

## ITALIAN JET-PROPELLED TRAINING AIRCRAFT.

AN event that has drawn attention to the revival of the Italian aircraft industry, which was severely disrupted by the Second World War, was the first flight, in December, 1951, of a high-performance jet-propelled two-seat multiple-purpose training aeroplane, the Fiat G80, constructed by the aviation division of the Società per azioni Fiat, Corso 4 Novembre 300, Turin, to the design of Professor G. Gabrielli. The prototype aircraft is powered by a de Havilland Goblin engine, developing a sea-level static thrust of 3,500 lb.; the second aircraft will be fitted with a 5,000-lb. thrust Rolls-Royce Nene engine, and later aircraft will be

equipped with Ghost engines, which are already being produced by the engine section of the Fiat organisation under agