drop permitted. Nevertheless, it did appear that some saving of copper might be possible in the range of small cables, the ratings of which were not dictated by thermal considerations alone. The Institution have, therefore, issued as a temporary relaxation a revised table incorporating the higher current ratings for cables with conductors up to 7/0·029 in. which were adopted in 1942, but with the limits of voltage drop reduced to those shown in the current edition of the Regulations. It has also been agreed that the tables in the current edition shall be reviewed in the light of the results of the research, which is now being undertaken on the thermal rating of cables. The temporary relaxation became effective on December 15, and will continue in force until further notice. Copies can be obtained from the secretary of the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, on receipt of an envelope bearing a 1½*d.* stamp and marked "W.R."

LECTURES ON REFRIGERATION.—A series of ten lectures has been arranged by the National College for Heating, Ventilating, Refrigeration and Fan Engineering on the general subject of "Mechanical Refrigeration—the relation between theory and design." The first four will be concerned with thermodynamical principles. Later lectures will deal with problems of design. The lectures will be held on Wednesday evenings at 7 p.m., commencing January 14, 1953, at the Royal Sanitary Institute, 90, Buckingham Gate, London, S.W.1. The fee will be 25*s.* Applications should be made to the Head of the College at 103, Borough-road, London, S.E.1, before January 5.

OVERHEAD CONSTRUCTION FOR 50-CYCLE SINGLE-PHASE TRACTION.

BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD., LONDON.

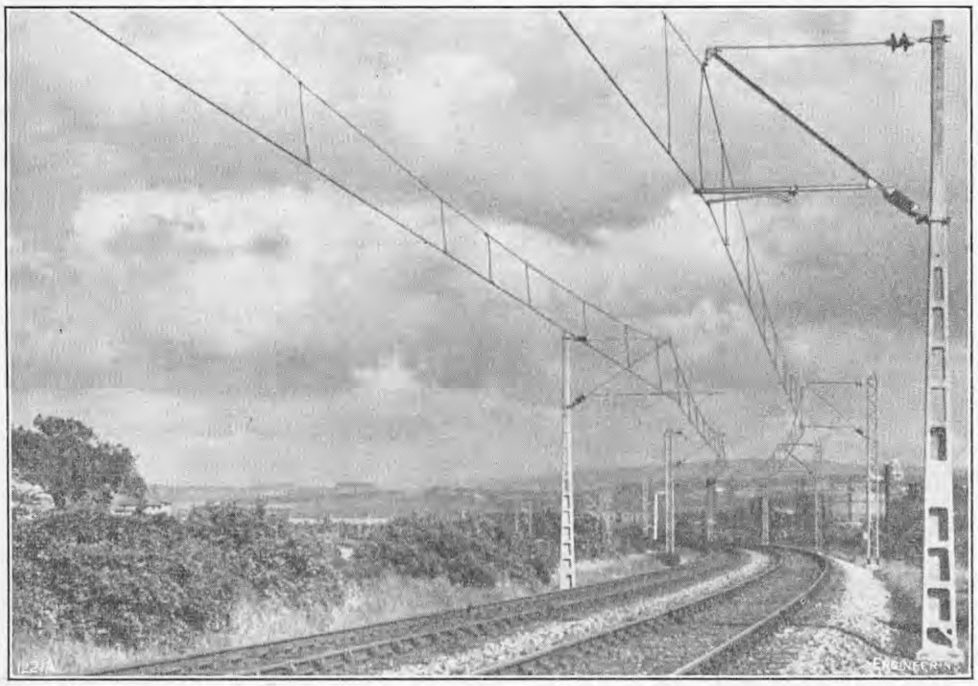


FIG. 1. REINFORCED-CONCRETE POLES ON CURVED TRACKS.

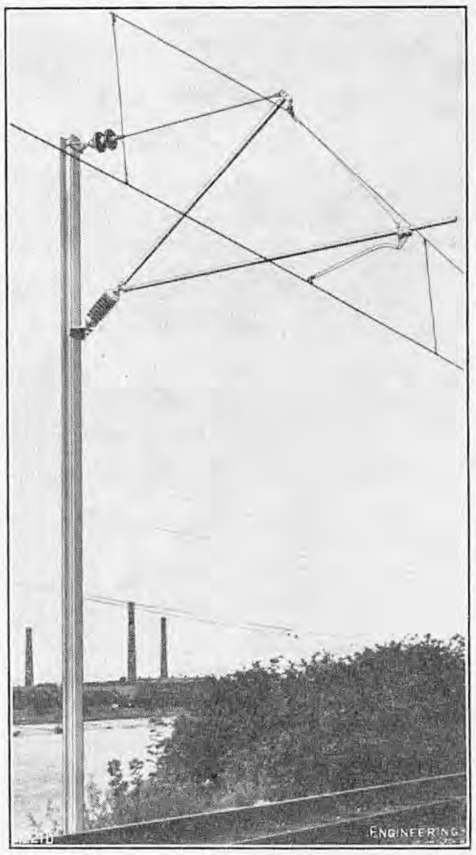


FIG. 2. POLE AND TUBULAR CANTILEVER OF ALUMINIUM ALLOY.

OVERHEAD CONSTRUCTION FOR 50-CYCLE SINGLE-PHASE TRACTION.

As announced on page 659 of our 172nd volume, British Railways decided about a year ago to carry out trials of the 50-cycle single-phase system of electric traction on the Lancaster-Morecambe-Heysham line of the London Midland Region. It may be recalled that this line, which comprises 20 single track miles with a number of sharp curves and low bridges, was first electrified by the former Midland Railway Company in 1908. Originally a supply of power for this purpose was drawn from the Heysham Harbour power station on the single-phase system at 6·6 kV and 25 cycles, but later a 50-cycle supply was obtained from the Morecambe Corporation and converted to 25 cycles by frequency changers. The traffic was carried in three trains, each consisting of a motor car and two trailers. Two of the motor cars were equipped with 180 h.p. motors and one with a 150-h.p. motor, which were supplied at a mean terminal voltage of 250 volts through a transformer with six tappings on the low-tension side. These trains had to be withdrawn from service in February, 1951, owing to age. The overhead equipment consisted of steel bridges carried on wooden poles set in concrete foundations with a stranded cadmium-copper catenary and a single contact wire of the same material attached to the catenary by dropper wires. Unlike the rolling stock, it was in good condition and is suitable for use at a higher frequency.

The power for operating the line during the 50-cycle experiments will be drawn from a new substation at Green Ayre station, Lancaster, at 6·6 kV. This will, in turn, be supplied from the network of the North Western Electricity Board. British manufacturers are to be given an opportunity of demonstrating 6·6 kV 50-cycle equipment and with that end in view about 4,000 ft. of the old two-track portals have been dismantled by British Insulated Callender's Construction Company, Limited, 21, Bloomsbury-street, London, W.C.1, and have been replaced by light single-track hinged cantilever construction of various designs by the same company.

The new overhead equipment, typical examples of which are illustrated in Figs 1 to 6, on this page and on page 16, is designed for 20-kV, as British Railways may later decide to increase the voltage of the system to that figure. It consists of a catenary of stranded hard-drawn copper made up of seven 0·116-in. wires attached to a cadmium-copper contact wire with a cross-section of 0·166 sq. in. by dropper wires. Automatic tensioning by means of balance weights has been adopted. The different forms of supporting structures that are being tested on the experimental length, include rolled-steel joists, steel broad-flange beams, aluminium broad-flange beams, lattice steel, steel tubes, prestressed concrete and creosoted wood. Some of the hinged cantilevers are fabricated from steel angles and T's, others from steel tubes and others, again, from aluminium-alloy sections. Pin type, cap-and-pin and solid-core insulators are all being used. A number of different processes have been employed for protecting masts, such as galvanising, flame cleaning and painting, shot blasting and metal spraying.

As regards rolling stock, the three existing three-coach trains have been refitted with rectifiers, and direct-current motors by the English Electric Company, Limited, Kingsway, London, W.C.2. Trial running for experimental purposes has begun, and a number of problems peculiar to this system of traction are being investigated. Service running may come into operation this Year.

STANDARD CLASS-4 2-6-0 LOCOMOTIVES; BRITISH RAILWAYS.

THE seventh of the 12 standard types of locomotives which are being designed and built under the direction of Mr. R. A. Riddles, the Railway Executive member for mechanical and electrical engineering, is a Class-4 2-6-0 tender locomotive with 5 ft. 3 in. coupled wheels, and is evidently intended for mixed-traffic duties.* Many of its components are interchangeable with those of the other standard engines and, as Figs. 1, 2 and 3, opposite, show, it has the familiar foot-framing set high, the footplate extending over the front end of the tender, several of the boiler mountings arranged outside the cab front and a cut-away tender to give good visibility backwards. The design also includes a rocking grate, and the motion follows very closely that of the Class-3 tank engines, having the same valve events and with many parts the same on both engines. The two cylinders are $17\frac{1}{2}$ in. by 26 in., the boiler pressure is 225 lb. per square inch, the tractive effort is 24,170 lb. and the adhesion factor is 4·59.

Horwich locomotive works recently turned out the first, No. 76000, of 25 which are to be built at Horwich and Doncaster. The parent office for the design of the engine is Doncaster, but the 3,500-gallon tender is the same as that already in use with the 4-6-0 Class-4 engines built at Swindon. Engines Nos. 76000 to 76004 are to be allocated to the Scottish Region, 76005 to 76019 to the Southern Region and 76020 to 76024 to the North Eastern Region.

The design of the boiler follows closely that of the London Midland Region Class-4 2-6-0 engine; they both work at 225 lb. per square inch and the flanged plates are common to both. The superheater surface, however, is slightly increased, being 254·3 sq. ft. compared with the 231 sq. ft. of the L.M.R. Class 4 engines when they were introduced in 1948. The tube heating surface is correspondingly less—1,061 sq. ft. compared with 1,090 sq. ft.—but the firebox surface is the same at 131 sq. ft. Similarly the grate area is 23 sq. ft. The free flue area of the new engines is 3·8 sq. ft. There are 24 large tubes, $5\frac{1}{8}$-in. outside diameter by 7-s.w.g. thick, and 154 small tubes $1\frac{5}{8}$-in. outside diameter by 12-s.w.g. thick. The length between tubeplates is 10 ft. $10\frac{1}{2}$ in. and the superheater elements are $1\frac{3}{8}$-in. outside diameter by 10-s.w.g. thick.

The boiler shell plates are of ordinary quality steel. The barrel consists of two rings, the first being cylindrical, $\frac{5}{8}$-in. thick, and the second tapered, of $\frac{11}{16}$-in. plate. The outside diameter is 4 ft. $9\frac{1}{2}$ in. at the front, where a $\frac{3}{4}$-in. drumhead tubeplate is fitted, and 5 ft. 3 in. at the firebox end. The Belpaire firebox is 7 ft. 6 in. long and 4 ft. $0\frac{1}{2}$ in. wide outside; it has a $\frac{9}{16}$-in. steel wrapper plate and an $\frac{11}{16}$-in. vertical throat-plate. The inner firebox is of copper, with a $\frac{5}{8}$-in. wrapper plate and a 1-in. tubeplate. All firebox water-space stays are of Monel metal, fitted with steel nuts inside the firebox;

* Articles on the first six standard classes appeared in ENGINEERING as follows: 4-6-2 Class 7, vol. 171, pages 126 and 341 (1951); 4-6-0 Class 5, vol. 171, page 528 (1951); 4-6-0 Class 4, vol. 171, page 752 (1951); 2-6-4 Class 4 tank, vol. 172, page 138 (1951); 4-6-2 Class 6, vol. 173, page 108 (1952); and 2-6-2 Class 3 tank, vol. 173, page 698 (1952).

CLASS-4 STANDARD 2-6-0 LOCOMOTIVE; BRITISH RAILWAYS.

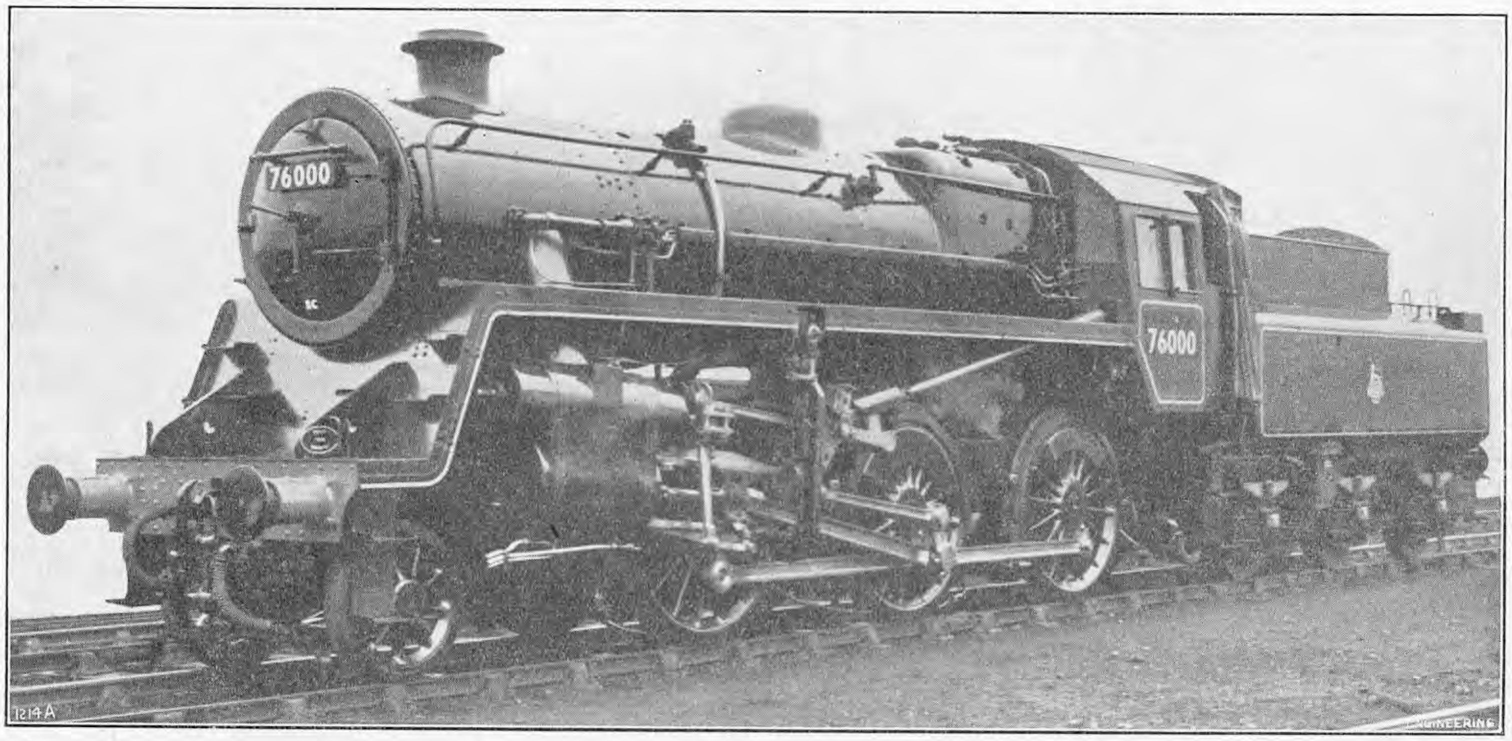


FIG. 1.

Fig. 2.

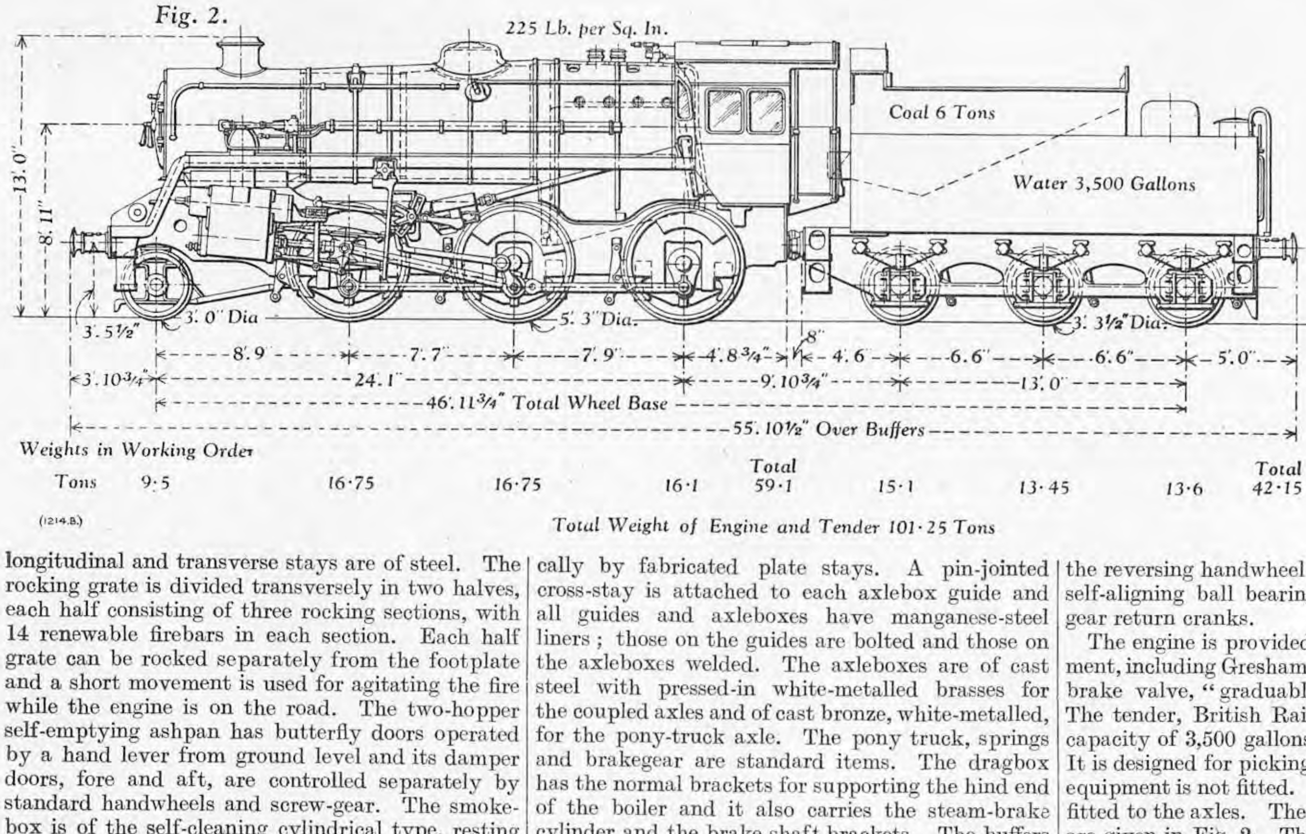
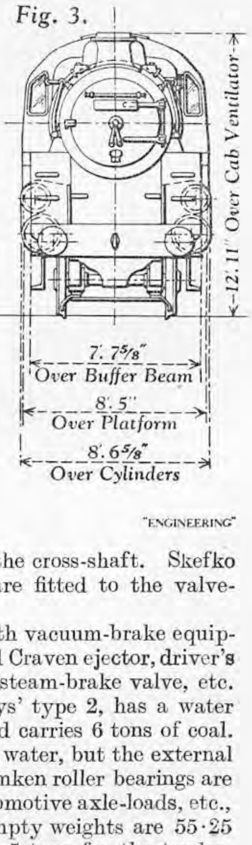


Fig. 3.



(1214.B.)

Total Weight of Engine and Tender 101·25 Tons

"ENGINEERING"

longitudinal and transverse stays are of steel. The rocking grate is divided transversely in two halves, each half consisting of three rocking sections, with 14 renewable firebars in each section. Each half grate can be rocked separately from the footplate and a short movement is used for agitating the fire while the engine is on the road. The two-hopper self-emptying ashpan has butterfly doors operated by a hand lever from ground level and its damper doors, fore and aft, are controlled separately by standard handwheels and screw-gear. The smokebox is of the self-cleaning cylindrical type, resting on a fabricated saddle and containing a blast pipe with a standard plain circular cap which has a 4⅝-in. nozzle and incorporates the blower ring.

A regulator of the slide-valve type, fitted in the dome, is actuated by an external pull rod (visible in Fig. 1), which is connected to a transverse shaft working through a stuffing box in the second barrel plate. The boiler fittings include a manually-operated blow-down valve supplied by the Everlasting Valve Company (Great Britain), Limited, 125, Balham High-road, London, S.W.12. The superheater elements were made by the Superheater Company, Limited, 53, Haymarket, London, S.W.1, and the boiler and firebox are lagged with Fibreglass mattresses provided by W. Gilmour Smith and Company, Limited, Glasgow, C.2.

The main frames are 1⅛-in. plates spaced 4 ft. 0½ in. apart and well braced both horizontally and vertically by fabricated plate stays. A pin-jointed cross-stay is attached to each axlebox guide and all guides and axleboxes have manganese-steel liners; those on the guides are bolted and those on the axleboxes welded. The axleboxes are of cast steel with pressed-in white-metalled brasses for the coupled axles and of cast bronze, white-metalled, for the pony-truck axle. The pony truck, springs and brakegear are standard items. The dragbox has the normal brackets for supporting the hind end of the boiler and it also carries the steam-brake cylinder and the brake-shaft brackets. The buffers were supplied by George Turton, Platts and Company, Limited, Wincobank, Sheffield.

The two cylinders, which are of cast-steel and linered, are fitted with box pistons, each with two rings and a spring-loaded bronze slipper which supports the head clear of the cylinder bore. The piston valves, actuated by Walschaerts valve gear, are 10 in. in diameter and have a steam lap of 1½ in., a lead of ¼ in., and a maximum travel in full forward gear (75 per cent. cut-off) of 6¼ in. Lubrication of the motion pins and reversing gear, as on the other standard locomotives, is by grease gun and nipples. The cylinders and valve chests are lubricated by oil from mechanical lubricators. The atomiser steam is controlled by the cylinder-cock lever, and a notice to this effect is displayed in the cab. A screw-and-nut drive is provided at the forward end of a Hardy Spicer shaft which connects the reversing handwheel to the cross-shaft. Skefko self-aligning ball bearings are fitted to the valve-gear return cranks.

The engine is provided with vacuum-brake equipment, including Gresham and Craven ejector, driver's brake valve, "graduable" steam-brake valve, etc. The tender, British Railways' type 2, has a water capacity of 3,500 gallons and carries 6 tons of coal. It is designed for picking up water, but the external equipment is not fitted. Timken roller bearings are fitted to the axles. The locomotive axle-loads, etc., are given in Fig. 2. The empty weights are 55·25 tons for the engine and 10·5 tons for the tender. The brake force for the engine and tender is 64·12 per cent. The pony-truck wheels are 3 ft. and the tender wheels 3 ft. 3½ in. in diameter. The minimum radius of curve, with gauge-widening, is 4½ chains.

FILM EXHIBITION.—The Atlas Diesel Co., Ltd., Beresford-avenue, Wembley, Middlesex, showed two films at an exhibition in London on December 18. The first film was made by the parent company, Aktiebolaget Atlas Diesel, Stockholm, Sweden, at the time of their 75th anniversary in 1948, and was of a historical character, but it also contained many shots taken in their factories in Sweden to show the processes involved in the manufacture of the company's products. The second film showed the methods employed in driving a large tunnel, 48 ft. high, 40 ft. wide and 3,800 yards long, through granite for a hydro-electric power scheme, using compressors and rock drills made by the company.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

TRIALS OF SINGLE-DECK OMNIBUS IN GLASGOW.—A new type of single-deck omnibus, carrying as many standing as seated passengers, has been lent by the Daimler Company to Glasgow Corporation Transport Department for testing on a variety of routes. Built by Walter Alexander & Co., Stirling, on the latest Daimler "freeline" chassis, the vehicle has a carrying capacity of over 60 persons and is claimed to offer a considerable saving in running and maintenance costs. Advantages claimed for it, in comparison with double-decked vehicles, are that it facilitates the collection of fares, saves time in loading and unloading passengers, and is easier to handle on sharp bends.

NEWHOUSE INDUSTRIAL ESTATE.—Negotiations with a large electrical-engineering firm to take over the factory space formerly occupied by Vactric Ltd., at Newhouse Industrial Estate, have fallen through. It had been hoped that the firm in question would move in as Vactric Ltd. vacated the factory, one of the most modern in the country.

IMPROVEMENTS IN GLASGOW-LONDON SLEEPING-CAR SERVICE.—All four-berth sleeping cars are to be withdrawn from the Glasgow (Central)-London (Euston) route after January 4, it was announced by British Railways on December 22. They are to be replaced by two-berth cars with hot and cold running water in each compartment. Additional first-class sleeping cars will also be available, except on Saturdays, on the regular services.

POLYTHENE-COATED PAPER TO BE MADE IN GLASGOW.—The Clyde Paper Company, Rutherglen, near Glasgow, have installed a machine for producing polythene-coated paper. The process adopted is extrusion-lamination. The heat-insulating properties of polythene are utilised in the making of vapour-proof and moisture-proof bags. Polythene paper is also used as a protective wrapping against the corrosion of machine parts, and interest is being shown in its use for the packaging of ammunition.

THE UNION-CASTLE LINER "LLANDOVERY CASTLE."—The 10,639-ton Union-Castle liner Llandovery Castle arrived on December 22 at Inverkeithing, where she will be broken up by Thos. W. Ward, Ltd.

RESEARCH ON VISION AT ABERDEEN.—The Nuffield Foundation have granted 5,000*l*. to assist research on vision, in progress in the physiology department of Aberdeen University. The subject of the research is the bearing of the quantum theory on the functioning of the eye.

HARBOUR FACILITIES AT GREENOCK.—Derequisitioning of the Great Harbour at the James Watt Dock, Greenock, may result from recent negotiations between the Harbour Trust and the Admiralty, under whose control it has been since the early days of the war. When the Harbour was taken over by the Government a new ship-repair wharf, about 900 ft. long, was built. For some time the Trust have been urging that the Harbour should be made available for the fitting out of the large oil tankers now being built on the Clyde, as the existing facilities at the James Watt Dock are being severely taxed.

CLEVELAND AND THE NORTHERN COUNTIES.

IRON PRODUCTION ON THE NORTH-EAST COAST.—At the year end, 25 blast furnaces were in operation in the Tees-side area. This is only one more than twelve months ago, but the output is now considerably higher and the make of pig iron in North East Yorkshire and County Durham now averages 50,000 tons a week.

TYNE IMPROVEMENT COMMISSION.—At a meeting of the Tyne Improvement Commission at Newcastle it was reported that about 70 per cent. of the reinforced-concrete piling had been completed for the new coaling staith at Whitehill Point, North Shields. At the new iron-ore quay at Tyne Dock, 80 per cent. of the steelwork has been delivered and 69 per cent. (or 1,980 tons) erected, for the new ore-handling plant. Eighty-three per cent. of the quay piling has been driven and 63 per cent. of the deck-slab concrete placed.

THE PALLION WORKS OF THE BRISTOL AEROPLANE COMPANY.—Alterations to cost 20,000*l*. are proposed to the Pallion, Sunderland, works of the Bristol Aeroplane Co., Ltd. A licence is expected shortly for a 6,000*l*. scheme for an X-ray department for testing castings and components. The firm's expansion plan at Sunderland is being delayed, however, through shortage of machine tools. Only half the machines required have been delivered and some of the remainder will not be delivered until 1954.

APPRENTICES IN THE WELDING INDUSTRY.—The report of the Sunderland Youth Employment Committee, for the year ended July, 1952, refers to the fact that, during the 12 months covered by the report, only three apprentice welders were engaged in local works. This, it is stated, is due to the welders' union (the Boilermakers' Society) placing a ban on the employment of further apprentice welders. The Society's policy is to have a ratio of one apprentice to five journeymen welders. At present, however, there are 230 apprentices to 520 journeymen, and the Society are not prepared to lift the embargo until the five to one ratio is restored.

PROPOSED MARSHALLING YARD AT SOUTH SHIELDS.—Residents of the Gipsies' Green estate, South Shields, are calling for the abandonment of a scheme by the National Coal Board for the construction of a marshalling yard adjoining the estate. The residents have set up an "Action Committee" and secured a promise from the M.P. for South Shields, the Rt. Hon. J. Chuter Ede, to investigate the matter. It is hoped that a public inquiry into the scheme will be held.

DERWENTHAUGH COAL STAITHS.—After being out of commission for 18 months, following extensive fire damage, Derwenthaugh coal staiths, Newcastle-on-Tyne, are to be brought back into use on January 12. The staiths handle about 500,000 tons of coal annually, and since the fire, which destroyed about 100 yards of timber supporting the railway, much coal has had to be diverted to Dunston staiths.

POTASH DEVELOPMENT AT WHITBY.—Imperial Chemical Industries, Ltd., have announced that the experiments at Upgang, Whitby, for the winning of potash by the brining method have been completed. An exploratory borehole has been operated as an experimental brine well, to obtain technical information on winning potash by dissolving it out of deposits which have been proved to exist at a depth of 4,000 ft. This work having been completed, the surface plant is to be dismantled. Mr. A. Spearman, M.P. for the Whitby area, is to give an account of the potash developments at Whitby to the Whitby Chamber of Trade on January 16.

PROGRESS AT DURHAM COLLIERIES.—Houghton-le-Spring Urban District Council have approved plans of the National Coal Board for a new shaft at Lambton "D" pit and for the reconstruction of the surface works at Herrington Colliery. The output at Dawdon Colliery has reached its highest weekly figure since 1932, namely, 18,528 tons. The pit's record output in 1932 was 19,822 tons.

LANCASHIRE AND SOUTH YORKSHIRE.

THE DEMAND FOR REFRACTORIES.—Sheffield and district makers of refractories state that the closing weeks of 1952 showed definite signs of a slackening in the demand. This is not regarded as serious and is welcomed by some makers as an opportunity to improve on delivery dates. Mr. A. McKendrick, a director of General Refractories Ltd., states that the question for 1953 is whether a continued advancement can be better obtained by greater collaboration between manufacturers of refractories or by intensified research by individual makers.

SHEEPBRIDGE BLAST FURNACE.—The new blast-furnace blown in just before Christmas at the works of the Sheepbridge Co. Ltd. marks the last stage of a 2,750,000*l*. modernisation scheme. It stands on the site of the firm's old No. 4 furnace. This is the second new furnace; the first was blown in about 20 months ago.

FURNACE MODERNISATION.—The Appleby-Frodingham Steelworks, Scunthorpe, a branch of the United Steel Companies Ltd., Sheffield, are to scrap their oldest blast-furnace, No. 8, built in 1884. Since Nos. 9 and 10 furnaces have been re-lined, and their hearths enlarged, they are producing 800 tons more iron a week, according to Mr. G. D. Elliott, the ironworks manager. Even without No. 8 furnace, he states, an average of 19,500 tons of iron a week could be produced for steelmaking, which is sufficient to maintain a full working week in the rolling-mill plant. Two new blast-furnaces are under construction at the works.

THE LATE MR. ERNEST TWIGG.—We have learned with regret of the sudden death on December 16, at the age of 64, of Mr. Ernest Twigg, A.C.I.S., F.C.W.A., managing director of Robert Jenkins & Co., Ltd., Rotherham. He was the firm's first indentured apprentice, having been articled to the late Mr. A. T. Jenkins in 1901. He was appointed secretary when the company was formed in 1917 and held that position until 1946, when he became managing director on the retirement of Mr. Edgar J. Jenkins. He was also managing director of the Rotherham Motor Company and of Joseph T. Rodgers & Co., both subsidiaries of Robert Jenkins & Co.

HYLAND, LTD., WAKEFIELD, AND VICKERS-ARMSTRONGS, LTD.—Vickers-Armstrongs, Ltd., announced in December that they had acquired the sole right to make and sell the ships' equipment previously supplied by Hyland, Ltd., Wakefield, whose works and plant they bought in February last. The works will now be known as the Wakefield Works of Vickers-Armstrongs, Ltd. The former Hyland products—hydraulic steering gears, cargo winches, capstans and windlasses—will still be made there, and the works will also be used to increase the production of Vickers variable-speed gears.

THE MIDLANDS.

MIDLAND INDUSTRY IN 1952.—In the heavy industries of the Midlands there has been no noticeable change in conditions during 1952. Heavy engineering, and most producers of capital equipment, have continued to experience a firm demand, and iron and steel production has been at a very high level. In light engineering and foundry work there has been some decline during the last six months of the year, largely as a result of reduced orders from the motor industry. In the engineering industry generally, there is a marked reluctance to speculate on the future. The continued improvement in iron and steel supplies has placed engineering manufacturers in a better competitive position regarding delivery dates for export orders, and the industry generally is confident of its ability to compete successfully in overseas markets. It is pointed out, however, that much depends upon import restrictions imposed abroad.

RISE IN ELECTRICITY CHARGES.—The Midlands Electricity Board have announced that electricity charges, both industrial and domestic, are to be raised from January 1, 1953. The Board state that increased costs have made it necessary to raise the charges, and that the rises have been kept as low as possible.

COVENTRY WATER SUPPLY.—Coventry Corporation Waterworks Committee have announced that the city's project for obtaining water from the river Severn is approaching completion, and that the official opening ceremony will probably be in May. The Corporation started to construct a 40-miles pipe line from Upton-on-Severn to a newly-constructed reservoir at Meriden, near Coventry, in 1947. The scheme will provide 6,000,000 gallons of water a day, to be increased later to 10,000,000 gallons. Preliminary filtering will be carried out at the Upton-on-Severn intake, and there is an extensive water-treatment plant at Strensham, near Tewkesbury. The pipe line is 27 in. in diameter for a large part of its length, and 30 in. for the remainder.

THE INSTITUTION OF MECHANICAL ENGINEERS.—The Midland Branch of the Institution of Mechanical Engineers, finding that many members have difficulty in attending meetings in Birmingham, have arranged to hold a series of meetings, experimentally, at Rugby.

SPECIAL MOTOR CAR FOR CONTINENTAL RALLIES.—Dellow Motors Ltd., Alvechurch, Warwickshire, are putting into production a car specially designed for Continental rallies. The car is based largely on Ford components, and has a Ford 10-h.p. engine.

SOUTH-WEST ENGLAND AND SOUTH WALES.

PROSPECTS IN SOUTH WALES COALFIELD.—The prospects for the South-Wales coalfield are brighter than those for any other British coalfield, states Mr. D. M. Rees, chairman of the South Western Divisional Coal Board, in a message to miners and officials. In the first half of last year, South Wales was showing a greater improvement in production than any other coalfield, but the lead was lost in the second half of the year owing to stoppages. These stoppages, Mr. Rees states, were futile because, in the end, the disputes always had to be settled by the established machinery of conciliation. He therefore appeals for the utmost use to be made of that machinery in 1953.

PRE-CHRISTMAS COAL OUTPUT.—Only nine pits operated the ban on the Saturday shift in the week-end before Christmas. As a result, the output from the coalfield, during the week ended December 20, reached the highest level of the year, namely, 517,238 tons. This, however, was below the level reached in the Christmas week of last year, when 541,150 tons were raised.

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.—*South Midland Centre:* Monday, January 5, 6 p.m., James Watt Memorial Institute, Birmingham. "Post-Graduate Activities in Electrical Engineering," by Mr. W. J. Gibbs and others. *Merseyside and North Wales Centre:* Monday, January 5, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Uses of Earthed Signal Conductors on Transmission Circuits," by Mr. W. Casson. *District Meeting:* Monday, January 5, 6.30 p.m., Crown and Anchor Hotel, Ipswich. "275-kV Developments on the British Grid," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *Measurements and Radio Sections:* Tuesday, January 6, 5.30 p.m., Victoria-embankment, W.C.2. "An Improved Scanning Electron Microscope for Opaque Specimens," by Mr. D. McMullan. *North-Western Centre:* Tuesday, January 6, 6.15 p.m., Engineers' Club, Manchester. "The Characteristics and Control of Rectifier-Motor Variable-Speed Drives," by Mr. P. Bingley. *North Midlands Centre:* Tuesday, January 6, 6.30 p.m., 1, Whitehall-road, Leeds. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. *Southern Centre:* Wednesday, January 7, 6.30 p.m., Technical College, Brighton. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *Institution:* Thursday, January 8, Victoria-embankment, W.C.2, 4.30 p.m., "Nuclear Reactors and Applications," by Sir John Cockcroft, F.R.S. 6 p.m., Symposium on "Nuclear Reactor Instrumentation."

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Monday, January 5, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "The Modern Single-Layer Selenium Photocell," by Dr. G. A. Veszi. *Scottish Section:* Thursday, January 8, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. Film Display.

INSTITUTE OF MARINE ENGINEERS.—*Junior Section:* Monday, January 5, 7 p.m., 85, The Minories, E.C.3. Questions and Answers on "The Apprentice's and Junior Engineer's First Trip."

INSTITUTION OF THE RUBBER INDUSTRY.—*Preston Branch:* Monday, January 5, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. "Problems of the Rubber Manufacturer," by Mr. L. Colledge.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Leeds Branch:* Monday, January 5, 7.30 p.m., Great Northern Hotel, Leeds. Discussion on "Contactor-Type Switchgear." *North-East London Branch:* Monday, January 5, 8 p.m., Angel Hotel, Ilford. "The Principle of the Metadyne," by Mr. D. H. Taylor. *West London Branch:* Tuesday, January 6, 7.30 p.m., Windsor Castle Hotel, King-street, Hammersmith, W.6. "Installation Practices During a Quarter of a Century," by Mr. J. Flood. *Nottingham Branch:* Tuesday, January 6, 7.30 p.m., Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. "Modern Fixing Practice," by Mr. R. P. Dunn.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, January 5, 7.30 p.m., College of Commerce and Technology, Pond-street, Sheffield, 1. Discussion on "Methods of Making a Typical Casting in Iron, Steel and Non-Ferrous Metal." *West Riding of Yorkshire Branch:* Wednesday, January 7, 6.30 p.m., Technical College, Bradford. "Economical Use of Metal in Foundry Practice," by Mr. D. W. Hammond. *Burnley Section:* Wednesday, January 7, 7.30 p.m., Municipal College, Ormerod-road, Burnley. "Production of Heavy Castings," by Mr. C. F. Lawson. *Lincolnshire Branch:* Thursday, January 8, 7.15 p.m., Technical College, Lincoln. Report on "Flow of Metal," presented by Mr. E. M. Currie. Also at the *Scottish Branch:* Saturday, January 10, 3 p.m., Royal Technical College, Glasgow. *Newcastle Branch:* Saturday, January 10, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Ultrasonic Methods of Inspection," by Mr. N. H. Baddeley.

INSTITUTION OF CIVIL ENGINEERS.—*Maritime Division:* Tuesday, January 6, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Reconstruction of Greenwell's No. 1 Dry Dock and Ancillary Works at Sunderland," by Mr. Harry Ridehalgh. *Midlands Association:* Thursday, January 8, 6 p.m., James Watt Memorial Institute, Birmingham. "Prestressed Concrete in Civil Engineering Works," by Mr. A. J. Harris.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Tuesday, January 6, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Contemporary Methods of Watch Production," by Mr. R. A. Fell and Mr. P. Indermuhle. *London Graduates' Section:* Tuesday, January 6, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Industrial Power Transmission Clutches and Couplings," by Mr. K. J. Freeman. *Institution:* Friday, January 9, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Thomas Lowe Gray Lecture on "Welding in Marine Engineering," by Mr. H. N. Pemberton. *Automobile Division:* Tuesday, January 13, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Life Assessment Tests for Commercial Vehicles," by Mr. J. H. Alden. *East Midlands Branch:* Wednesday, January 14, 7.30 p.m., County Technical College, Newark-on-Trent. Repetition of the Thomas Hawksley Lecture on "The Mechanism of Work-Hardening in Metals," by Professor N. F. Mott.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch:* Tuesday, January 6, 6.30 p.m., Cleveland Scientific and Technical Institution, Middlesbrough. Open Meeting. *Institution:* Thursday, January 8, 6 p.m, 11, Upper Belgrave-street, S.W.1. "Construction of Eight Prestressed-Concrete Tanks," by Colonel A. R. Mais and Mr. A. C. Little.

ENGINEERS' GUILD.—*West Midlands Branch:* Tuesday, January 6, 6.30 p.m., Imperial Hotel, Birmingham. "Presentation of Technical Information," by Professor R. O. Kapp.

INSTITUTE OF FUEL.—*Scottish Section:* Tuesday, January 6, 7 p.m., Royal Technical College, Glasgow. "The Ridley Report and After," by Mr. Gerald Nabarro. *North-Western Section:* Thursday, January 8, 6.30 p.m., Engineers' Club, Manchester. Various papers on "Fuel and Fuel Efficiency." *East Midland Section:* Wednesday, January 14, 7 p.m., Welbeck Hotel, Nottingham. "Peak Steam Demands and Thermal Storage," by Dr. E. G. Ritchie.

INSTITUTE OF METALS.—*Oxford Section:* Tuesday, January 6, 7 p.m., Black Hall, St. Giles, Oxford. "Recent Advances in Alloy Chemistry," by Dr. J. W. Christian. *Birmingham Meeting:* Thursday, January 8, 2.30 p.m., The University, Edgbaston, Birmingham. Informal Discussion on "Rolls and Their Maintenance in the Non-Ferrous Metals Industry."

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, January 6, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Discussion on "The National Fuel Policy." *Edinburgh Branch:* Tuesday, January 6, 7 p.m., 25, Charlotte-square, Edinburgh. Open Meeting. *South Wales Branch:* Tuesday, January 6, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "A Plant Engineer Tours America," by Mr. G. E. Halter. *Southampton Branch:* Wednesday, January 7, 7.30 p.m., Polygon Hotel, Southampton. "Metallising in Relation to Plant Maintenance," by Mr. J. Porter.

INSTITUTION OF PRODUCTION ENGINEERS.—*Nottingham Section:* Tuesday, January 6, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Economics in Production Engineering," by Dr. F. A. Wells. *South Wales Section:* Thursday, January 8, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Precision with Production," by Mr. G. H. Clements. *Leicester Section:* Thursday, January 8, 7 p.m., Bell Hotel, Leicester. "Planing Machines and Practice," by Mr. G. Butler. *London Section:* Thursday, January 8, 7 p.m., Old Ship Hotel, Brighton. Film Display. *Reading Section:* Thursday, January 8, 7.15 p.m., Great Western Hotel, Reading. "The Use of Rubber as an Engineering Material," by Mr. G. W. Trobridge. *West Wales Section:* Friday, January 9, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Electronics in Industry," by Mr. A. G. Hickman. *Eastern Counties Section:* Friday, January 9, 7.30 p.m., Public Library, Ipswich. "Motion Study: Some Practical Applications," by Mr. R. Craven.

INSTITUTION OF ENGINEERING INSPECTION.—*Coventry Branch:* Tuesday, January 6, 7.30 p.m., Technical College, Coventry. "Developments in the Manufacture and Use of Glass," by Dr. R. E. Bastick. *South-Western Branch:* Tuesday, January 6, 7.30 p.m., Grand Hotel, Broad-street, Bristol. Film Display.

NEWCOMEN SOCIETY.—Wednesday, January 7, 5.30 p.m., Institution of Civil Engineers, Great George-street, Westminster, S.W.1. "Some Factors in the Early Development of the Centrifugal Pump, between 1689 and 1851," by Mr. L. E. Harris.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, January 7, 7 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address on "Some Aspects of Modern Materials Handling," by Mr. O. J. B. Orwin. *Institution:* Friday, January 9, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Automatic Feed Pressworking," by Mr. C. H. Crawford.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*East Midland Centre:* Wednesday, January 7, 7.30 p.m., Mechanics' Institute, Nottingham. "Application of Synthetic Resin Adhesives in the Road Transport Industry," by Mr. T. Maxwell-Hudson. *Western Centre:* Thursday, January 8, 7.30 p.m., Grand Hotel, Bristol. "Electrical Equipment as Applied to the Modern Heavy Commercial Vehicle," by Mr. W. A. Bevis.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 9, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Further Applications of the Moment Distribution Method of Analysis to the Transverse Strength of Ships," by Mr. H. J. Adams.

PERSONAL.

The Council of the Institution of Mechanical Engineers have awarded the 1953 James Watt International Medal to SIR HARRY RICARDO, B.A., LL.D., Hon. M.I.Mech.E., F.R.S., for his contributions to knowledge of the fundamental principles of internal-combustion engines and the application of these principles to design and development.

SIR FREDERICK BRUNDRETT, deputy scientific adviser to the Ministry of Defence, has been appointed honorary scientific adviser to the Ministry of Civil Aviation in succession to SIR ROBERT WATSON-WATT, M.I.E.E., F.R.Ae.S., F.R.S., who has relinquished the appointment of chief scientific adviser on telecommunications, as from December 31, 1952.

WING COMMANDER J. C. G. BELL, R.A.F. (ret.), who has been sales manager of the Sperry Gyroscope Co. Ltd., Great West-road, Brentford, Middlesex, since 1947, has been elected a director of the company.

MR. H. R. WATLING has retired, as from January 1, from the office of director of the British Cycle and Motor Cycle Manufacturers' and Traders' Union, after nearly 34 years of service. At the request of the Council of the Union, however, he will continue to act in a consultative capacity. MR. H. M. PALIN, M.B.E., who has acted as Mr. Watling's assistant during the past seven years, has succeeded him as director.

MR. J. C. MITCHESON, B.Sc. Mining (Birm.), has been appointed to the Chair of Mining of the University of London, tenable at the Imperial College of Science and Technology, S.W.7.

Trollope and Colls Ltd., Trocoll House, 41-44, Great Queen-street, London, W.C.2, announce that MR. A. RAYMOND MAIS, O.B.E., T.D., D.L., B.Sc., M.S.E., and MR. F. T. WEST, directors, have been appointed assistant managing directors; that MR. R. B. McC. POTTER, B.Sc., M.I.C.E., M.I.Struct.E., and MR. C. E. D. WESTERMAN, technical directors, are to be directors; that MR. R. J. C. THOMPSON, contract manager, and MR. SIDNEY BROWNING, commercial manager of the Concrete Pipe and Product Department, are to be technical directors and that MR. L. H. COLLS, B.A., a technical director of Trollope and Colls, has been appointed a director of Ludgate Investment Co., Ltd., and St. Brides Property Co., Ltd.

MR. F. C. BARFORD, T.D., M.I.E.E., formerly manager of the Newcastle-upon-Tyne district office of the British Thomson-Houston Co., Ltd., Rugby, has been appointed manager of the firm's Manchester district office, in succession to MR. A. B. RACE, who is retiring after 22 years in that position. As already announced, Mr. Barford is succeeded at Newcastle by MR. S. J. CLARKE, T.D.

MR. FREDERICK SWEET, secretary of the Durham and Northumberland Coalowners' Associations since 1937, retired on December 31.

MR. W. G. BROWN, assistant to the general manager of the Tyne Improvement Commission, has been promoted to the position of assistant general manager and traffic manager. MR. A. J. CLARKSON, the present traffic manager, has been promoted assistant to the general manager. Mr. Brown has been with the Commissioners for 40 years and Mr. Clarkson for 13 years.

MR. PHILIP RACKHAM, previously south-eastern regional manager, A.C.V. Sales Ltd., is appointed home-sales manager, and MR. P. J. ARROW, formerly divisional manager, south-eastern region, is appointed sales manager, south-eastern region, in succession to Mr. Rackham.

MR. T. E. SLATER, manager of the North Skelton Mine, Saltburn, Yorkshire, for the past 19 years has retired.

MR. HOWARD J. ASHBY, tyre sales manager of the Dunlop Rubber Co. Ltd., for the south region, London, retired on December 31 on account of ill-health. His successor is MR. H. J. HOLMES, the firm's sales manager for the West of England, in Bristol.

MR. R. S. GOUGH, branch manager, Bristol office, and MR. T. R. THOMAS, branch manager, Cardiff office, British Insulated Callender's Cables Ltd., have retired.

MR. S. B. HASLAM, 93, St. Mary-street, Cardiff, South Wales representative of WALKER BROTHERS (WIGAN) LTD., Pagefield Iron Works, Wigan, retired on December 31. Walker Brothers also inform us that they ceased to have an office at Newcastle-upon-Tyne on December 31. Pending further arrangements all inquiries from South Wales and Newcastle should be sent direct to the firm's head office at Wigan.

A newly-formed company, KENT-NORLANTIC LTD., Horner-avenue, Toronto 14, Canada, has taken over from the parent company, GEORGE KENT LTD., Luton, Bedfordshire, the responsibility for marketing, throughout Canada, Kent industrial instruments and other products, and Norlantic meters.

GRIFFITHS BROTHERS & CO. LONDON LTD., have opened a new depot and offices at Armour House, 28, Hyde-road, Ardwick, Manchester, 12. (Telephone: Ardwick 1142.)

OVERHEAD CONSTRUCTION FOR 50-CYCLE SINGLE-PHASE TRACTION.

BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD., LONDON.

(*For Description, see Page* 12.)

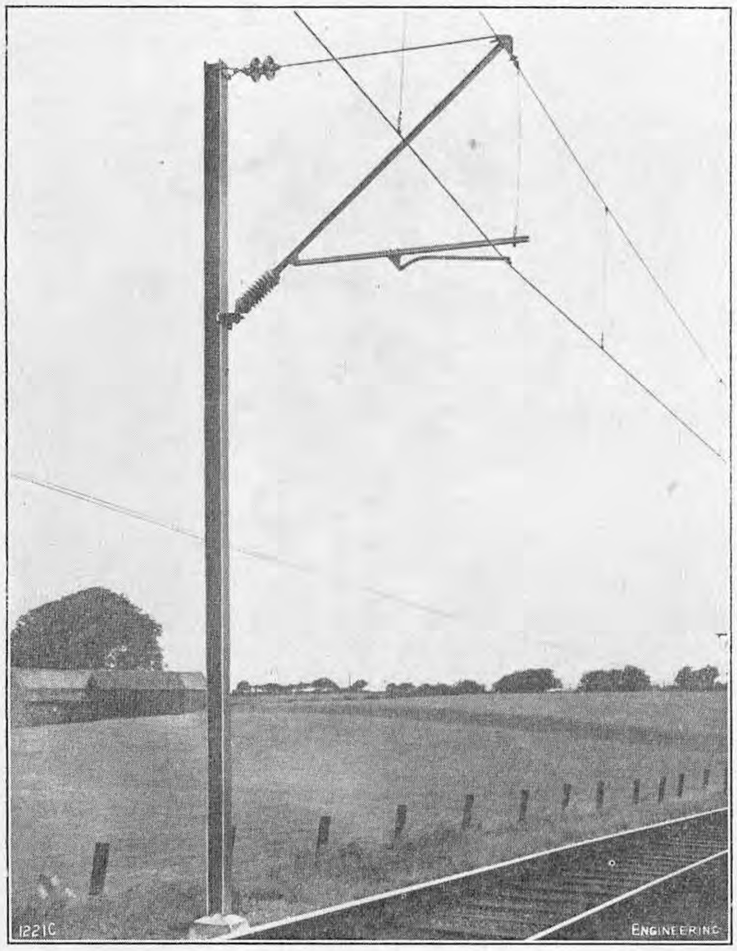


FIG. 3. BROAD-FLANGE BEAM POLE WITH GALVANISED-STEEL CANTILEVER.

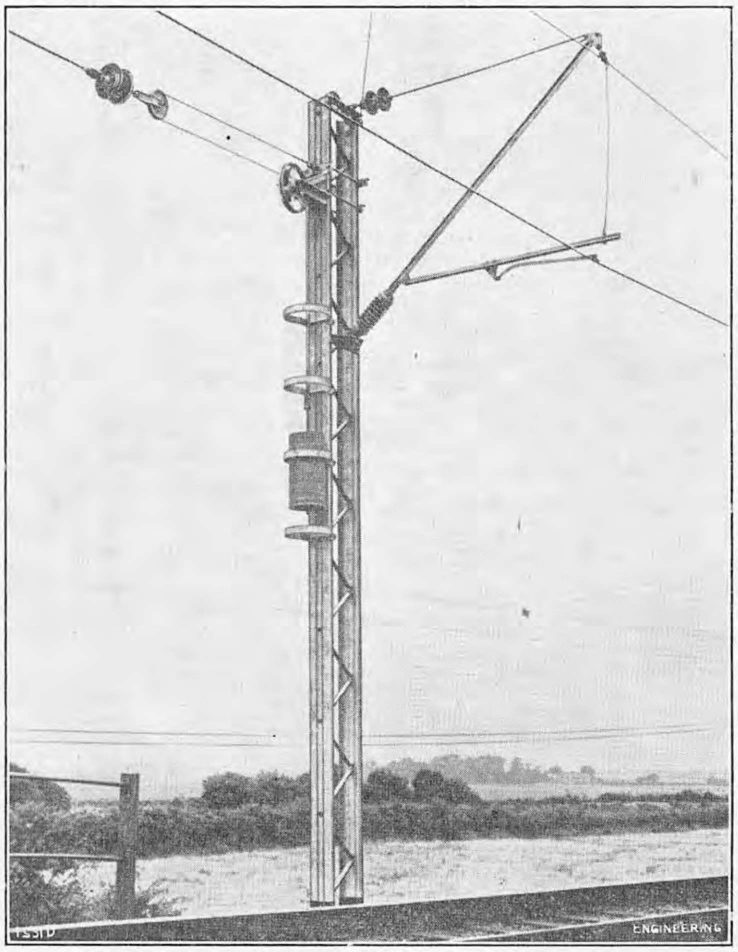


FIG. 4. BALANCE-WEIGHT TERMINATION ON POLE.

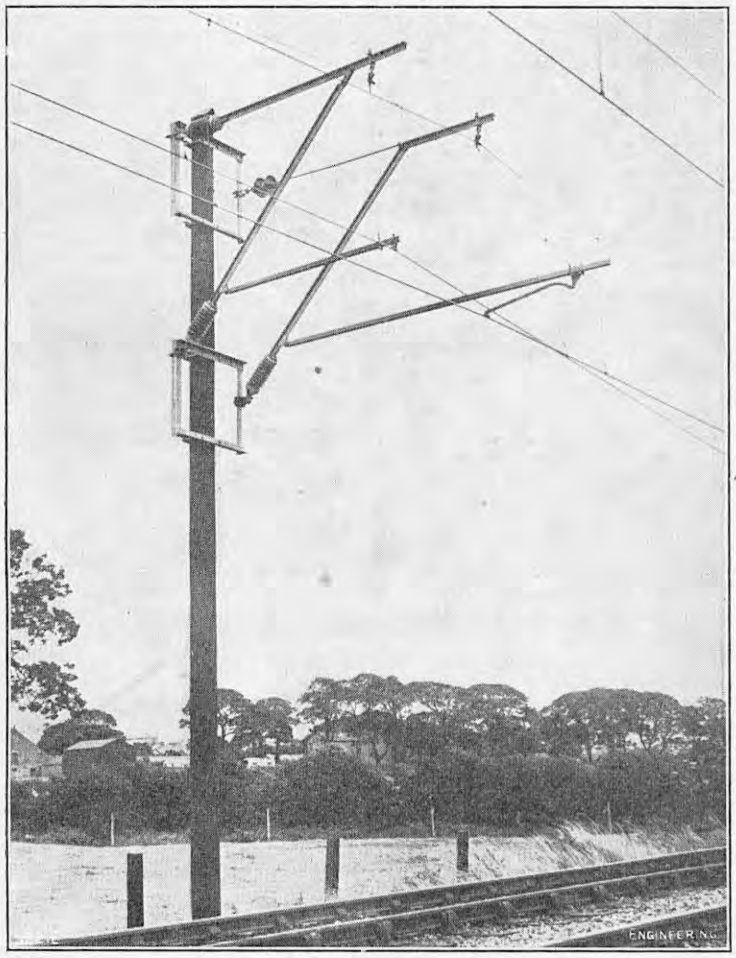


FIG. 5. DOUBLE CANTILEVERS ON WOODEN POLE.

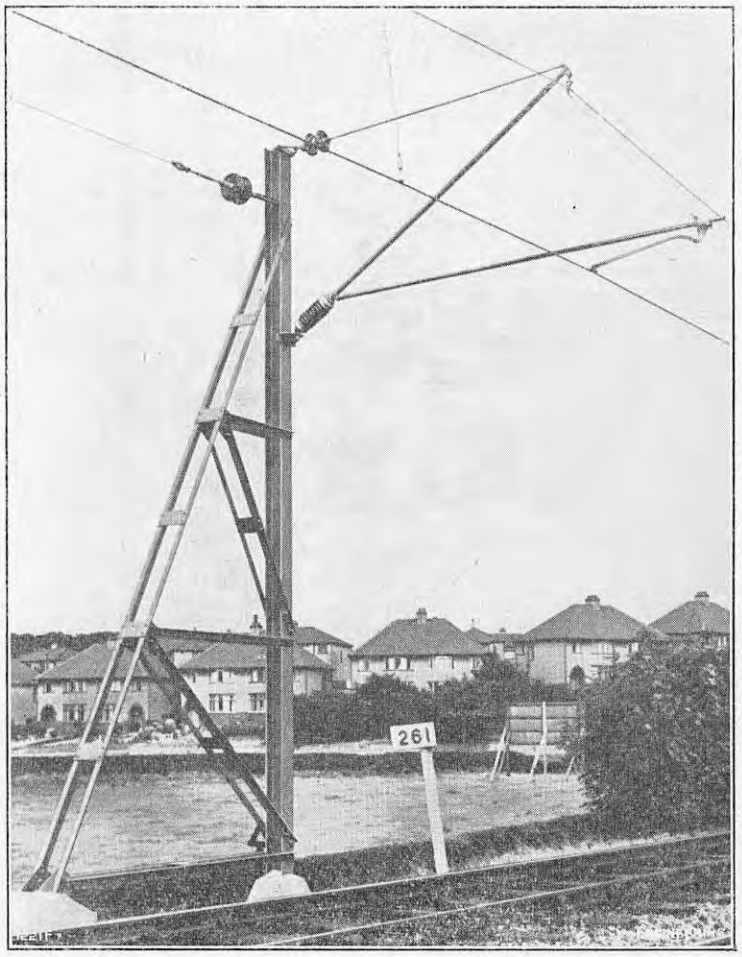


FIG. 6. MID-POINT ANCHOR ON BROAD-FLANGE BEAM POLE.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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

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Telephone Numbers :
TEMPLE BAR 3663 and 3664.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates :—5 per cent. for six ; 12½ per cent. for thirteen ; 25 per cent. for twenty-six ; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

INDEX TO VOL. 173.

The Index to Vol. 173 of ENGINEERING (January-June, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

CONTENTS.

ENGINEERING

FRIDAY, JANUARY 2, 1953.

VOL. 175. No. 4536.

YEAR OUT, YEAR IN.

FEW of the thousands, or possibly millions, of normally rational human beings who, on Wednesday evening, stayed out of bed and even out of doors for the purpose of "letting the New Year in"—a monumental act of condescension, when the phrase is critically examined—are likely to have realised how extremely irrationally, in fact, they were behaving. When listening, for example, to an ardent Scot belauding the importance of Hogmanay, it is not difficult to be persuaded that there really is some special significance in the transit from December 31 to January 1, requiring the pouring of propitiatory libations to the appropriate gods, and, incidentally, interrupting to a certain extent the pursuit of that increased productivity to which the modern world is, or supposedly should be, dedicated. To them may be commended a study of the article on the "Calendar" which the erudite W. S. B. Woolhouse (on the foundation provided by Thomas Galloway, F.R.S.) contributed to the ninth edition of the *Encyclopædia Britannica* ; for it was simply postulated by Mr. Woolhouse—better known, perhaps, to historically-minded engineers as the reviser, for John Weale the publisher, of the 1838 edition of Thomas Tredgold's book, *The Steam Engine*—that "A calendar is a method of distributing time into certain periods adapted to the purposes of civil life . . ." and that "the civil year . . . varies among different nations, both in respect of the season at which it commences and of its subdivisions."

"Only this, and nothing more," to the analytical mind of Mr. Woolhouse ; but it may well be questioned whether, after all, the position (which he held) of actuary to the National Loan Fund Life Assurance Society, and the authorship of learned works on annuities and on *The Measures, Weights and Moneys of All Nations*, are the best preparation for understanding the emotional impact of the transition from one year to another. Fundamentally, in his recognition of this annual event, the average man is going back to the primitive acceptance of the relentless, but eternally hopeful, procession of the seasons ; the rejuvenation of all living things after the enforced stagnation of winter, and the perennial expectation that, however depressing the immediate past may have been, the future will bring, perhaps occasional mists, but also a "mellow fruitfulness." Happily, this often illogical faith is frequently justified. So may it be in 1953, despite the gloomy prognostications of that very odd physician, Michael Nostradamus—the 450th anniversary of his birth falls on December 14 in this New Year—whose involved prophetic verses, according to some of his interpreters, appear to indicate that this will be, to say the least, a critical year in the history of Europe. Those who have lived through the first half of the present century may be excused, perhaps, for feeling that he was on safe ground in forecasting that much about any of the recent years that Europe has experienced, and a few of those still to come ; but still we hope, and will go on hoping.

Certain it is that, whatever the New Year may bring forth, engineers will be closely concerned in it, for never was there a time when the works of their hands and brains were so essential to the well-being of their fellow men or so influential in directing the course of events. Not so many centuries ago, civilisation centred on the shores of the Mediterranean, for reasons that may have seemed casual but, in fact, were almost wholly climatic. Now, Man has learned to make his own climate and can, with assurance, plan settlements in the Arctic regions or the tropics in the knowledge that local conditions will not prevent him from doing whatever may be necessary to exploit their natural resources. Making the desert to blossom like the rose is no longer merely a flight of poetic fancy, but an entirely practicable proposition, governed only by the basic economics of the development. When, half a century ago, water was piped 350 miles to the Coolgardie goldfield, the feat was regarded as something phenomenal. To-day, gas and oil are piped for much greater distances, and the accomplishment is taken for granted ; and in the past ten years alone, there have been developments in the utilisation of water power that would have seemed fantastic to the previous generation.

Forty years ago, according to *Whitaker's Almanack* for 1913, the population of the world was estimated to be 1,623 millions. At the present time, according to the 1953 *Whitaker*, it is in the region of 2,377 millions ; but, despite the wars of the intervening period, and the still considerable effects of pestilence, famine and other restrictive influences, it is safe to say that the living conditions of a great proportion of that population are at least as good as, and probably more stable than, their fathers ever knew. For that, engineers are more directly responsible than any other section of the community. To claim so much is not to neglect the labours of the scientists ; but, as a rule, the scientist relies upon the engineer to apply the results of scientific research. Sometimes the fear is expressed that science is developing more quickly than the ability of the human race to apply it wisely. Admittedly, much recent history tends to support that conclusion ; but not many thinking men would maintain that the sum total of human happiness would be enhanced by enforcing a general return to a more primitive style of living. Arcadian simplicity may be all very well, but there is still a lot to be said for pure water and good drainage, even though, in the pursuit of these and similar amenities, the engineer may be making a rod for his own back and for that of the world at large. Five hundred years ago, in 1453, the capture of Constantinople by the Turks scattered the scholars of the eastern Mediterranean over the greater part of Europe; a personal tragedy, no doubt, to many of the refugees, but, in the outcome, one of the most potent influences ever exerted for the spreading of knowledge. Since then, there have been several such enforced diffusions of learned men in new fields of activity, and now the philosophies and techniques that they and their disciples have developed are flowing to the East. What the eventual outcome may be, remains to be seen, but Britain, at least, may look forward with confidence, if not to another Renaissance, at least to the unfolding of a new Elizabethan Age.

WORLD POWER RESOURCES AND THEIR UTILISATION.

PARTLY, no doubt, as an aftermath of two world wars, a stirring of national aspirations is to be seen in many of the countries which it has been usual in the West to refer to as "backward." In many cases the aspirations are formless; in some they are destructive. The term "backward" might, in this connection, be defined in various ways, but contrasted with the proceedings of "progressive" countries one of the fundamental features of backward countries is that they have not developed, or taken proper advantage of their natural resources. Other factors certainly have weight, and many would lay more stress on certain moral and spiritual values than on material things. Professor Arnold Toynbee, in his recent Reith Lectures, appeared to attribute the upsurge of national movements in what may conveniently be called the East, to the weakening of the spiritual and moral content of the practice and message of the West, and described Communism, which has arisen as a rival and a threat to the Western way of life, as "a spiritual weapon"; though it is hardly the spiritual content of Communism which has fastened its cheerless doctrine on so many countries of Eastern Europe so much as the guns and tanks of the Russian Army.

Fortunately, the mechanical, or material, lessons which the world is learning are not solely, or mainly, concerned with methods of conflict. Their subject is the wider one of methods of utilisation of natural resources for the benefit of the population at large, and methods of utilisation may be just as important, or more important, than the resources themselves. The great Nineteenth-Century development of the industries of Great Britain was based on coal, but it would not have taken place if certain mental and moral qualities had not been possessed by the people at large. Those qualities cannot be exported, but the fruits of the data and accumulated experience to which they have led can be. The essential part which this accumulated experience of the West must play in transforming a "backward" country into a "progressive" one is glaringly illustrated in Persia to-day. Plants dealing with the only natural resource of the country, designed and paid for by the West, have been seized presumably with the idea that the plants alone were the source of wealth, oblivious apparently of the fact that without the necessary technical knowledge and accumulated experience they were dead things.

The countries of the West have never attempted to make secrets of their methods and educational facilities have been offered to, and utilised by, many from the backward countries. The "many," however, compared with the populations from which they were drawn, are but few, and it is to be feared that it has been assumed too frequently that a few are sufficient to leaven a whole nation. The building up of a Western material civilisation demands the inculcation of a tradition and a way of life in the entire population, and the accumulation of long administrative experience. The technically-trained "few" of the backward countries will do something towards the inauguration of a Western civilisation, but long years must elapse before they can influence and educate the masses of their people.

In speculating when, if ever, the populations of, say, Africa will enjoy a standard of living comparable with that of Western countries, it is not necessary to suggest a period of the order of Sir Charles Darwin's million years, but it may safely be placed at several centuries. The material potentialities are there, but the abilities to use them are very thinly spread and if a tendency to reject the assistance of the West, of which signs exist, should develop, those centuries may require multiplication by a substantial figure. Power, or the potentiality of power, is one of the main natural endowments on which material civilisation is based. According to Dr. A. Parker, in his 1949 Thomas Hawksley Lecture, the potential water power of Africa is 612 million kW, compared with 876 million kW for the the rest of the world. How far the continent has still to go is made clear by the fact that while the potential water power of Europe is 153 million kW, the present installed capacity is 26 million kW. The corresponding figure for Africa is 0·3 million kW.

Figures for the potential water power of a country, let alone of a continent, are frequently little more than inspired guesses; even careful estimates are frequently far from accurate. Accurate figures can, however, be obtained for the power developed, and the information they convey is some measure of the approach which the various countries of the world are making towards a standard of civilisation in which most of the people will at least have enough to eat. The valuable collections of statistics published by the World Power Conference give particulars of coal, timber, oil, natural gas and water power. They are now available for every year from 1933 to 1950, and the latest issue, the sixth,* in addition to covering the year 1950, includes such returns for 1951 as have become available.

Although it is convenient in a broad survey, the consideration of this subject in terms of continents has the disadvantage that countries of widely different types are taken as a group. In the case of Africa, for instance, the great water-power potential is largely situated in the least developed central areas, so that it is unlikely that a percentage development approaching that of some Western countries will be achieved for very many years. The World Power statistics credit French Equatorial Africa with a potential capacity of 44,815,000 kW, but do not indicate that any development has taken place. The existence of the enormous power possibilities in Central Africa, however, carries the promise that sooner or later, probably later, the countries concerned may become centres of industry.

Had the water-power resources of Africa been located in the highly-developed South, a very different percentage utilisation would probably have been seen. This is illustrated by the corresponding figures for coal. Africa has not been favoured in this natural endowment and Dr. Parker credited it with only some 203 million tons of reserves, as compared with 3,000 million tons for North America. So far as is known at present, the greater part of the reserves are located in the Union of South Africa, but it is quite possible that others may be found in areas not yet fully investigated. Africa is not favoured with oil, the other great power agency on which material civilisation is based. What sources there are lie in the north, and 21 million tons have been produced in Egypt since the beginning of commercial exploitation in 1911.

In speculations about the future distribution of world industry, the largely-undeveloped resources of South America must be taken into consideration. The potential water power of South America is estimated at 50 million kW, as compared with 63 millions for North America. The extent to which it has been utilised is of a very different order. North America has an installed capacity of some 27 million kW; South America, of less than 2 million kW. In a report prepared by the United States Geological Survey in 1947, it was stated that Brazil had water-power reserves of 28 million h.p. and an installed capacity of only 1,360,000 h.p. The World Power returns give the installed capacity, in 1949, as 1,616,000 kW. Brazil's coal and oil productions, compared with those of the United States, are trivial, but, as the example of Canada shows, great industrial development may be based on water power and possibly in the course of years a southward movement of industrial activity may be seen in the American continent.

No brief notice can do full justice to the remarkable collection of statistics presented in the World Power report; it must be studied to be properly appreciated. For those who can weigh the significance of the figures, they present a picture of the direction and rate of the material advance of the countries of the world. Although Man, in many places, is doing his best to hamper the peaceful progress of his contemporaries, the urge to take advantage of the technical possibilities developed and made available by the countries of the West is gradually modifying and improving the material conditions of a majority of the inhabitants of the globe.

* *Statistical Year Book of the World Power Conference No. 6. Annual Statistics for 1948–1950.* The Central Office, World Power Conference, 201–2, Grand Buildings, Trafalgar Square, London, W.C.2. [Price 35*s.* net, postage 9*d.*]

NOTES.

NEW YEAR HONOURS.

MANY engineers, industrialists and scientists are among those whose names are contained in the New Year Honours List which was published yesterday. Sir Clive L. Baillieu, K.B.E., C.M.G., chairman of the Dunlop Rubber Company, Limited; and the Rt. Hon. Lord Eustace S. C. Percy, P.C., Rector of the Newcastle Division of the University of Durham since 1937, are to be created Barons in the peerage of the United Kingdom for their public services. The honour of Knight Bachelor is to be conferred upon Mr. John Benstead, C.B.E., deputy chairman, British Transport Commission; Mr. A. G. E. Briggs, Deputy Controller of Supplies, Ministry of Supply; Dr. Harold Roxbee Cox, D.I.C., B.Sc., M.I.Mech.E., F.R.Ae.S., Chief Scientist, Ministry of Fuel and Power; Mr. Arthur Croft, chairman and managing director of Crofts (Engineers), Limited, Bradford; Mr. M. W. Drysdale, chairman of Lloyd's; Mr. Lincoln Evans, C.B.E., general secretary, Iron and Steel Trades Confederation; Mr. C. K. F. Hague, M.I.Mech.E., deputy chairman and managing director, Babcock and Wilcox, Limited, and deputy chairman of the Royal Ordnance Factories Board; Mr. A. H. S. Hinchliffe, governing director, Glazebrook, Steel and Company, Limited, for services to the Association of British Chambers of Commerce; Dr. Harold Jeffreys, F.R.S., M.A., Plumian Professor of Astronomy and Experimental Philosophy at the University of Cambridge; Mr. S. C. Parkin, C.B.E., general manager and secretary, National Dock Labour Board; Mr. W. H. Pilkington, chairman, Pilkington Brothers, Limited, St. Helens, and vice-president of the Council of Building Material Producers; and Alderman T. D. Straker-Smith, J.P., B.E., director of Smith's Dock Company, Limited, North Shields. The Rt. Hon. Lord Brabazon of Tara, P.C., M.C., President of the Royal Institution and chairman of Associated Commercial Vehicles, Limited, and of David Brown and Sons (Huddersfield), Limited, has been made a Knight Grand Cross of the Order of the British Empire for his services to civil aviation. Mr. G. H. Fretwell, C.B., M.I.C.E., Director-General of Works, Air Ministry; Sir Robert M. Gould, C.B., Chief Industrial Commissioner, Ministry of Labour and National Service; and Colonel H. C. Smith, C.B.E., D.L., chairman of the Gas Council, have been appointed Knights Commanders of the Order of the British Empire. Many other awards were made to men prominent in the engineering profession and industry, and their associated sciences, and a summary of these will be given in our next issue.

ENGINEERING CENTENARIES IN 1953.

In the list of centenaries of interest to engineers which occur in 1953 are those of the Lancashire textile inventor, Samuel Crompton (1753-1827), whose statue stands in the middle of Bolton, which city paid him a remarkable tribute in 1927; the Scottish engineer, James Carmichael (1776-1853), who, with his brother Charles, constructed the first locomotives built in Scotland, and the centenary of whose birth was marked by the erection of the statue of him in Albert-square, Dundee; the Cumberland-born instrument maker, Edward Troughton, F.R.S. (1753-1835), whose bust by Chantrey is in the Royal Observatory, Greenwich, and whose name, together with that of his partner, Walter Simms, is perpetuated by the York firm of Messrs. Cooke, Troughton and Simms; and Charles, the third Earl of Stanhope, F.R.S. (1753-1816), who, in his day, played many parts. He constructed calculating machines, wrote on electricity, improved printing machines, tried to drive a boat by steam, and, at his home at Chevening, Kent, made experiments on rendering buildings fireproof. He was a lover of liberty and, during the French Revolution, was known as "Citizen Stanhope." It was said of him that, in all that he did, he worked for the public good. The same might be said of his contemporary, Sir Benjamin Thompson, Count Rumford (1753-1814). Born on a farm at North Woburn, Massachusetts, this remarkable man was an apprentice in a shop, a teacher at Rumford (now Concord), New Haven; as a Loyalist, became a lieutenant-colonel of dragoons and an Under-Secretary for the Colonies, and was made F.R.S. in 1779. He was knighted in 1784, and from 1783 to 1795 zealously served the Elector of Bavaria, who secured for him the rank of a count of the Holy Roman Empire. Wherever he went, and whatever his environment, he was constantly experimenting, and his philanthropy had for its main object, the improvement of the conditions of the working classes by the adoption of better cooking, better heating, and better lighting; hence the Rumford soups, stoves and fireplaces. This was at the back of his proposals which led to the foundation in 1799 of the Royal Institution in Albemarle-street, London, which he directed for a year or two and then abandoned to others. From London, he removed to Paris, and there married the widow of Lavoisier, only to find her, as he wrote, a "female dragon." They were both wealthy, both dogmatic, and they soon separated. Rumford's last days were passed at Auteuil, where his grave is still kept in order by Harvard University and the American Academy of Arts and Sciences. The British and American Rumford Medals were both founded by him, but his finest monument is the Royal Institution. The years of Rumford's residence in Paris saw the beginning of the brilliant career of the French mathematician, physicist and astronomer, François Jean Dominique Arago (1786-1853), secretary and then director of the Paris Observatory and perpetual secretary of the Paris Academy of Sciences. His electrical researches were in line with those of Oersted, Ohm, Ampère and Faraday, and paved the way for the race of Nineteenth Century electrical engineers, a distinguished representative of whom was Elihu Thomson (1853-1937), a native of Manchester, who was born seven months before Arago died. Taken to America at the age of five, he was 26 when, in collaboration with Professor Edwin James Houston, he founded the Thomson-Houston Company in Philadelphia. Honoured alike at home and abroad, he received the Rumford, Edison, Fritz, Hughes, Grashof, Faraday, Kelvin and other medals, and in 1931, read to the British Association his paper, "Pioneering in Electrical Engineering Half a Century Ago."* Thomson died at Swampscott, near Lynn, Massachusetts, on March 13, 1937. Three years later, a memorial tablet to him was erected in Ludlow-street, Philadelphia, inscribed "Birthplace of alternating current distribution in America." No less famous in their respective spheres were the two Dutch physicists, Hendrik Antoon Lorentz (1853-1928) and Heike Kamerlingh Onnes (1853-1926), both of whom received the Rumford Medal of the Royal Society; and the German chemist, Friedrich Wilhelm Ostwald (1853-1932), one of the early Nobel Prizemen. Looking back to much earlier times, the year 1653 saw the birth of Joseph Sauveur, who, though dumb till his seventh year, became a mathematical professor. For 20 years, he experimented on sound, and firmly laid the foundations of acoustics. He was born and educated at La Flèche, and died in Paris in 1716.

* Reprinted in ENGINEERING, vol. 132, page 602 (1931).

PROPOSED WEIGHTS AND MEASURES LEGISLATION.

The abolition of the Imperial system of measurement in favour of the metric system would have far-reaching effects on this country's industries, particularly the engineering industry. A proposal on these lines was the principal feature of the report of a committee on weights and measures legislation which was published in May, 1951, and the Board of Trade have now announced that they would be glad to receive comments on any of the committee's recommendations from interested parties. In addition to the proposal regarding the metric system, the report also advocated the re-definition of the Imperial yard and pound in terms of the international metre and kilogramme, and the appointment of a permanent commission to advise the President of the Board of Trade on the most suitable legal definitions of the "derived" units of capacity, temperature, heat and electricity; on the possibility of defining in law the unit of time; and on the nature and construction of primary standards which would be actual representations of the fundamental and derived units. Though the President said in the House of Commons recently that legislation would not be introduced for some time, owing to the wide variety of the recommendations and the extensive nature of the consultations, it is clear that, whenever it is introduced and passed, it will involve the country in considerable expense. The committee, however, did not express any doubt that the long-term benefits would more than offset this expense. The issue is not as clear-cut as the committee represented; the Imperial system, for all its "conglomeration of units," has much in its favour. It is extremely difficult, if not impossible, for anyone to see the whole picture, so various are the ramifications of the Imperial units and their uses in commerce and industry. The committee heard evidence from 189 sources; the same sources, and others, may now wish to submit their comments. All correspondence should be addressed to the Controller, Standards Department, Board of Trade, 26, Chapter-street, London, S.W.1. The report was the subject of an article in ENGINEERING, vol. 171, page 598 (1951), and since the war there have been several articles and many "Letters to the Editor" which have argued the case from both sides.

MARKER BUOY FOR SUBMARINES.

It is announced by the Admiralty that a new type of marker buoy has been developed for use by H.M. submarines in case of distress. It is of cylindrical shape and consists of an annular light-alloy case containing a number of hollow capsules for buoyancy and is equipped with a flashing light. Experiments are proceeding with an automatic radio transmitter which may be added subsequently. The principal requirements in the design of a marker buoy are that it should be light in weight small enough to be carried in the superstructure of a submarine, and strong enough to withstand all the operating conditions to which the submarine itself may be exposed; it should be visible at a reasonable range to searching aircraft and surface craft, by day and night; it must remain afloat and anchored to the submarine under all conditions of weather; and it should be able to transmit some form of distress signal, visual or otherwise. These requirements are believed to have been satisfactorily met in the new design. The outer casing consists in essence of a drum within a drum, the annular space between them containing 216 watertight pressure-resistant light-alloy capsules, about 6 in. long and 2½ in. in diameter. The mooring is attached to a steel stirrup, like the handle of a bucket, which hangs below the buoy. The upper surfaces of the outer container are painted with "Dayglow" composition, which has a high visibility range in daylight, and on the top is a ring in which are mounted 24 reflecting studs of the type used on roads. The buoy also carries a short mast with a red flag of nylon. The light and warning apparatus is carried within the inner drum, the flashing-light unit being housed in a pressure-tight container of light alloy. The light comes into operation automatically when the buoy is released. Current is supplied by two batteries of 21 ampere-hours capacity, connected in parallel so as to give a minimum life of 42 hours; on test, an actual duration of 52 hours was obtained. The 2·5-watt lamp is visible for 3,500 yards under good weather conditions. The prototype buoy is now under test at sea (though without the flashing light) in H.M. submarine Andrew, and a second, equipped with the light, is being fitted to the Seraph, at present undergoing a refit. Other submarines will be supplied in turn with buoys of the new type, as they are taken in hand for refitting.

THE NICKEL INDUSTRY IN 1952.

The production of nickel in the free world outside the U.S.S.R. and satellite countries was approximately 315,000,000 lb. in 1952, compared with 295,000,000 lb. in 1951. The Canadian output, last year, was about 280,000,000 lb., or some 90 per cent. of the total. These figures were quoted by Dr. J. F. Thompson, chairman of the International Nickel Company of Canada, Limited, in an end-of-the-year review issued by the Mond Nickel Company, Limited, Sunderland House, Curzon-street, London, W.1. Dr. Thompson stated that his company were actively pursuing the programme of underground mining extensions at Sudbury, Northern Ontario, which scheme was due to be completed in 1953. This would enable the company to maintain the current rate of production of approximately 250,000,000 lb. of refined nickel per annum. Other nickel-producing companies also had development programmes in hand. The Falconbridge Nickel Mines, Limited, in Northern Ontario, Canada's second largest nickel producers, were engaged on an expansion programme intended to give the company an annual capacity of 35,000,000 lb. of nickel in 1954. The Nicaro nickel project in Cuba, financed by the United States Government, was now in operation once more and was reported to be approaching its goal of 30,000,000 lb. of nickel annually. Moreover, Sherrit Gordon Mines, Limited, a firm developing a nickel-copper deposit at Lynn Lake, Manitoba, was reported to be constructing a refinery capable of producing 17,000,000 lb. of nickel per annum, which is scheduled for completion this year. Furthermore, the French firm, S.A. Le Nickel, New Caledonia, was stated to be producing about 14,000,000 lb. of the metal per annum. The largest proportion of the refined nickel produced continued to be consumed by the steel industries of the United States, the United Kingdom, and Canada, mainly for the manufacture of engineering steels, stainless and heat-resisting alloys and special materials for use in jet engines and gas turbines. In general, continued Dr. Thompson, steels for military purposes had required more nickel per ton in 1952 than had been used for civilian applications. In both fields, however, nickel had been conserved for the more critical uses. Conservation had been achieved by the substitution of steels either lower in nickel content, or containing no nickel at all. Broadly speaking, substitutions for nickel had involved the use of elements such as boron, manganese and chromium.

PHOTO-ELASTIC RESEARCH ON PLATES IN TRANSVERSE BENDING.

By Dr.-Ing. Albrecht Kuske.

The photo-elastic method was initially confined to the study of plates loaded in their planes only. It depends on the well-known phenomenon that most isotropic transparent materials become doubly-refracting when strained mechanically in any way.*† A light vibration, after passing through a polarising filter, oscillates in one plane only. When such a vibration passes subsequently through a doubly-refracting material it is split into two components which vibrate in planes perpendicular to each other. In materials which become doubly refracting on the application of stress, these planes coincide with the directions of the principal stresses.

The two components travel at different speeds, the difference between which is proportional to the difference of the principal stresses in the plate. After having travelled some distance through the doubly-refracting body, the two component vibrations will have a certain phase difference and their resultant vibration, therefore, will no longer be a plane oscillation but, in general, an elliptical one. As a result, the light vibration will have a certain component in the direction at right-angles to that of the original oscillation, so that a component of the light leaving the doubly-refracting body will pass through a polarising filter, even if the plane of polarisation is normal to that of the first polarising filter. When a doubly-refracting body is placed between two " crossed " polarising filters, fringes of different colours, called isochromatics, are observed.

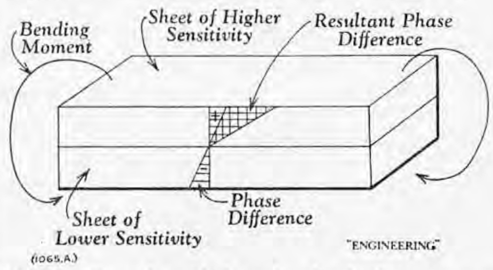
When monochromatic light is employed, the isochromatics are dark and bright fringes. The dark fringes of the pattern indicate places where the phase difference is zero or an integral multiple of the wavelength of the light used. Since the phase difference is proportional to the difference of velocity of the two components, the dark lines in a model under load are lines of equal difference of the principal stresses.

If the planes of polarisation of the two filters are parallel, the dark and bright fringes are interchanged. When the filters are crossed, there is another set of dark lines in the model which indicate the places where the direction of one of the principal stresses coincides with the direction of polarisation of the first polarising filter. In these places, the vibration is not split into two since the component in the direction normal to that of the original vibration remains zero. There is, therefore, no component which could pass the second polarising filter. Lines of this kind are called isoclinics. By making use of this result, the directions of the principal stresses can be found at any point by rotating the polarising filters about an axis in the direction of propagation of the light. It is then possible to draw a set of lines the directions of which coincide with the directions of the principal stresses at any point. These lines are called isostatics. The presence of isoclinics is inconvenient if the isochromatics only are to be observed, but their occurrence can be avoided if circularly-polarised light instead of plane-polarised light is used. The latter can be transformed into circularly-polarised light by means of a quarter-wave-plate.

There are several mathematical and graphical methods of determining the amount of the principal stresses from the pattern of isochromatics and isoclinics, and several other methods are known for finding the absolute magnitude of the two principal stresses without using the isochromatics or isoclinics. For example, by means of an interferometer, the amount of the two principal stresses at any point can be determined by measuring the absolute velocities or optical length of path of the two component beams. In this way, the directions of the principal stresses and their values, or that of their difference, can be found experimentally after the relation between the optical effect and the stress has been determined experimentally. This method, however, is limited to the study of plates loaded in their planes only. It cannot be used in the investigation of plates in transverse bending or for other three-dimensional problems. Plates in transverse bending, examined photo-elastically, would produce no optical effect, since the tension on one side of such plates has the same absolute value as the compression on the other side. The phase difference produced in the first half of the light's path would, therefore, be cancelled in the second half. Other methods, therefore, have had to be found for solving problems of this kind.

Several photo-elastic methods for studying plates in transverse bending have been developed. The freezing or solidifying method depends on the ability of some hard transparent plastics to behave like rubber at elevated temperatures. After being loaded at a temperature in the neighbourhood of 100 deg. C. and cooled under load, they conserve the state of strain and their double-refracting properties. A model prepared in this way can be cut into slices and investigated by photo-elastic methods. This procedure can be used to determine the stress distribution in any three-dimensional problem.* It has been applied to plates in transverse bending by several authors.†‡

Fig. 1. PHASE DIFFERENCE IN TWO-SHEET MODEL.



In another method, a state of pure tension is frozen into a plate in the way mentioned above and the bending stress is superimposed after the model has cooled. Although a state of transverse bending alone cannot be detected by the usual photo-elastic methods, as already explained, the superposition of pure tension and transverse bending results in a certain photo-elastic effect if the directions of principal stresses of these two states do not coincide. In the latter event, the directions of the resultant stresses on the two sides of the plate include an angle and the retardations in the plate have a resultant, though it is somewhat different from that usually observed in two-dimensional photo-elasticity.§

A method which depends on the polarisation of the light which is scattered in a model can be used to investigate any three-dimensional problem and could, therefore, be applied to plates in transverse bending. So far as is known, however, it has not been so used.*‖¶ In another method, a model made of two sheets is used, one of these being transparent and the other made of a reflecting material such as polished steel*†‡ In a modification of this method, a model is made of two sheets of transparent plastic and a reflecting foil is cemented between them. The photo-elastic effect can be observed from the reflected light.§ A method based on a mathematical analogy between the differential equations of plates in transverse bending and plates loaded by forces acting in the direction of their plane can also be employed. In this method, problems of plates in transverse bending are solved experimentally by the ordinary methods of two-dimensional photo-elasticity.‖¶

It is not the aim of this article to discuss these methods but, rather, to describe a new method recently developed by Favre and Gilg** and by the author,* and to give some results obtained by means of it. In this method, a model made of two sheets of different materials is used. The photo-elastic constants of these two materials (i.e., the relations between stress and double-refraction) must be different. This means that the photo-elastic effects in the two sheets do not annul one another, as would be the case if the model were made of uniform material.

According to the theory of elastic plates in transverse bending, the directions of the principal stresses are constant along any line normal to the plane of the plate, except for a small deviation caused by the transverse shear stress. An exception to this rule, however, occurs when concentrated loads act on the surface of the plate. The methods of two-dimensional photo-elasticity can be applied to this kind of model only if the effect of the transverse shear stresses is negligibly small; otherwise they would cause the plane of polarisation to rotate. In most of the experiments no such rotation was observed. The effect of concentrated loads, however, can be observed since they cause certain abnormalities in the isochromatics and isoclinics. This effect, however, is generally confined to a small region and does not cause too much disturbance. It was observed by the author that the effect is the more observable the thinner the sheet of material having the higher sensitivity compared with the other sheet.

The types of model used by Favre obviously did not allow the application of loads large enough to produce isochromatics of several wavelengths, which are necessary when the method of isochromatics is used. As an interferometer is rather expensive and is both delicate to handle and tedious to use, the method of isochromatics was preferred by the author. Its application became possible after he had succeeded in making models free from mechanical or optical defects. Favre used models made of glass and Homalite CR 39††, a plastic consisting of polyester. It is difficult, of course,

* H. T. Jessop and F. C. Harris, *Photoelasticity, Principles and Methods*, London University Press (1949).

† A. Kuske, *Verfahren der Spannungsoptik*, Düsseldorf (Germany) V.D.I-Verlag. (1951).

* A. Kuske, *Verfahren der Spannungsoptik*. Düsseldorf (Germany) V.D.I.-Verlag, (1951).

† H. G. Poertner, *Diss*, Washington Univ., St. Louis, Missouri, U.S.A. (1943).

‡ R. Kuhn, *Diss.* Techn. Hochsch. Munich, Germany, (1949).

§ D. C. Drucker, " Photoelastic Analysis of Transverse Bending of Plates in the Standard Transmission Polariscope," *J. Appl. Mech. Trans. A.S.M.E.*, Vol. 9, No. 4 (1942).

‖ R. Weller, "A New Method for Photoelasticity in Three Dimensions," *J. App. Phys.*, Vol. 10, page 266 (1939).

¶ H. J. Menges, *Die experimentelle Ermittelung räumlicher Spannungszustände an durchsichtigen Modellen mit Hilfe des Tyndalleffektes*, Z.A.M.M., Vol. 20, page 210, (1940).

* A. Kuske, *Verfahren der Spannungsoptik.* Düsseldorf (Germany) V.D.I.-Verlag, (1951).

† M. Mesnager, " Sur la détermination optique des tensions intérieures dans les solides à trois dimensions," *C.R. Acad. Sci.*, Paris, vol. 190, page 1249 (1930).

‡ G. Oppel, " Das polarisationsoptische Schichtverfahren zur Messung der Oberflächenspannung am Bauteil ohne Modell," *Z.V.D.I.*, vol. 81, page 803 (1937).

§ J. N. Goodier and G. H. Lee, " An Extension of the Photoelastic Method of Stress Measurement to Plates in Transverse Bending," *J. Appl. Mech. Trans. A.S.M.E.*, vol. 63, A-27 (1941).

‖ R. Kuhn, *Diss.* Techn. Hochsch. Munich, Germany, (1949).

¶ R. V. Baud, " Entwicklung und heutiger Stand der Photoelastizität und Photoplastizität," Bericht No. 118 of Eidgen, Materialprüfungsanstalt, Zürich, Switzerland (1938).

** H. Favre and B. Gilg, " Sur une méthode purement optique pour la mesure directe des moments dans les plaques minces fléchies." Schweiz. Bauztg., Nos. 19 and 20, pages 253 and 265 (1950).

†† A product of the Homalite Corporation, Wilmington, Delaware, U.S.A.

"CRESCENT" WING BOMBER AIRCRAFT.

HANDLEY PAGE, LTD., LONDON.

FIG. 1.

to cement glass to any other material so that the bond will withstand a considerable amount of shear stress.

The models used by the author consisted of a sheet of polymethacrylate (Plexiglas*) and a sheet of another plastic. The material of the second sheet was a polyester resin or phenol formaldehyde (Trolon†). (Phenol formaldehyde is generally known as Bakelite.) Different kinds of glue were tried. A compound (Plexigum KP 8013*) was found to be most effective, but the most solid models were obtained by casting a sheet of polyester resin‡ on a sheet of Plexiglas. The models made of a sheet of Plexiglas and a sheet of polyester resin cemented by Plexigum are of excellent transparency as the indices of refraction of the three materials are practically the same.

Obviously, the method of determining the isostatics by means of the isoclinics can be used in this method in the same way as in two-dimensional photo-elasticity, except for those regions where the pure bending stress is influenced by the irregularities mentioned. The amount of phase difference observed in this method is indicated in Fig. 1, opposite. In a model made of uniform material, the sum of the phase differences is zero, but in one made of two different materials the positive and the negative amounts of phase change are different. The difference is indicated by the cross-hatched triangle. Its magnitude can be computed from the following formula, if Young's modulus has the same value in both sheets.

$$G = (C_1 - C_2)\int_0^{h'} \sigma\left(1 - \frac{2z}{h}\right) dz$$
$$= (C_1 - C_2)\,\sigma h'\left(1 - \frac{h'}{h}\right) . \quad . \quad (1)$$

where G is the phase difference, C_1 and C_2 are the photo-elastic constants of the two materials, σ is the effective stress, z is the co-ordinate normal to the plane of the plate, h' is the thickness of one of the two sheets, and h is the thickness of the plate. If Young's modulus is not the same in the two sheets, the value of G differs slightly from that given by (1). No experimental difficulty, however, results.

(To be continued.)

* A product of Röhm und Haas, Darmstadt, Germany.
† A product of Dynamit A.G., Troisdorf Bz. Köln, Germany.
‡ A product of Bädische Anilin und Sodafabrik, Ludwigshafen a. Rh., Germany.

Fig. 2.

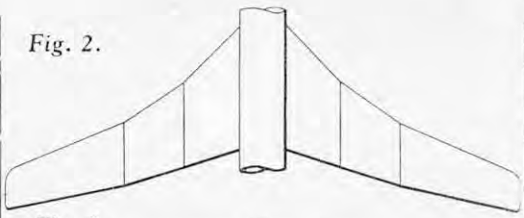
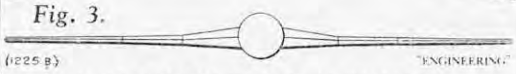


Fig. 3.



"CRESCENT" WING BOMBER AIRCRAFT.

ON Christmas eve, a new four-engine high-speed medium bomber aeroplane, the H.P.80, designed and constructed by Messrs. Handley Page Limited, Cricklewood, London, N.W.2, carried out its maiden flight successfully at Boscombe Down, Wiltshire. The H.P. 80, illustrated in Fig. 1, is the first British operational aircraft to be fitted with a "crescent" wing—that is, a wing in which the sweep-back is progressively reduced towards the tip, as shown in the diagrams reproduced in Figs. 2 and 3, which represent a typical "crescent" wing in plan and in front elevation and do not necessarily depict the plan form of the H.P.80. Owing to the low degree of sweepback at the wing tip, the crescent wing should not suffer from adverse aero-elastic effects and the tendency to tip-stalling that are associated with highly-tapered wings; it has a higher aspect ratio than the alternative solution, the stiff delta-wing plan, which is an advantage for an aircraft designed, as the H.P.80 is, for long range at high altitudes, at high subsonic speed.

The Handley Page H.P.80 is powered by four Armstrong-Siddeley Sapphire jet engines, completely enclosed in the wing root, each pair of engines sharing a common intake opening in the leading edge. A type-tested version of the Sapphire engine, it may be recalled, has developed a static thrust of 8,300 lb. A bogie-type tricycle undercarriage is fitted. The swept-back tailplane is set at the top of a sharply swept-back fin, clear of the jet efflux and disturbed air flow. It will be observed that leading-edge flaps are provided on the outer part of the wing, presumably for the purpose of improving lateral control at low forward speeds.

OIL-FIRED LOCOMOTIVES IN NEW ZEALAND.—Increases in the price of fuel oil in New Zealand will lead to consideration being given to the reconversion of 77 oil-fired locomotives to coal-burning if the improvement in coal supplies continues. The price of fuel oil rose from 9*l*. 1*s*. 3*d*. in February, 1951, to 20*l*. 18*s*. 8*d*. in February, 1952, according to the annual statement of the New Zealand Railways.

EXTENSION OF "SUPERPRIORITY" TO FIVE NEW AIRCRAFT.

THE Minister of Supply, Mr. Duncan Sandys, has announced that "superpriority" is to be given to the production of two new medium-bomber aircraft —the Avro Vulcan delta-wing bomber, constructed by Messrs. A. V. Roe and Company, Limited, Greengate, Middleton, Manchester, which appeared in public for the first time at the 1952 flying display of the Society of British Aircraft Constructors, and the H.P.80 "crescent" wing bomber, which is described on this page. Military aircraft already in the scheme are the English Electric Canberra twin-engine bomber aeroplane, the Vickers-Armstrongs Valiant medium bomber, the Hawker Hunter and Vickers-Armstrongs Swift single-seat fighters, the Gloster Javelin two-seat night fighter, and the Fairey Gannet anti-submarine aircraft. For the first time, three civil air liners will also come under the superpriority scheme—the de Havilland Comet jet-propelled air liner, already in service with British Overseas Airways Corporation and on order by Canadian Pacific Air Lines, Union Aéromaritime de Transport, Air France, British Commonwealth Pacific Airlines, Japan Air Lines, Linea Aeropostal Venezolana, and Pan American Airways; the Vickers-Armstrongs Viscount turbo-propeller air liner, due for delivery to British European Airways during the next few days, and also on order by Aer Lingus, Air France, Trans-Australia Air Lines, Trans-Canada Air Lines, and British West Indian Airways; and the Bristol Britannia turbo-propeller air liner, which flew for the first time in 1951 and is now undergoing development trials; it is on order for British Overseas Airways Corporation. Commenting on this decision, Mr. Sandys explained that superpriority was being extended into the civil field to back up the export drive. British designers and engineers had succeeded in developing the finest passenger aircraft in the world, but the ability to sell them abroad depended on being able to offer early deliveries in sufficient numbers. That was where superpriority could help. Since last March, the superpriority scheme had speeded up deliveries to aircraft firms of special alloy metals and other materials and components, in many cases by as much as six to twelve months.

WHEELBARROW WITH RUBBER BODY.—The Dunlop Rubber Co., Ltd., Fort Dunlop, Birmingham, have developed a rubber body for wheelbarrows. Tests have shown that its flexibility prevents damage when the barrow is carrying something fragile, and that in cases where the contents tend to stick they can readily be emptied. For all practical purposes, the barrow is not affected by acids or alkalis, and it is also lighter in weight than a conventional barrow. The rubber body varies in thickness according to the purpose for which the barrow is designed, and it is fastened to a steel frame mounted on the chassis.

ACCURATE AND RAPID CONTROL OF MACHINE-TOOL SLIDES.

A SIMPLE optical method of controlling tool position, feed or depth of cut can be applied with advantage to a standard machine tool to increase the accuracy and rapidity of control on jobs where some or all of the following conditions obtain: precision machining is to be carried out at quantity-production rates; the design of the workpiece is such that the operator has difficulty in observing the cutting tool; the conventional use of stops and graduated dials would hinder quantity production; repeated measuring and inspection during machining are to be avoided; and it is desirable to use a standard machine tool for work which, at first sight, would appear to require a special machine tool. The example described in this article relates to optical equipment applied to a Webster and Bennett 48-in. boring mill for machining the internal grooves in an aluminium-alloy compressor casing, but the method is equally applicable to other machine tools for other machining purposes. Messrs. Alfred Herbert, Limited, Coventry, Messrs. Hilger and Watts, Limited, 48, Addington-square, London, S.E.5, and a firm of aircraft engineers co-operated in the development of this application. An 82-per cent. saving has been effected over the older method.

The compressor casing, in two halves bolted together, is mounted on the boring-mill table. The upper edge of the casing can just be seen in Fig. 1. Also to be seen here are the turret of the machine, with a tool bracket fixed to one of its faces, an engraved scale attached to the right-hand vertical edge of the turret slide, and a Hilger optical projector which is mounted on the saddle and aligned on the scale (in Fig. 1 it is shown opposite the bottom of the scale, the turret slide being near the upper limit of its travel). The machining to be carried out consists of facing the upper edge of the casing, rough and finish machining the internal grooves, and rough and finish forming the undercuts which give the grooves a "T" section, as shown in Fig. 2. Only the upper three grooves are shown in Fig. 2, but there are altogether 14 such grooves, which vary in width but are of the same form and diameter.

The optical projector provides a magnification of ×25 on its screen, showing the relevant part of the scale, which is illuminated by a 12-volt lighting unit. The scale is a length of $1\frac{1}{2}$-in. bar of the same material as the compressor casing, so that they have the same coefficient of expansion and errors due to changes in ambient temperature will not arise. The scale is graduated with marks which are numbered to correspond to the vertical positions of the tool slide required to produce the numbered edges of the grooves shown in Fig. 2. In the case of the compressor casing these numbers run from 1 to 53, from the bottom of the lowest groove to the top of the uppermost groove. The corresponding numbers appear on the scale, but are arranged with No. 1 at the top and 53 at the bottom, since the top of the scale is opposite the projector when the tool is at the bottom of the casing. Two series of graduations are provided on the scale for each number, as shown in Fig. 3: one for the initial coarse setting, directly by eye, and one for optical setting. The latter series of graduations are engraved on the lapped ends of 53 hardened steel rollers which are set in the bar, and each one is projected in turn on to the projector screen, as shown on the right of Fig. 4 for No. 52. The screen has two parallel lines, and the tool slide is adjusted vertically until the engraved line on the appropriate inset roller is between them. The scale is mounted in two dovetail slots, one at each end. The upper slot is provided with an adjusting screw to locate the scale accurately endwise relative to the bottom face of the compressor casing. The scale is then clamped at this end. At the lower slot the scale is free to move endwise to permit expansion or contraction.

The casing is clamped to the table and the end face machined to the correct length. Groove 51-52, Fig. 2, is then rough-formed relative to the top surface, measurement by vernier being taken for

CONTROL OF MACHINE-TOOL SLIDES.

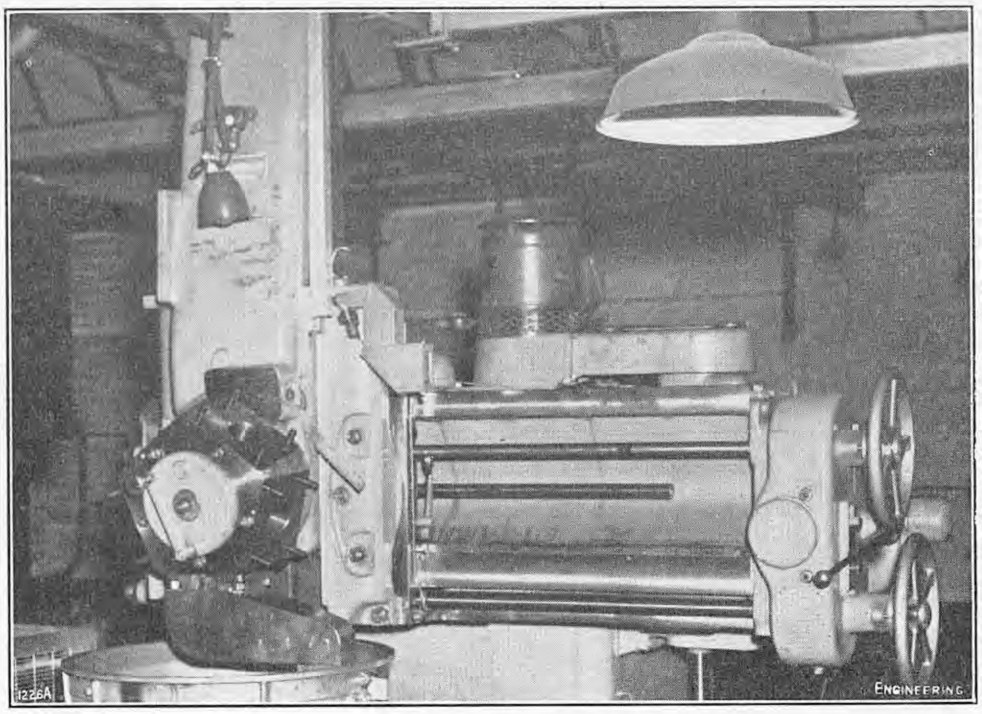


FIG. 1. BORING MILL FITTED WITH OPTICAL CONTROL.

Fig. 2.

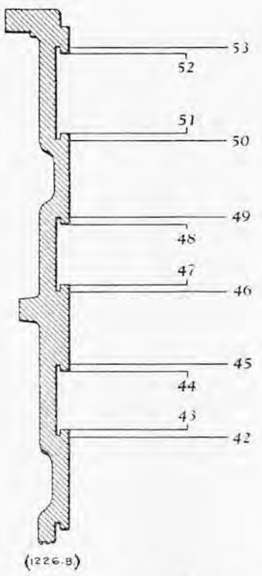


Fig. 3.

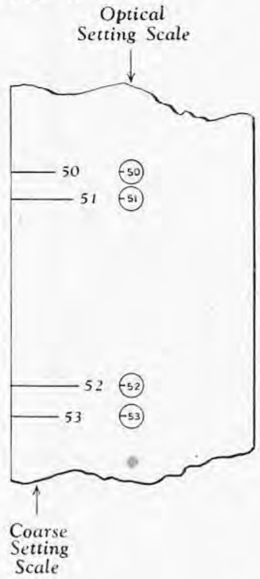


Fig. 4.

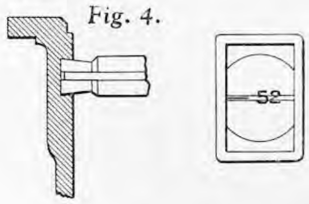


Fig. 5.

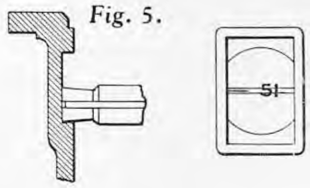
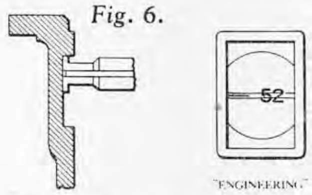


Fig. 6.



accurate location. Two cuts are taken, as shown in Figs. 4 and 5, as the width of the tool is only equal to the smallest grooves at the opposite end of the casing. The scale and projector are then set in relation to the initial two rough grooving operations. This setting is then permanent for a batch of casings. Figs. 4 and 5 show the relationship of the tool to the scale reading when cutting the first, top groove. Figs. 2 and 3 show the relationship of the scale to the casing. The operator adjusts the turret slide until the engraved line 52 is central between the twin white lines on the screen. The saddle can then be traversed across the cross rail, depth of cut being taken from the dial and pointer controlling the saddle movement. This reading is recorded. The tool is then withdrawn and the turret slide fed further down the casing until mark 51 is seen in position on the projector screen. The tool is again fed into the work until the dial reading mentioned above is obtained. The groove 51-52 is now rough formed, and the same operation is repeated until all the grooves are machined in relation to the scale.

The grooving tool is then replaced by the double-edge undercutting tool shown in Fig. 6. The same scale and dial reading used when forming the grooves enables the undercutting tools to be accurately located in the rough-formed grooves (Fig. 6). The turret slide is now traversed up or down to machine the two undercuts in each groove. The depth of the undercut is controlled by the operator feeding up or down by traversing the turret slide, until the scale markings are seen in position on the screen. This sequence is continued to complete the rough forming of the undercuts in the casing. The finishing operation is identical; the tools, however, are of a greater width to take light cuts on all surfaces. Since the accuracy of machining depends on the accuracy of grinding the width of the cutting tools, composite tools are used so that, after regrinding, shims can be inserted between the two halves of the tool and the whole bolted together. The tool has an accurately ground shank and is clamped in a tool-holder provided with a precision-cut slot and locating stops. This tool holder is bolted on the end face of the bracket which is mounted on one face of the revolving turret (Fig. 1). Although special scales to individual specification can be provided by Alfred Herbert, Limited, a range of standard glass and steel scales, which are less costly, is available to meet most requirements.

ROAD RESEARCH.

THE report of the Road Research Board for 1951,* which has recently been published, describes the work of the Road Research Laboratory of the Department of Scientific and Industrial Research to "increase the sum total of knowledge of the function of the road as a channel for trade and for the flow of community life." A large part of the work mentioned in the report has already been published in greater detail in papers given by the Director of the Laboratory, Dr. W. H. Glanville, C.B.E., M.I.C.E., and members of his staff, before scientific and engineering societies and in the technical Press. Broadly speaking, the report divides the work of the Board into two parts, the first being concerned with traffic problems and, in particular, the causes of accidents and the means of preventing them, the second with materials and methods of construction.

TRAFFIC AND VEHICLE INVESTIGATIONS.

One of the striking features of research is the fact that small, previously insignificant, items often prove to be important, demanding skill, thought and attention. Such an item was the rear light of road vehicles, and the first three pages of the report are concerned with investigations into the importance of the rear light in reducing accidents at night. Repeated trials had shown that if a rear light was to be seen at 400 ft. by the driver of a following vehicle when he was dazzled by the headlight of an oncoming car, it had to have an intensity of at least 0·25 candela; this figure had been arrived at after making allowance for "adverse conditions" such as might be met frequently when driving at night. Surveys made at different places and times had led to the disturbing realisation that three-quarters of all licensed vehicles and 98 per cent. of pedal cycles failed to reach the desired minimum. Analysis of the cars involved in front/rear collisions showed a marked drop, to one-sixth of all other vehicles, for post-war private cars which were fitted with twin rear lights, each of the required power. The Director notes with gratification the manner in which both the road users and the vehicle manufacturers accepted the laboratory's findings in this matter, and it is recorded that the Road Haulage Executive and at least one of the larger manufacturers of commercial vehicles have announced their future intention to fit twin rear lights, separately wired, to the backs of their lorries. In considering the accident rate of different types of vehicle, the report shows that solo motor-cycles were involved in five times as many accidents, in proportion to their numbers, as other types of vehicle. The added stability of a sidecar—or the increased sense of responsibility of the drivers of combination motor-cycles—reduced the accident rate for such vehicles to only twice that of private cars or public-service vehicles.

Numerous counts of vehicles at different road points, and at given points under varying weather conditions, have made it possible to deduce equations showing how these factors affect the numbers of vehicles on the road. One of the factors considered was the reduction in the different forms of vehicles with an increase in rain. As might be expected, between Mondays and Fridays, rain has no effect whatsoever on the numbers of commercial vehicles on the road, but there was a reduction of 6·0 per cent. per millimetre of rain per day in the case of motor cycles, and only half this reduction in the numbers of cycles. Over the week-end, when vehicles were used more for pleasure, the use of both cycles and motor-cycles was equally curtailed and there was found to be a total reduction of 4 per cent. per millimetre of rain in the total number of vehicles on the roads. The report defines road capacity as the flow of vehicles per hour at a minimum acceptable journey speed for the route concerned, and observation showed that this capacity was quickly reduced where important routes crossed. In particular, for a 30-ft. carriage-way, where traffic had a mean speed of 12 m.p.h., the capacity of the road was found to drop from 950 vehicles per hour to about 400 vehicles per hour as the number of major road intersections increased from naught to six per mile. A similar reduction in traffic capacity was found when measured against the number of pedestrians crossing the street: thus, the capacity of an otherwise uninterrupted street, 30 to 33 ft. wide, was found to be reduced by about 5 per cent. for each 1,000 pedestrians crossing per hour per mile of roadway. The report deals similarly with the effect on capacity of parked vehicles and other obstructions.

In an analysis of the gross cost of all road transport for the year it was found that over 10 per cent. of the nation's current resources were committed directly to the various aspects of road transport. Of this total, however, only 7½ per cent. was devoted to the construction and maintenance of roads, including their lighting, and in considering this proportion it is to be remembered that the roads, together with the railways, have suffered more than most public utilities from Government restrictions on capital expenditure. By far the largest item of the total expenditure, about 90 per cent., consisted of direct expenditure by road users in the course of vehicle operation, and the greater part of this figure was that part paid in drivers' wages in respect of commercial and public-service vehicles. Direct expenditure on fuel, lubricants, tyres and vehicle maintenance (this last item included the relevant labour charges) for all types of road vehicles amounted to approximately 25 per cent. of the total.

METHODS OF ROAD CONSTRUCTION.

In the second part of his report, the Director briefly relates the numerous investigations into materials and methods of construction that were continued during the course of the year. The objects of the investigations were twofold: first, to improve the materials themselves and, secondly, to consider the problems of road construction in terms of the present-day financial stringency, and to achieve the means of effecting economy in both materials and labour. This second issue was concerned with determining an improved method of designing a road structure, by giving full consideration to the nature of the subsoil and the traffic to be carried. Full-scale tests to this end had been undertaken by laying experimental stretches of road, of various thicknesses and of various compositions, and by recording the flow of traffic and condition of the road with the passage of time. It is hoped that the accruing evidence will yield sufficient information to lay down standards so that suitable forms of road construction may be adopted for a particular density of traffic. A more refined classification of traffic than "heavy," "medium" and "light" was being attempted, and for this purpose the Laboratory was collecting information in respect of the weights and the numbers of vehicles passing typical road points, with the object of classifying traffic in terms of equivalent numbers of repetitions of a standard wheel load.

The construction of secondary roads and minor roads of the type found on housing estates had been developed by the more extensive use of soil stabilisation; the Laboratory was concerned with work on several sites. The stabilised layer was usually made 6 in. thick and the amount of cement used was equivalent to about 10 per cent. of the weight of the disturbed soil. The type of surface adopted had depended on the expected traffic: for secondary roads it was usual to lay a 4-in. carpet of bitumen in two courses, but for minor roads this had been reduced to a thickness of 2 in. It had become customary not to lay the final surface while constructional work was proceeding in the area, but to protect the stabilised subsoil by a temporary dressing of tar and stone chippings. Soil samples taken from two sites proposed for new roads showed that the soil had an organic content of 1 per cent., and it was found that this was sufficient to retard the hardening of the soil-cement mixture by about a month. In both these cases the sand in the soil absorbed calcium from the cement to the extent of 75 mg. per 100 grammes of dry sand. This absorption and "fixing" of the calcium was eliminated by the addition of between 1 and 2 per cent. of calcium nitrate or calcium chloride to the soil-cement mixture. In general, greater strengths were obtained by using an ordinary Portland cement and maintaining a lengthy curing period rather than by using a rapid-hardening cement. In order to stabilise a particular heavy clay, it was found to be necessary to use 20 per cent. ordinary Portland cement to which a further 2 per cent. of hydrated lime had been added.

For heavier road slabs, observations made on plain concrete showed that it quickly cracked and disintegrated due to weathering and traffic, and the report gives no support for the continued use of unreinforced-concrete road sections. Experiments were begun to determine the most satisfactory method of carrying the reinforcement across the road joint, and the action of dowel bars in transmitting the load between the ends of successive slabs has been examined and found to be satisfactory. Observations made on slabs varying in length from 45 ft. to 690 ft. failed to produce any evidence of buckling in even the longest slab. The report shows that little progress had been made by the end of 1951 towards solving the problems arising from attempts made to prestress road slabs. Without giving any details, the report notes that resistance strain gauges had been devised that gave reliable results over long periods when buried in concrete, and this had made it possible to study the influence of both shrinkage and creep in the behaviour of road slabs. Without doubt, since then, such gauges will have been put to wider use.

The report mentions that an approach was made to the problem of re-surfacing streets paved with stone setts, at one time a common material for road construction, particularly in northern England and in Scotland. The setts, although very durable, were often irregular, and very slippery in wet weather, and a new surface was required that would prolong their life as the essential road fabric. The application of a two-course hot-processed rolled asphalt was found to improve the riding qualities and to provide a long-lasting surface suitable for heavy traffic. There was, however, a continued need to find a cheaper process which would involve a thinner surface treatment to save the expense of raising the kerbs and pavements.

* *Report of the Road Research Board, with the Report of the Director of Road Research, for the Year* 1951. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 3s. 6d. net.]

CONTRACTS.

During November, the British Electricity Authority placed contracts for equipment for power stations, transforming stations and transmission lines, amounting, in the aggregate, to 4,794,244*l*. The principal contracts included: for Rye House power station, near Hertford, cables and accessories, with BRITISH INSULATED CALLENDER'S CABLES, LTD.; for Tilbury power station, low-pressure piping equipment, with STEWARTS AND LLOYDS LTD.; for Castle Donington power station, near Derby, circulating water valves, with J. BLAKEBOROUGH & SONS, LTD., and circulating water pumps, with WORTHINGTON-SIMPSON LTD.; for Bold power station, near St. Helens, circulating-water make-up supply mains, with SIR ALFRED MCALPINE & SON LTD.; for Ince power station, near Ellesmere Port, four cooling towers, with FILM COOLING TOWERS (1925) LTD.; for Dolgarrog power station, Caernarvonshire, 33-kV switchgear, with FERGUSON, PAILIN LTD.; for Wakefield power station, the main civil-engineering works, with MITCHELL CONSTRUCTION CO., and six boiler-feed pumps with MATHER AND PLATT LTD.; for Stella North power station near Newcastle-upon-tyne, ash and dust handling plant, with BABCOCK AND WILCOX LTD.; for Stella South power station, control-building superstructure, with SIR ROBERT MCALPINE & SONS (NEWCASTLE-UPON-TYNE), LTD., and ash and dust handling plant, with BABCOCK AND WILCOX LTD.; for York power station, one 20,000-kW turbo-generator and feed-heating plants, with the BRUSH ELECTRICAL ENGINEERING CO., LTD.; for Roosecote power station, Barrow, ash and dust handling plant, with B.V.C. INDUSTRIAL CONSTRUCTIONS LTD.; for Clyde's Mill power station, Glasgow, auxiliary switchgear, with A. REYROLLE & CO., LTD.; for Daventry substation, 132-kV 2 500-MVA switchgear, with the GENERAL ELECTRIC CO., LTD.; 275-kV twin 0·4-sq. in. overhead line from Slough (New Denham) to Elstree, and 132-kV overhead line from Stony Stratford to Bedford, both with WATSHAM'S LTD., and 132-kV overhead line from Keadby to Creyke Beck, with RILEY AND NEATE LTD.

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.

Stirrup Pumps.—A new specification, B.S. No. 1901: Part 1, covering stirrup pumps of the piston type, has been issued to replace a British Standards Institution specification, A.R.P. No. 33, published during the late war. In the new specification all unnecessary constructional details given in the old publication have been eliminated and workmanship and performance are the two matters primarily dealt with. Only those dimensions which are necessary to ensure adequate performance are specified. It is the intention to issue at least one further part to this specification covering stirrup pumps of a different type. [Price 2*s*., postage included.]

Flexible Metallic Tubing and Connector Ends for Gas Appliances.—A revision of specification B.S. No. 669, dealing with flexible metallic tubing and connector ends for appliances burning town gas, has now been issued. The specification was first published in 1936 and the new edition has been divided into two parts. The first part covers general-purpose domestic tubing and connector ends for portable appliances. Two types of tubing are dealt with in part 1, namely, plain tubing and plastics or synthetic-rubber covered tubing. Part 2 covers heavy-duty armoured tubing and connector ends. Metal screwed connector ends ensuring maximum safety in use have been adopted. Certain clauses covering the quality of the rubber used in the construction and assembly of the tubing have been modified and clauses covering the tensile strength of various materials have been extended. New clauses concerning crushing strength and the quality of the nickel plating used on springs have been inserted. Certain finishes have been deleted from the new edition and additions and modifications have been made to the dimensions of the tubing in the light of current manufacturing practice. The specification does not provide for tubing which is required to be electrically insulated from end to end; in such cases special insulating washers are necessary on the inside of the metal connector ends and the covering material must possess adequate insulating properties. [Price 6*s*., postage included.]

Performance Tests for Protective Schemes on Steel Sheet and Wrought Iron.—A revision of B.S. No. 1391, first issued in provisional form in 1947 at the request of the Ministry of Works, has now been published. It deals with performance tests for protective schemes used in the protection of light-gauge steel and wrought iron against corrosion. The new edition includes not only the A.R.E. salt-droplet test, based on a method of testing with a sea-water spray devised by the Armament Research Establishment, Ministry of Supply, but also the newer C.R.L. test, involving exposure to humid sulphur dioxide, introduced by the Chemical Research Laboratory, Department of Scientific and Industrial Research. Both tests have been standardised as a result of investigations made by the Methods of Testing (Corrosion) Sub-Committee of the British Iron and Steel Research Association. The tests are intended to apply mainly to parts used in permanent building construction where a single coat of stoving paint is applied to bare, phosphated, or metal-coated steel. No hard and fast standards of performance have been stipulated, as it is felt that users should be left to choose standards to suit their individual requirements, such as by specifying a minimum test duration to a specified degree of breakdown. [Price 5*s*., postage included.]

Wrought Aluminium-Copper-Magnesium-Silicon-Manganese Alloys for Aircraft.—Four new specifications in the series for aircraft material have been issued. The first two specifications, L.70 and L.71, relate to aluminium-alloy sheets and strips containing 4·4 per cent. of copper, 0·7 per cent. of magnesium, 0·7 per cent. of silicon and 0·6 per cent. of manganese. Specification L.70 covers material which has been solution-treated and aged at room temperature, and L.71, material No. 20 S.W.G. (0·036 in.) thick and thicker, which has been solution-treated and precipitation-treated. The second and third specifications, L.72 and L.73, relate to these same alloys after they have been coated with aluminium. L.72 covers material solution-treated and aged at room temperature and L.73 material which has been solution-treated and precipitation-treated. In all four specifications the clauses set out concern the quality of the material and its chemical composition, heat treatment and mechanical properties. Clauses relating to inspection and testing procedure and to identification and marking are also included. [Price of each specification 1*s*., postage included.]

LABOUR NOTES.

It was announced last week that the Engineering and Allied Employers' National Federation had recommended its members to pay an increase of 7*s*. 6*d*. a week to their draughtsmen and scientific staffs, as from Monday, December 22, 1952. An increase of this amount was offered by the Federation to the unions representing workpeople in these categories during the course of negotiations in mid-December. The sum is the same as that granted recently to clerical employees in the engineering industry. The Association of Engineering and Shipbuilding Draughtsmen rejected the offer when it was made and is understood to have pressed for the granting in full of its original claim for increases of 10*s*. a week for members aged 21, with proportionate increases for older men up to the age of 25. It is believed that the greater part of the Association's 50,000 members would have benefited.

At the time of going to press, there are indications that the executive committee of the Association of Engineering and Shipbuilding Draughtsmen may decide to submit their demands to arbitration, and the Engineering and Allied Employers' National Federation has made it clear that its recommendation to firms to pay the 7*s*. 6*d*. increase is subject to any national settlement which may eventuate. On the other hand, the Association of Scientific Workers, which represents the scientific staffs of engineering firms, appears to consider that the increase of 7*s*. 6*d*. a week represents a fairly satisfactory advance for its younger members. When the Association's executive committee meets later this month, however, it is expected that a fresh claim will be put forward, on behalf of senior scientific employees in engineering firms.

A four-day working week came into operation yesterday at the Manor Mills factory of the Hercules Cycle and Motor Company, Limited, Birmingham, and affected about 1,500 of the firm's 4,000 employees. Its introduction was decided upon by the company and the unions concerned as an alternative to the dismissal of some 300 workpeople on redundancy grounds. A statement issued on behalf of the firm explained that there was "no air of crisis" about the decision. The move had been made solely on account of prevailing world conditions and it was hoped that the factory would revert to full-time working in a month or two, when its existing heavy stocks of components had been reduced. For some time past, the company had concentrated on increased output and had been employing part-time labour, often on night work, in consequence of which larger stocks than required had accumulated. Another reason was the closing, probably until February or March, of markets in India and Pakistan.

The offer by the National Coal Board to increase the minimum rate of wages paid in the industry by 6*s*. a week was unanimously rejected at a special delegate conference of Scottish miners, at a meeting in Edinburgh on December 23. Representatives from all branches of the National Union of Mineworkers in Scotland were present. It had been estimated that about 150,000 of the lowest-paid day-wage miners in all parts of Britain would have benefited from the concession. The President of the Scottish area of the N.U.M., Mr. Abe Moffat, stated after the meeting that the delegates had not only turned down the Board's offer but had also voted against the resolution passed by the union's national delegate conference on December 18. In the opinion of the Scottish miners, Mr. Moffat said, that resolution did not go far enough.

It may be recalled that the resolution passed by the national delegate conference in London instructed the union's executive committee to intensify its negotiations with the N.C.B. for new national rates of wages for all miners employed on a day basis. Mr. Moffat announced that the Edinburgh conference demanded that the union's executive committee should continue to urge the Board to grant a minimum increase for all day-wage miners and that that committee should consider taking whatever measures might be necessary to obtain a satisfactory conclusion of its negotiations. The delegates also called upon the executive of the N.U.M. to give notice to the Board to terminate the extended hours agreement when it expired in April next. There were many delegates, Mr. Moffat concluded, who had stressed the need for the taking of strike action to enforce their demands, but the decisions of the Edinburgh conference had eventually been carried unanimously.

The size of manufacturing firms in Great Britain is the subject of continuous inquiry by the Ministry of Labour and National Service, in accordance with the provisions of the Statistics of Trade Act, 1947, and forms to secure the required information are supplied monthly by the Ministry's local offices to all manufacturing establishments employing more than ten persons. The *Ministry of Labour Gazette* for December, 1952, contains an analysis of the returns for May last, from which it appears that 56,638 manufacturing firms with over ten workers were then in existence. Altogether, they employed 7,180,000 persons, of whom 2,298,000, or about 32 per cent., were women and girls.

These totals are analysed by the *Gazette* into nine groups according to the number of employees. The first group comprises firms employing between 11 and 24 persons. There were 17,441 such firms and together they had 299,000 workpeople, of whom 97,000, or about 32 per cent., were women and girls. The group with the largest total number of employees was that of establishments with between 100 and 249 workpeople. There were 8,364 such firms and they had 1,294,000 persons on their payrolls, of whom 496,000, or 38 per cent., were women and girls. It may be worthy of note that some three-quarters of the employers had fewer than 100 employees, and that another 15 per cent. came within the group having between 100 and 249 employees. Establishments with 2,000 or more employees each, arranged into two groups by the *Gazette*, numbered 361, and together employed 1,367,000 workpeople, or about 20 per cent. of all the employees.

The engineering, shipbuilding and electrical-goods industries were the largest trade group, both as to number of firms and total of employees; the 8,563 establishments in it employing 1,692,000 workpeople. Only 120 firms in this group had over 2,000 employees. There were 2,287 firms engaged in the chemical and allied trades, employing a total of 389,000 persons. The vehicles industry comprised 5,559 firms having, in all, 870,000 operatives. About one-quarter of all firms in Great Britain were located in London and South-East England. They numbered 13,411 and employed 1,408,000 persons.

Statistics issued by the Ministry of Fuel and Power yesterday indicate that 212,830,700 tons of deep-mined and 12,108,500 tons of opencast coal were mined during 1952, compared with 211,270,700 tons of deep-mined coal and 10,985,800 tons of opencast fuel last year.

An announcement issued by the Treasury on Wednesday last stated that the Chancellor of the Exchequer, Mr. R. A. Butler, had rejected the claim of the Civil Service unions for a flat-rate increase. As a result of this decision, there will now be no general increase of wages and salaries for the Service as a whole, and the unions concerned will have to submit their claims individually for consideration on the merits of each particular case. The staff side of the Civil Service National Whitley Council met yesterday and discussed the general situation. The claim was based on a rise of seven points in the index of industrial wage rates, compiled by the Ministry of Labour. Some 600,000 civil servants were concerned in the original claim and it was estimated that an all-round increase, in proportion to the rise in the index, would have cost some fifteen million pounds per annum.

CREEP PROPERTIES OF STEELS FOR POWER PLANTS—I.*

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., AND N. E. FROST, B.Sc., A.M.I.Mech.E.

IN the operation of power plant, periods occur during which operating conditions subject the plant to peak stresses and temperatures in excess of the rated value. Obviously, such overstress or excess temperature periods must have an important effect upon the magnitude of total creep occurring in plant components, and ultimately upon their life, the degree of such effect naturally depending, in general, upon the order and frequency of the peaks in question. In the design of such components, provision for the occurrence of these peak temperatures and stresses might be made by allowing a predetermined margin of temperature to cover their effects upon creep strain.

The major object of the work described below has been to examine the effects of practically possible fluctuations of stress and temperature upon the creep properties of four steels typical of those used in steam-power plant; namely, 0·17 per cent. carbon steel, a 0·5 per cent. molybdenum steel, and a steel containing 0·5 per cent. molybdenum and 0·23 per cent. vanadium in the fabricated form of both bar and pipe. In addition, the degree of accuracy with which it is possible to forecast the margin of temperature to be allowed in design by analytical means has been examined.

It is, of course, possible to suggest the lines which the behaviour of given steels may follow under conditions of fluctuating temperature. Naturally, materials in which creep has a higher-power exponential or other dependence upon stress or temperature, over the range of operating conditions concerned, would be expected to show greater sensitivity to temporary stress or temperature changes. Likewise, a stress or temperature increase which corresponded, for a particular material, to transition from one region of characteristic curves to another in which the stress or temperature dependence was of a higher order, would presumably be more critical than one in which the stress or temperature dependence of creep remained unchanged. Such a change might occur if the peak conditions corresponded with tertiary creep.

Again, creep recovery effects, both upon loading and unloading, will obviously play some part, and it might be expected that these effects would mean that increasing the frequency of overstress or temperature might minimise their importance; since, possibly, at high frequencies, recovery has a relatively greater significance over the shorter operating period.

Generally, it must be emphasised that, from what is known of the effects of previous stress, strain and temperature history on the creep behaviour of a given specimen of material, it would not be expected that the results of purely steady stress and temperature creep tests would provide, in all circumstances, a means of estimating the behaviour of a given material under conditions of variable stress and temperature. It is possible, nevertheless, that within a limited range of variation the normal steady-state creep results would give a reasonably correct approximate indication of what might happen.

However, it is clear that several possibly conflicting factors play their part; and, obviously, reliable forecasts of the effects of given varieties of cycles, and of the degree of approximation with which ordinary creep tests enable the effects of such cycles to be computed *ab initio*, must be based upon actual experiments, framed to simulate these various stress and temperature changes. Such a basis it has been the intention to provide by the work described below.

OUTLINE OF INVESTIGATION.

Details of all the materials concerned in the investigation are given in Table I, herewith. In

* Communication from the National Physical Laboratory. Abridged.

TABLE I.—DETAILS OF MATERIAL USED.

Material.	Form.	Heat Treatment.	Composition, Per Cent.									
			C.	Mn.	Si.	S.	P.	Mo.	Va.	Ni.	Cr.	Cu.
Carbon steel ..	1-in. diameter bar	Normalised at 950 deg. C. for 15 minutes; air-cooled.	0·17	0·72	0·20	0·024	0·022	—	—	—	—	—
Molybdenum steel	$1\frac{3}{16}$-in. diameter bar	Normalised at 925 deg. C. for 15 minutes; air-cooled.	0·15	0·52	0·21	0·021	0·031	0·52	—	0·16	0·23	—
Molybdenum-vanadium steel	$1\frac{1}{8}$-in. diameter bar	As received; hot-rolled from billet.	0·13	0·28	0·12	0·025	0·026	0·84	0·23	0·10	0·16	—
Molybdenum-vanadium steel	Pipe, $7\frac{15}{16}$ in. outside dia- and 1 in. thick	Normalised at 975 deg. C. for 1 hour; tempered at 690 deg. C. for 4 hours.	0·10	0·52	0·17	0·024	0·011	0·56	0·265	0·13	0·19	0·19

TABLE II.—OVERSTRESS AND EXCESS-TEMPERATURE TESTS ON 0·17 PER CENT. CARBON STEEL AT 959 DEG. F.

(*All tests of 300 hours' duration, approximately; basic stress in all tests, 4 tons per square inch.*)

Variety of Cycle.	Stress Peaks.						Temperature Peak.	Stress and Temperature Peak.
Cyclic period of test, hours	24	6	2	24	24	24	24	24
Per cent. of cyclic period under overstress ..	50	50	50	25	5	5	—	50
Value of overstress, per cent.	10	10	10	20	30	50	—	10
Per cent. of cyclic period under increased temperature	—	—	—	—	—	—	50	50
Value of temperature increase, deg. F.	—	—	—	—	—	—	13·5	13·5
Creep strain at 300 hours	0·00135	0·00122	0·0009	0·00137	0·00144	0·00257	0·00106	0·00128
Creep rate at 300 hours, per hour	0·0000027	0·0000021	0·0000018	0·0000027	0·0000032	0·0000087	0·0000018	0·0000029
Experimental value of equivalent steady temperature increase corresponding to creep rate at 300 hours	19·8	16·2	14·4	19·8	21·6	30·6	14·4	20·7
Experimental value of equivalent steady temperature increase corresponding to creep strain at 300 hours	17·1	14·4	6·3	18	18·9	32·4	10·8	16·2
Analytically derived value of equivalent steady temperature increase for values $a = 0·064$, $n = 7·3$ (Bailey's equation)	6·4	6·4	6·4	8·2	3·9	10·2	8·2	16·5
Analytically derived value of equivalent steady temperature increase for values $a = 0·049$, $n = 6$ (Bailey's equation)	6·7	6·7	6·7	8·1	3·6	8·5	7·9	16·1

TABLE III.—OVERSTRESS AND EXCESS-TEMPERATURE TESTS ON 0·5 PER CENT. MOLYBDENUM STEEL AT 1,085 DEG. F.

(*All tests of 300 hours' duration, approximately; basic stress in all tests, 4 tons per square inch.*)

Variety of Cycle.	Stress Peaks.							Temperature Peaks.			Temperature Peak and Pressure Peak.
Cyclic period of test, hours	24	6	2	24	2	24	24	24	6	24	24
Per cent. of cyclic period under overstress	50	50	50	25	25	5	5	—	—	—	25
Value of overstress, per cent.	10	10	10	20	20	30	50	—	—	—	20
Per cent. of cyclic period under increased temperature	—	—	—	—	—	—	—	50	50	25	25
Value of temperature increase, deg. F.	—	—	—	—	—	—	—	16	16	9	9
Creep strain at 300 hours	0·00068	0·00088	0·00116	0·00103	0·00103	0·00089	0·00139	0·00107	0·0011	0·00091	0·0011
Creep rate at 300 hours, per hour	0·00000165	0·0000019	0·0000029	0·0000022	0·0000022	0·0000021	0·0000030	0·0000025	0·0000030	0·0000021	0·0000027
Experimental value of equivalent steady temperature increase corresponding to creep rate at 300 hours	0	1·8	10·8	2·7	2·7	1·8	12·6	5·4	14·4	1·8	7·2
Experimental value of equivalent steady temperature increase corresponding to creep strain at 300 hours	0	2·7	14·4	8·1	8·1	3·6	34·2	9·9	10·8	3·6	10·8
Analytically derived value of equivalent steady temperature increase for values $a = 0·0385$, $n = 3$ (Bailey's equation)	4·0	4·0	4·0	4·4	4·4	1·5	2·9	9·4	9·4	2·6	8·0

order to estimate the effect upon creep properties of fluctuations of stress and temperature, some basic criteria of creep performance had to be chosen, and this, for all materials, was taken as a standard stress of 4 tons per quare inch, at such a temperature as would give a creep strain of approximately 0·001 in 300 hours. This train corresponds to the value frequently allowed by designers over long periods in practice. For each material, therefore, a number of creep tests were made at 4 tons per square inch and at various temperatures. That temperature which gave approximately 0·001 creep strain at 300 hours was then adopted as the general temperature of test. In the case of the carbon steel, this temperature was 959 deg. F.; for the molybdenum-steel, it was 1,085 deg. F.; for the molybdenum-vanadium bar material, it was 1,103 deg. F.; and for the corresponding pipe material, it was 1,193 deg. F. The convention adopted for the design stress and the degree of strain was suggested by Dr. R. W. Bailey, F.R.S. It will be noted that, in some instances, the temperatures involved in the tests are somewhat above those occurring in practice for these materials. Dr. Bailey also suggested the cyclic conditions used, in many cases.

Three sets of tests were made for each material, these being, respectively, tests in which fluctuations of stress only occurred, tests in which fluctuations of temperature only occurred, and tests in which the two were superimposed. In the case of the first two varieties of test, the effect of frequency of fluctuation of the cyclic variable concerned was examined, and in all three kinds of tests the nature of the fluctuation was varied. In many cases, the degree of variation of temperature was chosen to correspond approximately (as indicated by the general characteristics of the material, and the results of stress fluctuation tests) with the effect of fluctuations occurring in certain of the stress-peak series of tests. A summary of the nature of the various fluctuations is given in Tables II and III, on page 25, and Tables IV and V, herewith, and is commented upon in later paragraphs in some detail, for each of the various materials concerned.

As noted above, to form a basis of comparison of the effect of overstress or excess temperature in the creep tests, a series of tests at the criterion stress and at various temperatures were conducted for the several materials, the data obtained enabling the creep strain-raising effects of overstress or excess temperature, or both applied intermittently, to be expressed in terms of an equivalent increment of temperature, constant for the whole operational period of 300 hours. These and all subsequent tests were made in the National Physical Laboratory's creep-testing units, of 5 tons capacity. All tests were started under basic conditions for one half-period, followed by overstress or excess temperature for a half-period. It will be seen from the Tables that the normal operational period, whether of stress or temperature variation, was 24 hours; but that, in the examination of frequency effects, six-hour or two-hour operational periods were used.

In the case of operational periods, increments of stress or temperature were applied by manual operation of the loading jockey weight of the machine, or by temperature-control thermostat setting. In the case of six-hour and two-hour periods, however, manual operation was impracticable, and other means, described below, were adopted. Manual application of load was, however, again adopted in the case of relatively heavy increments of stress of 30 or 50 per cent., the period of imposition of which was only 5 per cent. of 24 hours; and, additionally here, careful manual loading was requisite, as it was most important to avoid any suspicion of inertia effects.

In the case of stress increments, the mode of automatic application of the increments was as follows. A rectangular steel weight of appropriate magnitude was applied automatically at such a point on the loading beam of the testing machine as to cause an appropriate increase of stress in the test-piece. Immediately above the weights was

TABLE IV.—OVERSTRESS AND EXCESS-TEMPERATURE TESTS ON 0·5 PER CENT. MOLYBDENUM, 0·23 PER CENT. VANADIUM STEEL (BAR MATERIAL) AT 1,103 DEG. F.

(Basic Stress in All Tests, 4 Tons per Square Inch.)

Variety of Cycle.	Stress Peaks.						Temperature Peaks.				Stress and Temperature Peaks.	
Cyclic period of test, hours	24	2	24	2	24	24	24	24	24	24	24	24
Per cent. of cyclic period under overstress ..	50	50	25	25	5	5	—	—	—	—	50	25
Value of overstress, per cent.	10	10	20	20	30	50	—	—	—	—	10	20
Per cent. of cyclic period under increased temperature	—	—	—	—	—	—	50	25	50	25	50	25
Value of temperature increase, deg. F. ..	—	—	—	—	—	—	5·4	8	36	54	5·4	8
Creep strain at 300 hours	0·0010	0·0009	0·00106	0·00094	0·00085	0·00105	0·00097	0·00078	0·00135	0·00137	0·00107	0·00113
Creep rate at 300 hours, per hour	0·0000021	0·0000019	—	0·0000019	0·0000018	0·0000024	0·0000021	0·0000018	0·0000032	0·0000033	0·0000024	0·000002
Experimental value of equivalent steady temperature increase corresponding to creep rate at 300 hours	8·1	0	0	0	0	14·4	8·1	0	27	28·8	14·4	14·4
Experimental value of equivalent steady temperature increase corresponding to creep strain at 300 hours	6·3	1·8	9	3·6	0	9	4·5	0	21·6	23·4	9	12·6
Analytically derived value of equivalent steady temperature increase for values a = 0·028, n = 6 (Bailey's equation)	10·5	10·5	13	13	6·3	15	2·8	2·2	22·5	22·7	15·3	18·7
Analytically derived value of equivalent steady temperature increase for values a = 0·031, n = 6 (Bailey's equation)	10·5	10 5	13	13	5·7	13·5	2·8	2·2	22·9	23·7	14	17·2

TABLE V.—OVERSTRESS AND EXCESS-TEMPERATURE TESTS ON 0·5 PER CENT. MOLYBDENUM, 0·23 PER CENT. VANADIUM STEEL (PIPE MATERIAL) AT 1,193 DEG. F.

(Basic Stress in All Tests, 4 Tons per Square Inch.)

Variety of Cycle.	Stress Peaks.						Temperature Peaks.			Stress and Temperature Peak.
Cyclic period of test, hours ..	24	2	24	2	24	24	24	24	24	24
Per cent. of cyclic period under overstress	50	50	25	25	5	5	—	—	—	25
Value of overstress, per cent...	10	10	20	20	30	50	—	—	—	20
Per cent. of cyclic period under increased temperature ..	—	—	—	—	—	—	25	50	25	25
Value of temperature increase, deg. F.	—	—	—	—	—	—	8·1	36	54	8·1
Creep strain at 300 hours ..	0·00095	0·00096	0·00089	0·00094	0·00098	0·00144	0·00089	0·00129	0·00163	0·00108
Creep rate at 300 hours, per hour	0·0000020	0·0000018	0·0000021	0·0000022	0·0000021	0·0000034	0·0000016	0·0000034	0·0000049	0·0000024
Experimental value of equivalent steady temperature increase corresponding to creep strain at 300 hours ..	6	6·3	10·8	12·6	10·8	23·4	2·7	23·4	30·6	14·4
Experimental value of equivalent steady temperature increase corresponding to creep strain at 300 hours	5·4	6·3	0	5·4	9	30·6	0	27	36	16·2
Analytically derived value of equivalent steady temperature increase for values a = 0·031, n = 6 (Bailey's equation)	10·5	10·5	13·1	13·1	5·7	13·6	2·2	22·8	23·7	17·4
Analytically derived value of equivalent steady temperature increase for values a = 0·027, n = 5·6 (Bailey's equation)	11·2	11·2	13·7	13·7	5·8	13·5	2·2	22·3	22·4	17·7

CREEP PROPERTIES OF STEELS FOR POWER PLANTS.

Fig. 1. 300 HOURS; 0·17% C. STEEL AT 4 TONS PER SQ. IN.

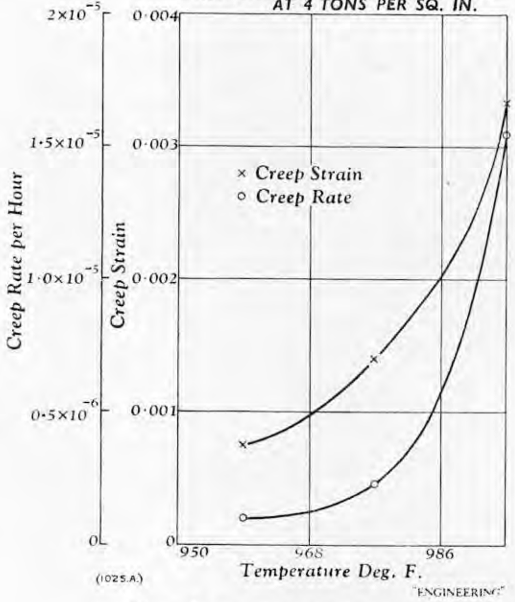


Fig. 2. 300 HOURS; 0·5% Mo STEEL AT 4 TONS PER SQ. IN.

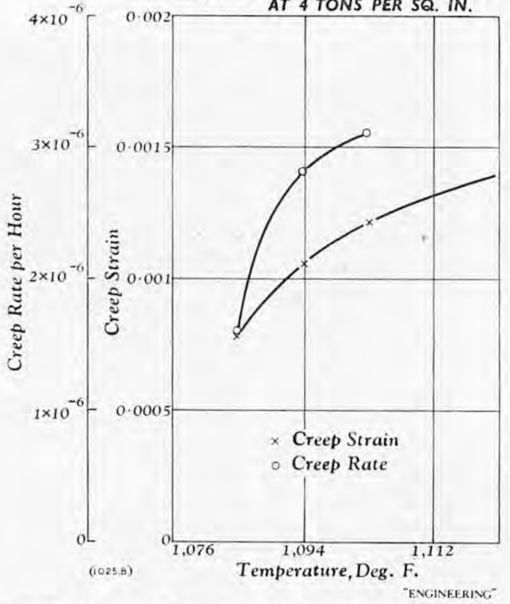


Fig. 3. 300 HOURS; 0·5% Mo 0·23% V STEEL (BAR MATERIAL) AT 4 TONS PER SQ. IN.

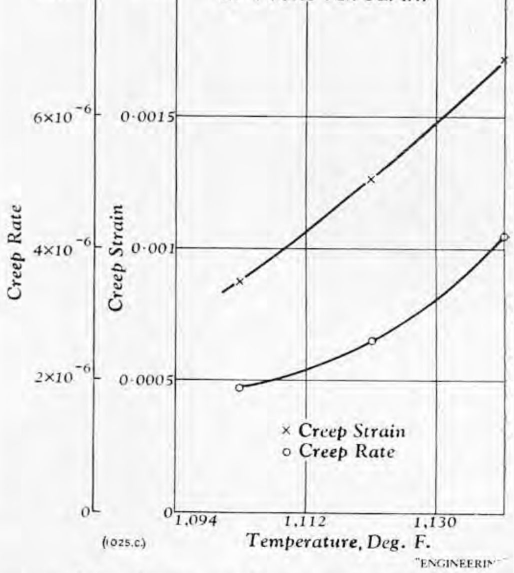
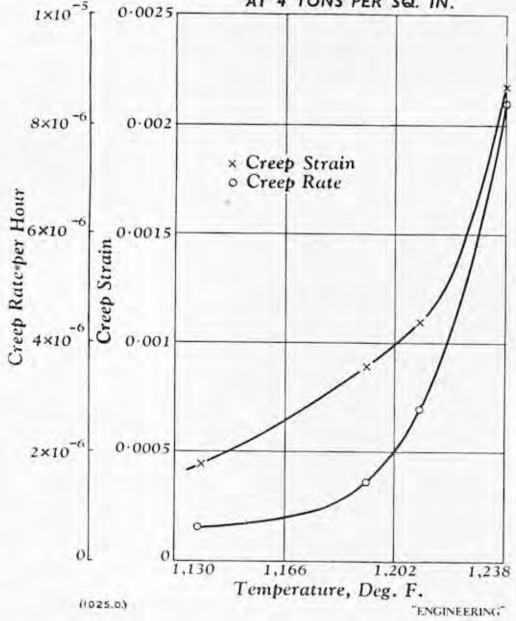


Fig. 4. 300 HOURS; 0·5% Mo 0·23% V STEEL (PIPE MATERIAL) AT 4 TONS PER SQ. IN.



suspended an electromagnet capable of lifting and withdrawing the weight at intervals of three hours or one hour, by means of a time switch with an appropriate setting. In the case of temperature cycles, a time-switch, set for the appropriate period, caused a small variable resistance in the bridge circuit of the thermostat controlling the specimen temperature to be shorted, the thermostat having previously been balanced at the operating temperature. This, of course, caused an appropriate temperature rise. The tests in which combinations of stress and temperature increment were applied simultaneously were all in the category of 24-hour cycles.

RESULTS OF TESTS.

The results of all tests are shown in Tables II to V, on pages 25 and 26; and in Table VI, herewith, which comprises results of tests performed at the standard stress of 4 tons per square inch, and at various temperatures for the four steels. Tables II to V and Table VI record, in addition to other data, the creep strains, and the rates at 300 hours in the various tests. These 300-hour creep strains and rates were made the bases of comparison of the creep tests throughout the investigation. In what follows, the nature of the purely experimental results is initially discussed in relation to each of the four materials. Subsequently, a comparison is made between the experimental results, and the prediction of behaviour, given by analysis, based upon data obtained from normal constant stress and temperature creep tests.

0·17 *Per Cent. Carbon Steel.*—The initial tests for this material were at 4 tons per square inch and the temperatures of 959 deg., 977 deg. and 995 deg. F., and Table VI indicates that, over this range of temperature, the creep strains at 300 hours rose in the ratio 4 : 1, and the corresponding creep rates in the ratio 15 : 1, the latter figure being occasioned by the fact that, at 995 deg. F., tertiary creep occurred. This range of creep rates and strains provided sufficient data to cover the increase due to overstress and temperature applied in the cycling tests. The test at 959 deg. F., which actually gave 0·00076 creep strain at 300 hours as against the nominal 0·001, was taken as the basic test of this particular series.

The series of tests included six in which purely stress fluctuations occurred, these being such as to produce 10 per cent. stress increment for 50 per cent. of each of three cyclic periods of 24, 6 and 2 hours (this comprising an examination of frequency effect); a stress variation of 20 per cent. for 25 per cent. of a cyclic period of 24 hours; and stress variations of 30 per cent. and 50 per cent. for only 5 per cent. of the cyclic period. Only a purely temperature fluctuation cycle was made for this material, this being 13·5 deg. F. for 50 per cent. of a cyclic period. Additionally, a compound cycle of 10 per cent. overstress and 13·5 deg. F. temperature rise was made for 50 per cent. of a cyclic period.

The mode of interpretation of the results of these tests is clear by reference to Figs. 1 to 4, herewith. In these figures, creep strain and creep rate at a period of 300 hours are plotted against temperature, the plots being based upon the group of constant-stress variable-temperature tests, appropriate to each material. (By "variable" in this case is meant, of course, variation from test to test of a temperature which, in any given test, is constant over the period of 300 hours). By use of these diagrams, the changes of creep rate and creep strain, relative to those of the basic tests recorded in Table VI, may be interpreted in terms of an equivalent design temperature increment, constant throughout the whole test, this increment, of course, being that which might be allowed by a designer to cover the fluctuating element of the test characteristics. The results of this consideration for the carbon steel are given in Table II.

Considering the three tests with a stress increment of 10 per cent. for 50 per cent. of periods of 24, 6 and 2 hours, it is apparent that, judged on the basis of the creep rates at 300 hours, very little frequency effect occurs; the creep strains certainly show a lower design temperature increment figure for the 2-hours cycle, but it is possible that this is due to some difference in strain upon loading this individual test, and may possibly be ignored in face of the other evidence provided. Accordingly, in dealing with other varieties of stress and temperature fluctuations for this material, it has been assumed that frequency effect is small. The average design temperature increment of the above set of tests was about 15 deg. F. A test having 20 per cent. stress increase for 25 per cent. of 24 hours gave much the same design temperature increment (about 19 deg. F.) as that given by 10 per cent. for 50 per cent. of the working period; while a temperature increment of 13·5 deg. F. gave about 12 deg. F., and a compound cycle of 10 per cent. stress increase, and 13·5 deg. F. temperature increase for 50 per cent. of the time, an equivalent design temperature increment of about 18 deg. F. Thus all the above cycles are equivalent to design temperature increments between 12 deg. and 20 deg. F.

Finally, considering the two tests in which rather heavy stress increments of 30 per cent. and 50 per cent. are applied for 5 per cent. only of the cyclic period, it appears that these are equivalent to design temperature increments of 20 deg. and 30 deg. F., respectively. It is evident that the 30 per cent. stress increment produces the same order of effect as several of the previously noted tests, but that the 50 per cent. increment gives an effect considerably more marked. It will be noted that, for this material, the two criteria of creep rate and creep strain give, in general, corresponding indications of performance. Where they do not, the average figure of the two is used in comparison.

0·5 *Per Cent. Molybdenum Steel.*—For this material, the characteristic creep curves at 4 tons per square inch, and at temperatures of 1,085 deg., 1,094 deg., and 1,103 deg. F., indicate that, roughly speaking, the creep strains and rates over this range of temperature only increase in the ratio 2 : 1. Nevertheless, this range was adequate to cover increases in creep strain and rate arising in subsequent tests. The test at 1,103 deg. F., giving

TABLE VI.—*Results of Basic Creep Tests at 4 Tons per Square Inch and Various Temperatures for 0·17 per cent. Carbon Steel, 0·5 per cent. Molybdenum Steel, and 0·5 per cent. Molybdenum, 0·23 per cent. Vanadium Steel (Bar and Pipe Material).*

Material.	Temperature, deg. F.	Creep Strain at 300 Hours.	Creep Rate at 300 Hours (Per Hour).
0·17 per cent. Carbon Steel	959 977 995	0·00076 0·0014 0·00335	0·000001 0·0000023 0·0000155
0·5 per cent. Molybdenum Steel	1,085 1,094 1,103	0·000785 0·00106 0·00121	0·0000016 0·0000028 0·0000031
0·5 per cent. Molybdenum, 0·23 per cent. Vanadium Steel, bar material	1,103 1,121 1,139	0·00087 0·00126 0·00172	0·0000019 0·0000026 0·0000042
0·5 per cent. Molybdenum, 0·23 per cent. Vanadium Steel, pipe material	1,139 1,193 1,211 1,238	0·000438 0·000891 0·00109 0·00218	0·00000065 0·00000144 0·0000028 0·0000084

0·00087 creep strain in 300 hours, was taken as the basic test for this material.

As in the case of the carbon steel, frequency effects were examined initially by a set of fluctuating stress tests in which the increment of stress was 10 per cent. for 50 per cent. of cyclic periods of 24, 6 and 2 hours. Here, some definite frequency effect seemed to arise, the equivalent design temperature increment being virtually negligible for the 24-hour periods, and increasing to about 12 deg. F. for the 2-hour period. Since, however, the effect at 6 hours is only of the order of 2 deg. F., it is possible that the result for the 2-hour period is, to some extent, due to a small difference in the initial condition of the specimen used, compared with the others. This view is somewhat strengthened by two facts. Firstly, if the frequency effect were in any way due to creep recovery, it would be expected to be of a reversed nature, since, presumably, recovery would have more effect in the case of high frequency, and would reduce the effect of stress increments. Secondly, two further tests with 20 per cent. stress fluctuation for 25 per cent. of the cycle, but with cyclic periods of 24 and 2 hours, showed identical results. Thus either the frequency effect was dependent upon the rate at which overstress occurs, or it is not really appreciable.

However, since some indication of an effect had been given by the stress fluctuation, a check was made in the case of two tests, involving temperature fluctuations of 16 deg. F. for 50 per cent. of the cyclic period, 16 deg. F. being expected to give an equivalent design temperature increment of much the same order as the highest frequency in the above stress series. The results indicated that there was possibly, as in the case of the stress-increment tests, a frequency effect resulting in an increase of the design temperature increment with frequency, but, obviously, it was fairly small. As expected, the fluctuation of 16 deg. F. gave, at the higher frequency, about the same design temperature increment as the highest frequency-stress tests.

A further pure temperature-fluctuation test was performed in which the temperature was raised 9 deg. F. for 25 per cent. of the operating period of 24 hours. This was expected to give much the same equivalent design temperature rise as the 20 per cent. stress increase of 25 per cent. of 24 hours. Actually, it proved to give a smaller rise, of an average value of about 3 deg. F. A composite stress-temperature cycle composed of 20 per cent. stress increase and 9 deg. F. temperature increase gave an average design temperature increment of 9 deg. F., which is much the same as the increment due to 16 deg. F. for 50 per cent. of 24 hours.

Finally, two stress-fluctuation tests, in which stress increments of 30 per cent. and 50 per cent. occurred during 5 per cent. of the period, gave average design temperature rises of 3 deg. F. and 23 deg. F., respectively. In both cases, however, a considerable disparity between the indications of the creep rate and the creep strain criterion was noted. However, it is indicated again that, as in the case of the carbon steel at 959 deg. F., the range between stress increments of 30 per cent. and 50 per cent. marks the beginning of a considerable increase in the increment of design temperature to be allowed. In other respects, however, the molybdenum steel at 1,085 deg. F. reacts more safely to the tests described than does the carbon steel at 959 deg. F. It is to be noted that the criteria of creep rate and creep strain, for quite a number of the tests, give considerably differing indications for this material, the equivalent design temperature based on creep strain being the larger in most cases.

(*To be continued.*)

THE LATE MR. J. G. ROBB.—We regret to announce the death of Mr. John Glover Robb, which occurred at Keswick on Tuesday, December 16, at the age of 62. Mr. Robb had been associated with Marconi's Wireless Telegraph Co. since 1909 and, after serving abroad and in the Royal Naval Volunteer Reserve during the 1914-18 war, was engaged with them in research work on short-wave beam broadcasting and telephony. In 1934 he was appointed development manager to the Company, becoming technical manager and director of research in 1939 and deputy engineer-in-chief in 1948. He retired in 1950.

MOULDED PLASTIC STRESSED COMPONENTS.

F. G. MILES, LIMITED, REDHILL.

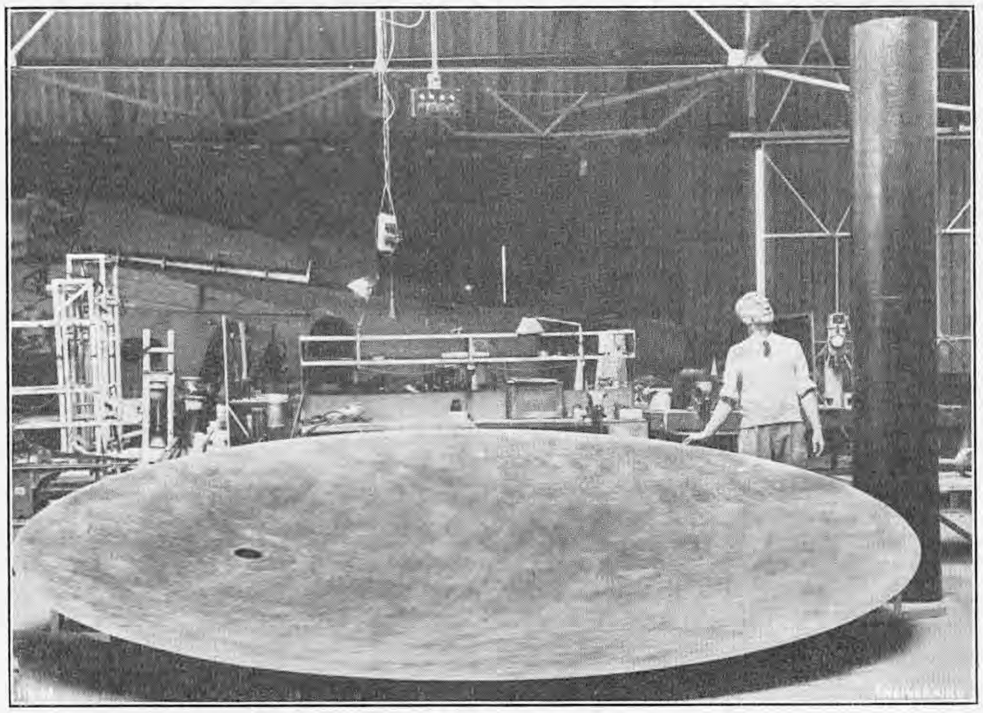


FIG. 1. LOAD-CARRYING PLASTIC COMPONENTS.

MOULDED PLASTIC RADAR SCANNERS AND STRESSED COMPONENTS.

A NEW technique in the manufacture of stressed components, which has been under development for the past few years, is illustrated by the two products shown in Fig. 1. This new development may well become of major importance to many industries on account of its simplicity in production and the possibilities of dimensional precision. In the foreground of Fig. 1, which shows a corner of the workshops of Messrs. F. G. Miles, Limited, Redhill Aerodrome, Surrey, may be seen an experimental radar scanner reflector, 14 ft. in diameter, and an 11-ft. length of 18-in. diameter tube. Both these components were moulded in one piece from an asbestos-fibre material impregnated with phenolic resin. In the background of Fig. 1 can also be seen a mould for part of a 60-ft. span aircraft wing which is to be constructed in the same material.

The use of phenolic-resin impregnated asbestos fibre as a structural material was originally developed by the Royal Aircraft Establishment at Farnborough, some seven years ago. This work was described, in a paper presented by Mr. J. E. Gordon at the third Anglo-American Aeronautical Conference in 1951, as an attempt "to build up a new kind of engineering based on the properties of fibres and resins." A summary of this paper was given on page 297 of our 172nd volume (September 7, 1951). More recently, Mr. Gordon has discussed "The Future of Plastics in Engineering" at the Plastics Institute, and an abridged version of his lecture was reproduced on page 701 (November 28) and page 770 (December 12) of our 174th volume (1952).

It may be recalled briefly that the specific ultimate strength (i.e. the ratio of strength to specific gravity) of the asbestos fibres themselves is considerably greater than that of either steel or aluminium alloy, but that the strength of the bonding resin is relatively weak. It will be seen, therefore, that the material is stronger along the grain than across it. Along the grain the specific strength and stiffness of the bonded asbestos material are lower than that of many aluminium alloys, but for certain applications various moulding techniques lend themselves to the production of asbestos-fibre structures of considerably lower weight and greater stiffness than the most efficient metal structure that can be designed for the same purpose. The radar scanner aerials illustrated in Figs. 1 and 2 are typical examples. In 1950, Messrs. F. G. Miles, Limited, were asked by Messrs. A. C. Cossor, Limited, Cossor House, Highbury-grove, London, N.5, to undertake the design and construction of certain radar scanner aerials for harbour and airport control. The wind loads on a large aerial mounted at the top of a tower are considerable; it must be able to operate continuously under a 70-knot wind with an infinitesimal amount of deflection, and must be able to withstand a 110-knot gust. It was thought, therefore, that a firm with a background of aerodynamic experience could best carry out the design of such equipment.

Up to this time, radar equipment of this type had generally been of metal construction, the reflector usually being built up of light-alloy sheet. In the large sizes of aerials now required—diameters of the order of 12 ft. to 14 ft. or more—there is considerable difficulty in manufacturing to the close tolerances necessary to avoid distortion of the beam and loss of efficiency. At this time, Messrs. F. G. Miles, Limited, were already engaged in experiments based on the R.A.E. "vacuum moulding" technique of phenolic-resin asbestos-fibre material in connection with aircraft construction. Clearly, the application of this technique to the manufacture of a radar scanner aerial of parabolic form offered great advantages in obtaining the desired accuracy, together with low weight, and high resistance to the effects of weather. The two firms, Miles and Cossor, decided therefore to extend the field of the former's research to radar aerials. A considerable amount of capital was sunk, and many failures and disappointments were experienced before a usable article came off a mould satisfactorily.

The material is well suited to withstand weathering in any climate, and by adopting a sandwich construction, with the outer layers of phenolic-resin-asbestos enclosing a resin-impregnated paper-honeycomb core, it has been possible to produce a scanner aerial as strong as, and stiffer than, an aluminium-alloy aerial of the same profile, which would weigh more than twice as much as the plastic aerial. The first successful aerial of this type was displayed in action throughout the Festival of Britain exhibition at the South Bank, and an improved model is now in production.

The 14-ft. diameter aerial illustrated in Fig. 2 is the first of a new type designed and built to the electrical specification of Messrs. A. C. Cossor,

MOULDED PLASTIC RADAR SCANNERS AND STRESSED COMPONENTS.

F. G. MILES, LIMITED, REDHILL.

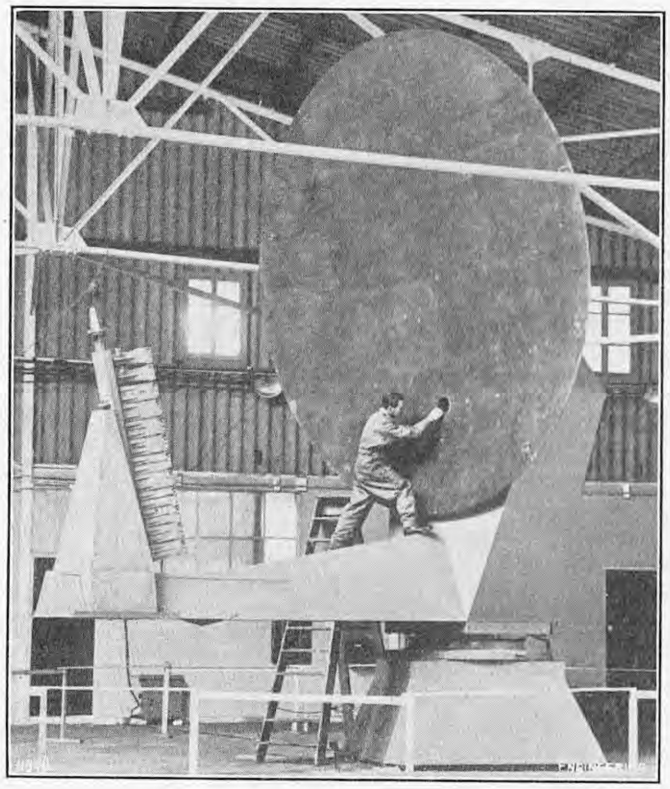


FIG. 2. PLASTIC RADAR-SCANNER AERIAL.

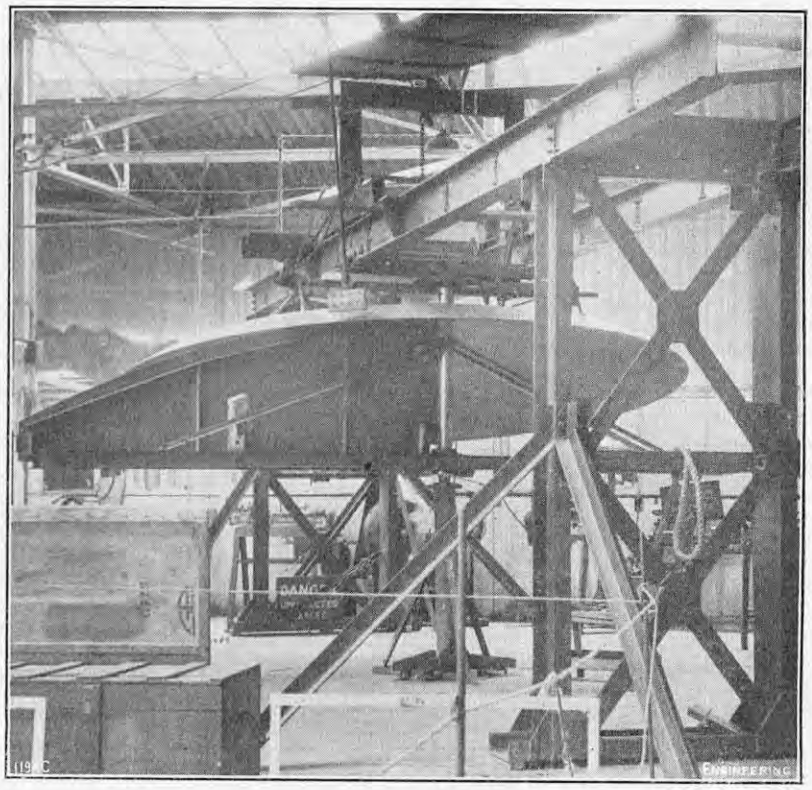


FIG. 3. PROFILE-CHECKING RIG FOR RADAR-SCANNER.

Limited, and is probably the largest one-piece moulded structure in the world. The mould on which it is constructed is built up in a special manner of reinforced concrete, shaped roughly to the paraboloid profile. The top surface of the mould is then covered with phenolic-resin asbestos which is subsequently machined accurately to the desired shape. Into this top surface are embedded resistance-heater mats and a series of thermocouples which are laid in a glass-cloth blanket. There are some 400 of these thermocouples, which are connected by way of an automatic telephone relay system to a Cambridge recorder. It has been found to be most important, in this early stage of development, to have an accurate record of curing temperatures and times. After curing, the mould, surface is finished to the required contour by a cutting machine designed and constructed for the work by F. G. Miles, Limited. It is of passing interest to note that the main shaft of this machine came from one of the axles of an 1860 railway locomotive.

Although it is not possible to describe in detail the techniques used in the manufacture of these moulded plastics structures, a brief description of the main processes can be given. The first operation consists of laying the resin-impregnated asbestos "felts," forming the face of the aerial to be moulded, on to the top of the mould. The number of plies and the direction of the grain are matched to the calculated stress distribution of the aerial. The filling in the sandwich, the strengthened "Dufaylite" honeycomb paper, is then laid, with more asbestos felts on top. Over the top of the sandwich thus formed are placed another set of resistance-heater mats, together with a further thermocouple blanket. The entire mould is then enclosed in a rubber "vacuum" bag from which air is evacuated, thereby removing moisture from the sandwich as it cures and supplying an even pressure over the surface of the mould. A typical curing plant comprises a 200-h.p. motor driving a variable-voltage generator which supplies power to the heater mats, and through a gearbox, drives various vacuum pumps. The latter are supplied with auxiliary water cooling owing to the extended running periods. This plant is sufficient to produce moulds of approximately 1,000 sq. ft. in area.

After curing is completed, the aerial is removed from the mould; it has been prevented from sticking to the mould by a suitable parting medium. The aerial is then mounted on a special rig, illustrated in Fig. 3, for contour-checking against a rotating steel template. Design tolerances are in the region of $\pm \frac{1}{16}$ in. In actual production, twice this accuracy is attained. Metal brackets are then riveted to the back of the aerial at positions previously reinforced, and the face is sprayed with metal to form the desired reflecting surface. Fig. 2 shows the 14-ft. diameter aerial mounted on its supporting structure, with the wave-guide horn in position. It should be mentioned here that it is possible to mould metal parts into the resin-impregnated asbestos material at the same time as the main curing is taking place, thereby forming a bond of considerable strength.

Apart from their work on moulded plastics radar aerials, F. G. Miles, Limited, are developing the uses of phenolic-resin impregnated asbestos in other fields. Unfortunately, the majority of this work is under contract to the Ministry of Supply, and details may not be published. It can, however, be mentioned that techniques have been evolved for the production of seamless tubes in this material. Various processes are employed in manufacturing these tubes, depending on the strength required and the use to which they will be put. Resin-impregnated asbestos tubes constructed by these techniques are resistant to most corrosive fluids, with the exception of the strongest alkalis, and develop a strength equivalent to that of a 65-ton steel tube of equal weight. They are also capable of withstanding temperatures of 165 deg. C. continuously, and considerably higher temperatures for short periods.

The brief description of the production of a radar aerial gives some idea of the simplicity of the moulding processes, but has not indicated the laborious steps taken to accumulate the technique and knowledge required to reach this stage. A few instances of some of the problems encountered are the cracking of the moulds due to the wide differences of temperature throughout the concrete mass, and the pinching action of the cured plastic mould surface; the inconsistency of the quality and effect of certain apparently identical mixes of resin, and the wide disparity of effect in certain parting media. Another important variable in the quality of the product is the aptitude of the individual worker and his appreciation of the factors affecting this quality. A close liaison between the design staff and the shops has been found to be extremely important and is instrumental in developing a completely new technique into a highly skilled craft.

COURSES ON FUELS AND ON CHEMICAL AND METALLURGICAL THERMODYNAMICS.

Two courses, each of eight evening lectures, are to be delivered in the Department of Applied Chemistry of the Northampton Polytechnic, St. John-street, London, E.C.1, during January and February. The first course, on "Liquid Fuels, their Properties and Utilisation," will be delivered by Mr. G. F. J. Murray, B.Sc., A.M.I.C.E., A.M.I.Mech.E., M.Inst.F., on Tuesday evenings at 7 p.m., commencing on January 6, 1953. The subjects dealt with will include fuel oil and other liquid fuels and their origin, properties, characteristics and grades; the layout of liquid-fuel burning systems; storage, pumping and piping arrangements; types of atomisers and burners; the use of liquid fuels in central-heating and large steam-raising plants, metallurgical furnaces and marine and other boilers; and oil as applied to gas production. The second course of lectures, on "Chemical and Metallurgical Thermodynamics," will be delivered by Dr. O. Kubaschewski on Wednesday evenings at 7.30 p.m., commencing on January 7, 1953. The first two lectures will deal with the fundamental laws of the thermodynamics of chemical reactions; lectures III and IV, with the thermodynamics of metallic solutions; lectures V and VI, with the determination of the basic data required for thermodynamical calculations; and the two last lectures with the application of thermodynamical data to practical metallurgical problems. The fee for each of the two courses is 1*l*., or 10*s*. to students already enrolled in a Polytechnic course.

THE APPLICATION OF RESEARCH TO THE GAS TURBINE.*

By HAYNE CONSTANT, C.B.E., M.A., F.R.S.

IT is in the nature of engineers and scientists to look to the future, for their work, whether by discovery or creation, is usually directed towards improving the lot of generations to come. A consideration of what has been done being frequently a sound discipline in guiding one's future actions, I propose to tell something of the thoughts and ideas that have guided me and some of my colleagues during our work over the last six years or so. I am choosing for the period of my review roughly the last six years covering the time that has elapsed since the formation of the National Gas Turbine Establishment in 1946, though many of the developments had their origins before 1946 in the two organisations, Power Jets and the Royal Aircraft Establishment, that were the parents of the present Establishment.

The formation of the Establishment in 1946 found us with considerable empirical knowledge of aircraft jet-propulsion gas turbines and their components, but there had not been sufficient opportunity during the war to amass the fundamental data without which a sound understanding of the aero-engine could not be obtained. Our experience of the propeller aircraft gas turbine was sketchy. We knew little of gas turbines for power stations, ships, locomotives, etc., and our background of general engineering was limited to things aeronautical. In this field of aircraft propulsion, our views had been steadily crystallising out during the war years. In 1946, we regarded the propeller turbine as a power plant which would be of value for the next ten to 15 years, during the period of development of really clean jet aircraft. We did not believe that it would be worth while to expend the necessary development effort on a machine with so short a future before it. We realised that the ducted-fan engine might fill a useful role, intermediate between those of the jet engine and propeller engine, but we failed to appreciate the possible virtues of the ducted-fan engine in being the nearest equivalent to a general-purpose engine.

The question of the best type of compressor to use had exercised our minds from the earliest days. We had had considerable experience of both the centrifugal and the axial, and the general consensus of opinion was that the axial compressor was most suitable on account of its higher efficiency. For aircraft use, it had the additional advantage of a higher throughput per unit frontal area. Although we knew that there might be applications in which the balance of advantage lay with the centrifugal compressor, many years of experience of this type of compressor led us to believe that progress would be obtained more rapidly by *ad hoc* development than by generalised research.

The biggest gap in our knowledge at that time was due to the absence of a body of systematic data on the basic performance of blade rows for turbines and axial compressors. We had no knowledge of, or, indeed, ideas for, the cooling of turbines. We had no appreciation of the problems which might result from the use of residual oil and other ash-forming fuels. We had, in fact, done little more than scratch the surface of some of the more immediate problems of the jet engine, leaving the real hard work of consolidation and filling in to be done later.

POLICY AND OUTLOOK OF THE ESTABLISHMENT.

One thing we did learn from the early years was that it is not possible to engage in work of this kind without some kind of guiding philosophy. To my mind, one of the keystones of such a philosophy is the importance of timing. Discovery is very competitive. One can only make a given discovery or invention once. If one works at a slower tempo than one's competitors and, as a result, they make the discovery first, most of one's own work goes for nothing. One learns from one's failures, it is true, but such knowledge is only of value if, at some later date, it is used to give one success in something else; and by success I mean priority in achievement. It follows, therefore, that if we are going to engage in research with the object of finding new knowledge and applying it to the improvement, in this case, of machines, we must be so clever or so well equipped or so lucky that we reach our objectives before all others who are travelling the same road. If there is not a reasonable chance of doing this, we should cease wasting our country's resources, and wait for success to be announced by other workers, while directing our own efforts to solve some other problem.

Good timing also implies a judgment of when to start and when to stop. If one starts too soon, the inadequate development of associated arts and sciences may prevent success. If one starts too late, one may not complete the work in time. So far as stopping is concerned, not only must one know when to cut losses if the work is failing, but also when to cease work and hand over to industry for exploitation, if it is successful. In the kind of mechanical engineering with which I have had experience, the actual development of the machine is best left to those who are, in the end, going to produce it. The research worker should do no more than satisfy himself and industry that the inherent problems of the machines have been or can be solved, and indicate the general nature of the solution.

A good example of the relation in timing between research and development is provided by our work on after-burning or reheat. It was in 1943 that we first pointed out on theoretical grounds that it should be possible to obtain great increases in thrust as a result of burning extra fuel in the exhaust pipe of a jet engine. We immediately put in hand rig tests, followed up with the first reheat engine tests in 1944. We went into flight for the first time in the same year. American industry was quicker to see the possibilities than was our own and development over here did not make much progress until 1947. We started to tail off our research work on reheat in 1950 and have now brought it to an end, in spite of the fact that development work in industry is probably now only at its peak.

If we accept it that the research man's job is not so much to make a particular machine work as to solve the problems that are inherent in that kind of machine, so that their unsolved existence may not retard the quick development of such machines by industry, a great simplification of the research process becomes possible. The machine can be split up into its functional or physical components and each studied in isolation. Scientific method can be applied with greater ease and a great saving of money and time effected. It often happens, however, that the process of breaking down the machine into units suitable for study can only be done effectively if one knows what are the problems which one is going to try to solve. Sometimes one is not too sure just what the real difficulty is; and then the best course of action is to make the complete mechanism and find out from experience, a technique which is usually expensive, but sometimes cannot be avoided. If successful, it brings results quicker than any other method and often throws up problems with embarrassing rapidity.

A research organisation that wished to play safe could take up an impartial attitude and pursue several possible lines of attack. In fact, people often take great credit to themselves for their impartiality, attributing it to the true scientific spirit. Such an attitude might have virtues in a timeless world in which progress halted until the issue was decided, but in the real world engineers usually have to make their decisions with inadequate knowledge and cannot afford to wait until the issues have been clarified with scientific detachment. The second pillar of my philosophy of research, therefore, is that it is necessary in most engineering research to make up one's mind, at an early stage in the proceedings, which of a number of alternative courses to follow. One should then concentrate all available resources into a single effort and pursue it until success is achieved or one becomes convinced that a mistake has been made.

There is another pitfall for those who are working on applied research; on work, that is, which is not producing knowledge that will be of permanent value, but is rather finding solutions to problems that are of only transient interest. Such workers face the danger that the problem which they are trying to solve may disappear before the solution is found, and all their work may go for nought. This disappearance of a problem is usually due to the direction of technical progress changing, so that new targets are raised and the old ones become of no further interest. The development of a turbine with a cooled rim to its disc, for example, would result in the disappearance of the problem of developing bearings capable of operating at higher temperatures. The only way of reducing the amount of effort that is wasted in this way is by a judicious selection of the problems on which to work. Considerable judgment is required to foresee the possible changes in the direction of technical development, to assess which are the real immovable difficulties that have to be surmounted, which are the obstructions past which a way round can be found, and which are the mirages which only exist when one is feeling depressed.

Finally, there is the problem of economy of effort. I have had considerable opportunities for seeing the effort in manpower and money that is expended, both within and outside Government organisations, on basic and applied mechanical research, and I have been shocked by the tremendous expenditures that have been required to obtain sometimes trivial information.

Most researches are failures to the extent that they do not succeed in solving the problem that was their objective, or in giving the information that it was hoped they would give. The only reason why research pays is that, when a piece of work is successful, the advantages that accrue more than make up for the losses on all the failures. It is therefore of the first importance to increase the percentage of success. In my opinion, this means very careful selection of the problems on which to work. It means picking those problems which are suitable in their nature and their difficulty for the kind of men and facilities that are available. This is a novel approach which, I think, is not generally accepted. The application of such a philosophy to a research organisation, particularly one controlled by a Government department, leads to many difficulties. It runs counter to the popular idea of how such work should be conducted. Research workers are sometimes supposed to be unaware of the passage of time and of the progress of the world around them. Government servants are often required to be impartial and are not given to enthusiasms. We were not affected by these difficulties as much as might be expected, for two good reasons. The first of these was that the gas turbine was so new a machine that there were few people outside our own organisation and a very limited industry that were in a position to argue with us. This freedom in working out our own ideas was further strengthened by our other asset—the chaos resulting from the aftermath of war; so, for some years, we were more our own masters than we had had any right to expect.

FORMATION OF A PROGRAMME OF WORK.

The application of these principles to our work involved many difficult decisions. There was far more work to be done than we had resources to deal with, and in most of this work a variety of possible solutions presented themselves. We could rarely afford more than one line of attack and that had to be decided on without sufficient information. In a field as broad as that of the gas turbine, and one in which the extent of the possibilities had not been properly explored, it was impossible to lay down a programme of research by the simple process of picking on the essentials. We were not sure what the essentials were. We therefore started to clear the ground by making a list of the things we would not work on. I will give you some of them.

We objected to the use of heat exchangers for turbine-driven aircraft on the ground that the world was not large enough to justify their use, and we decided to do no work on them. This decision may seem a blinding glimpse of the obvious to-day, but it was strongly contested at the time, and, in fact, much money was spent in vain in trying

* The 21st Andrew Laing Lecture, delivered to the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne on December 12, 1952. Abridged.

to develop an aero gas-turbine propeller engine with heat exchanger.

I had formed an adverse opinion of the possibilities of using ceramic materials for blades about 15 years ago. I obtained sufficient support in the Establishment to reach a decision that we would attempt to attain high temperatures by the use of cooling rather than by the use of uncooled materials, such as ceramics.

About ten years ago, we, who were then at the Royal Aircraft Establishment, had abandoned our advocacy of the propeller turbine, and had agreed with Sir Frank Whittle that jet propulsion was the most effective way of propelling an aircraft. We have since found no reason to change our views, and so we put propellers on our list.

We have not worked on gearing or on bearings, partly because they are components common to most types of machinery and not specifically related to gas turbines. Moreover, they do not usually introduce serious problems in the gas turbine, and the future of this type of power plant cannot be said to be dependent on the elimination of bearing or gearing troubles. Finally, there are already many skilled and experienced workers in this field.

Although most of my earlier work and experience was on centrifugal and displacement compressors, it became clear to most of us, many years ago, that neither of these types was likely to be as satisfactory for aircraft use as the axial type. At the end of the war, our interests were broadened to include all forms of gas turbines and it became necessary to decide on the best forms for land and sea. If we had not already committed ourselves to the axial type for the air, it is just conceivable, but I think unlikely, that we would have decided on the centrifugal as the best type for land and sea. As it was, our desire for concentration of effort and the elimination of unnecessary problems led us to adopt the axial as the most likely machine to use for almost all gas-turbine applications.

We decided against working on closed cycles on the ground that, once the cooled turbine was developed, the maximum temperature of the open cycle would rise above that of the closed cycle and give a higher efficiency. We objected, moreover, to the greater complexity and complication of the closed cycle for a power plant, the main point of which, after all, was its simplicity.

Finally, we turned our faces against very small engines because we believed in the teachings of Osborne Reynolds and felt that, both on aerodynamic and mechanical grounds, there was a minimum size below which satisfactory engines could not be made.

(To be continued.)

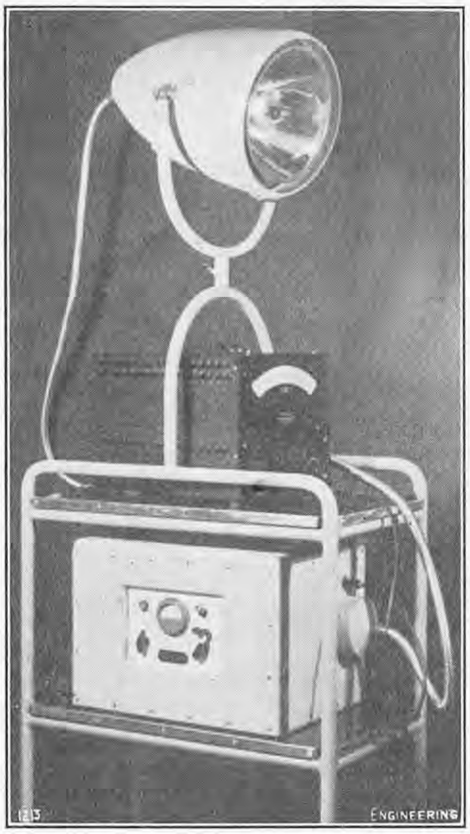
CROSS-COUNTRY AND WATER TESTS OF AUSTIN VEHICLE.—At a recent demonstration at Farnborough, the Austin Motor Company's "Champ," a four-wheel drive personnel carrier, was driven over extremely rough and water-logged ground and through water more than 5 ft. in depth. Its torsion-bar suspension withstood what can only be described as violent driving. On one run, over ground that had been deeply rutted by tanks and other military vehicles, the Champ was driven at right-angles to the ruts, one of which was almost equivalent to a vertical wall. In the underwater test the vehicle was completely immersed, except for the top of the air-intake stack pipe, the driver wearing a "frogman's" suit. The Champ was described on page 467 of our issue of October 10.

ALMANACS AND CALENDARS.—Daily tear-off wall calendars have been received from Richard Sutcliffe Ltd., Universal Works, Horbury, Wakefield; and the Universal Ball Bearing Repair and Manufacturing Co., 111-115, Hammersmith-grove, London, W.6. Monthly tear-off wall calendars have been sent to us by A. Darby's Advertising Service, Cobham House, 24 and 26, Black Friars-lane, London, E.C.4; and the Northern Manufacturing Co., Ltd., Albion Works, Gainsborough. Wall calendars with tear-off sheets showing on each the current month in heavy type, and the preceding and following months in smaller type, have come to hand from Fischer Bearings Co., Ltd., Upper Villiers-street, Wolverhampton; and A. A. Jones and Shipman Ltd., Narborough-road South, Leicester. The British Thomson-Houston Co., Ltd., Rugby, have also sent us a calendar of this type. As in previous years, this calendar reproduces twelve natural-colour photographs taken by employees of the company.

HIGH-INTENSITY RAPID-FLASH STROBOSCOPE.

FOR investigating the dynamical behaviour of high-speed mechanisms, a stroboscope capable of delivering light flashes, accurately timed to within $\pm 0 \cdot 1$ microsecond, of a duration less than 1 microsecond, and with a luminous flux of 150 lumens, has recently been developed by Dr.-Ing. Frank Früngel, Physikalisch-technisches Laboratorium G.m.b.H., Hamburg-Rissen, Germany. The instrument is marketed in the United Kingdom by Aga Standard, Limited, 16-17, Devonshire-square, London, E.C.2. It is suitable for a variety of applications, and is provided with means for triggering the flashes manually, mechanically, or by electric pulses from a variable-frequency oscillator. The instrument is designed to withstand vibration, and can be transported without elaborate precautions.

As may be seen in the accompanying illustration, the light source is mounted on the tubular-framework of a mobile trolley. A high-voltage power-pack and condenser unit are carried on the lower tier of the trolley, and on the upper tier is the electronic control unit. The latter can be dispensed with if the instrument is to be used only for manually-controlled single flashes.



The high-voltage power-pack comprises a transformer for stepping-up the supply voltage to a high condenser-charging potential, valves for releasing voltage discharges, and relays and circuit elements for triggering the light flashes mechanically or manually. The light source consists of a spark-discharge vessel, which can be dismantled for cleaning and for renewing the electrodes, and a bank of impulse condensers within the same housing. The walls of the discharge vessel are formed by a glass cylinder. It is charged with commercial argon under pressure, and contains a pair of replaceable tungsten electrodes, the spark gap between which is adjustable. The extremely short duration of the light flash is achieved by mounting the discharge condenser directly adjacent to the discharge vessel and by using short ribbon-type leads with an unusually low inductance. The peak current of the discharge attains a value of the order of 10,000 amperes, and the energy converted in the sparkover amounts to about 40 megawatts, resulting in a brilliant bluish-white flash. This high energy concentration has been brought about by adapting the aperiodic limit resistance of the condenser discharge circuit to the average spark resistance, which is about $0 \cdot 2$ ohm.

To obtain this spark resistance, an absolute gas pressure of about 5 atmospheres is required. If, however, a spark of longer duration and lower brilliance is required, the gas pressure can be reduced by adjusting a small valve, and the spark gap can be regulated to suit the gas pressure. The discharge vessel can, when necessary, be recharged with argon from an auxiliary flask which is supplied with the instrument.

As already mentioned, the light flashes may be triggered in several ways. For obtaining timed flashes in accurate synchronism with a cyclically-moving part, a contactor or interrupter mechanism is used so that the ignition pulses are triggered by the moving part itself. A special contactor, accurate to within 2 angular minutes, can be supplied as additional equipment, incorporating, if desired, a stepless friction drive which allows the flashing frequency to be varied by up to 2 per cent. above or below the speed of the driving shaft, thus presenting the illusion of slow forward or backward motion of the point observed. This is particularly useful for recording photographically slow motions of the order of 2 to 3 cycles per second, which cannot be studied visually with the stroboscope.

The electronic control unit is employed to provide accurately-timed periodic flashes at frequencies between 5 and 400 cycles per second. It comprises a second small stroboscope of the glow-lamp type, the energy pulses of which are applied to a thyratron which releases 200-kV ignition pulses to the ignition electrode of the discharge vessel. The use of an auxiliary stroboscopic lamp is advantageous when it is desired to utilise a single flash for photographic recording. In this case, with the main lamp switched off, the object to be studied is observed under the dim light of the auxiliary stroboscope, and the frequency is adjusted to give the desired phase relationship. The camera shutter is then opened and the "single flash" switch is closed, causing the next pulse from the electronic control unit or from the contactor mechanism to be fed to the ignition electrode, producing a single brilliant flash which effects the exposure.

The light of a single flash, it is claimed, is sufficient to produce a good image on a high-speed film with a lens aperture of $f/8$ at a distance of from 3 ft. to 10 ft. from the lamp. For single flashes of greater intensity, for recording photographically under water, for example, an auxiliary condenser battery is available which provides light flashes ten times as powerful, with a duration of about two microseconds. A watertight light source has been developed for underwater studies, such as observing cavitation effects on ships' propellers. Also available is an impulse-delaying mechanism for providing a time delay, within the range 1 to 50 microseconds, or 40 to 2,000 microseconds, between the triggering action and the flash. It is thus possible to observe or record rapidly-moving objects after a series of given time intervals. The mechanism includes a power-pack designed to supply four delayers with stepped delay impulses.

The instrument is intended primarily for use by the research and development staffs of industrial concerns, technological institutes, and universities. Among the applications of the Früngel stroboscope cited by the manufacturers may be mentioned its use for high-speed continuous film photography, for which the only additions required are a lens and a rotating film drum. By triggering 300 light flashes a second, 300 frames per second can be obtained, and since each frame is exposed for only one microsecond, sharper images result than those obtained with the normal ultra-rapid motion-picture camera. The stroboscopic light source, moreover, is free from harmful heating effects. Other applications of the instrument include the measurement of vibrations in turbine blades and other machine elements; recording clutch or belt slip and thus determining the friction losses in drives; demonstrating visually electro-acoustic vibration responses and the oscillations of piezo-electric quartz crystals; predicting the life of automobile tyres from stroboscopic observations of defects as they develop on the test bed; and observing the size and form of atomised droplets issuing from injection-pump nozzles.

NOTES ON NEW BOOKS.

Hose and Nozzle Charts for Fire Brigades.

Merryweather and Sons, Limited, Greenwich High-road, London, S.E.10. [Price 10s. 6d., including postage.]

THESE charts provide a simple and straightforward way of determining the principle information required in connection with pressure losses, heights of jets, etc. It is a pity, however, that the data on which they are based are not more up-to-date. Though little has been published on the subject, except for Freeman's work in 1889 and Blair's paper on "Characteristics of Fire Jets" to the Institution of Civil Engineers in 1941, the latter paper, based on more recent tests, showed that some slight modification to Freeman's figures was necessary, both for pressure loss in hose and for heights of jets. Merryweathers' values, however, appear to be based principally on Freeman's figures, though those for the hose losses have been increased about 20 per cent. and are, in consequence, much more in line with Blair's figures. The values for maximum heights obtainable from Merryweather's chart are likely to be some 20 per cent. higher than would be found in practice, and the nozzle pressures about 10 per cent. too high. Such a difference is, perhaps, not particularly serious, though it is unfortunate that it is on the optimistic side as regards the maximum height. Other minor criticisms are that it would be better if the units, particularly for L, N and H, were stated in the text, and it should be made clear that the gallons referred to are Imperial gallons.

Lighting in Industry.

British Electrical Development Association, 2, Savoy-hill, London, W.C.2. [Price 9s., including postage.]

THIS book, which is one of a series published by the British Electrical Development Association to cover specialised industrial applications of electricity, deals with factory lighting as an aid to, and perhaps even as a necessity for, efficient production. Its objects are to assist the user to make sound decisions at the planning stage, to suggest ways of improving existing installations and to provide essential data on the subject. It begins with an account of certain investigations which show the economic value of good lighting, this aspect also being stressed in describing the method of making a lighting survey. Drawing-office, work-bench, storage-area and dangerous-location lighting is considered in detail, as is the procedure which should be followed in installing devices for the inspection of polished and matt surfaces, edges and textiles, as well as for colour grading and other specialised purposes. The lighting arrangements recommended for use in a number of industries are described, together with their efficient use.

Government Information and the Research Worker.

Edited, with an introduction, by RONALD STAVELEY, B.A., F.L.A. The Library Association, Chaucer House, Malet-place, London, W.C.1. [Price 18s. to members, 24s. to non-members.]

IF it be accepted that commercial firms are, or should be, the most fruitful users of the results of research, and that—to quote from Mr. Staveley's introduction—"Government departments have become, in aggregate, probably the largest collectors of current research data in the country," it is clear that tax-paying industry is entitled to all such useful information as can be released. Much of it is released, though by no means all, and the problem therefore becomes one for industry: much useful information is available—how can it be found, with economy in time and expense? This book, which comprises a series of lectures delivered at a vacation course of the University of London School of Librarianship and Archives in April, 1951, provides the key. Each chapter deals with a Government department or office and is written by a member of the staff. Those of engineering interest deal with the Department of Scientific and Industrial Research, the Technical Information and Documents Unit (T.I.D.U.), the Ministry of Supply, the Ministry of Works, the Ministry of Fuel and Power, the Ministry of Labour, the Board of Trade, the Central Statistical Office, and H.M. Stationery Office.

RESEARCH AIRCRAFT.

SHORT BROTHERS AND HARLAND, LIMITED, BELFAST.

"SHORT SB/5" RESEARCH AIRCRAFT.

A NEW research aircraft, the SB/5, designed and constructed by Short Brothers and Harland, Limited, Queen's Island, Belfast, made its maiden flight at Boscombe Down, Wiltshire, on December 5 last. It may be recalled that the chief designer of Short Brothers and Harland, Limited, Mr. David Keith-Lucas, presented a paper on "The Shape of Wings to Come" before Section G of the British Association meeting held in Belfast last year; an abridged version of this paper was published on page 349 of the September 12 issue of ENGINEERING. The SB/5, shown in the accompanying illustration, is designed for investigating the low-speed behaviour of various swept-back wings, and for this purpose it is fitted with an extremely thin wing which can be adjusted, on the ground, to vary the setting of the mean chord through a maximum sweep-back of 50 deg. The corresponding sweep-back on the leading edge is thus considerably greater than that on any other aircraft yet built in this country. Since the aircraft is to be used solely for low-speed investigations, the tricycle undercarriage is non-retractable. The power unit is a Rolls-Royce Derwent jet engine.

BOOKS RECEIVED.

Belastungsgrenzen bei gerad- und schrägverzahnten Stirnrädern. Revised by PROFESSOR CONSTANTIN WEBER and DR.-ING. WERNER THUSS, and edited by PROFESSOR GUSTAV NIEMANN. Friedr. Vieweg und Sohn, Burgplatz 1, Braunschweig, Germany. [Price 16·80 D.M.]

Whitaker's Almanack, 1953. J. Whitaker and Sons, Limited, 13, Bedford-square, London, W.C.1. [Complete edition, without maps, price 15s.; shorter edition, 7s. 6d.; library edition, bound in leather, with maps, 30s.]

Productivity Report: Plant Maintenance. Report of a Visit to the U.S.A. in 1952 of a Specialist Team on Plant Maintenance. The British Productivity Council, 21, Tothill-street, London, S.W.1. [Price 2s. 6d., post free.]

British Railways. Mechanical and Electrical Engineer's Department. Performance and Efficiency Tests with Live Steam Injector. British Railways Standard Class 4, 2 Cyl., 4-6-0 Mixed Traffic Locomotive. The Railway Executive, 222, Marylebone-road, London, N.W.1. [Price 10s. net.]

Fifty-Year Index to A.S.T.M. Technical Papers and Reports, 1898-1950. American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price 6 dols.]

Welding Processes and Procedures Employed in Joining Stainless Steels. By HELMUT THIELSCH. Welding Research Council of the Engineering Foundation, 29, West 39th-street, New York 18, U.S.A. [Price 2 dols.]

Fuels and Combustion. By PROFESSORS MARION L. SMITH and KARL W. STINSON. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6·50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 55s. 6d.]

The Exporter's Year Book 1953. Edited by ARTHUR J. DAY. Syren and Shipping, Limited, 26-28, Billiter-street, London, E.C.3. [Price 40s. net.]

TRADE PUBLICATIONS.

Heavy Tractor Equipment.—The Hyster Company, 2902, N.E. Clackamas-street, Portland 8, Oregon, U.S.A., have issued a coloured brochure illustrating the uses of their range of tractor-mounted equipments.

Maintenance of Rolling Bearings.—A booklet dealing with the fitting and maintenance of their ball and roller bearings has been issued by Fischer Bearings Co. Ltd., Upper Villiers-street, Wolverhampton.

Industrial Electrical Products.—A catalogue published by Philips Electrical Ltd., Century House, Shaftesbury-avenue, London, W.C.2, contains concise accounts of their products under the headings of arc and resistance welding, high-frequency heating, magnetic filters, electronic instruments and variable transformers. Other publications recently issued by the firm include an arc-welding electrode wall chart.

"Redux" Bonding in Aircraft.—In Bulletin No. 118 of *Aero Research Technical Notes,* which are produced periodically by the Technical Service Department of Aero Research Limited, Duxford, Cambridgeshire, is reproduced a preliminary survey by the Fokker Company of Amsterdam of the comparative costs of labour, electricity and materials involved in riveting and in Redux-bonding light-alloy skin panels.

Technical Books.—We have received a classified list of scientific and technical books, available now or shortly to be published, which has been collated from information supplied by the publishing houses, by the Publishers' Circular Ltd., 171, High-street, Beckenham, Kent.

Machine Tools.—The Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware-road, London, N.W.2, have issued an illustrated brochure giving brief particulars of some of the lathes, milling and grinding machines, hydraulic presses, etc., for which they are agents.

X-Ray Accessories.—Solus-Schall Ltd., 18, New Cavendish-street, London, W.1, have sent us a booklet dealing with their X-ray accessories.

Fittings for Tungsten and Mercury Lamps.—Details of fittings for use with tungsten and mercury lamps are given in a broadsheet issued by Benjamin Electric Ltd., Brantwood-road, Tottenham, London, N.17.

Earth Scrapers.—We have received four leaflets from Blaw Knox, Ltd., 94, Brompton-road, London, S.W.3, describing their earth scrapers BK 40, BK 80, BK 90 and BK 120.

Small Machine Tools.—W. J. Meddings, Ltd., Ipswich-road, Slough, Bucks, have sent us a leaflet dealing with their "Paccra" light drilling machines, jig-sawing machines, drum sanding machines, etc.

Transformers and Electric Test Equipment.—Transformers, electric test equipment and voltage regulators are described in a leaflet received from Foster Transformers Ltd., South Wimbledon, London, S.W.19.

Display Lighting Equipment.—A booklet entitled "Coronation Celebrations," issued by the General Electric Co. Ltd., Kingsway, London, W.C.2, contains details of illuminated devices designed by them for use in connection with the Coronation.

Very High Frequency Multi-Channel Radio Equipment.—Automatic Telephone and Electric Co., Ltd., Arundel-street, London, W.C.2, have issued a booklet describing their very high frequency wide-band radio transmission equipment, and other apparatus.

Scraper Chain Conveyors.—British Jeffrey-Diamond, Ltd., Stannard Works, Wakefield, Yorks, have sent us catalogue No. 1489, describing their scraper chain conveyors for longwall and shortwall mining.

Aluminium.—Ten articles published by the Northern Aluminium Co. Ltd., Banbury, Oxfordshire, have now been issued in the form of a booklet entitled "About Aluminium."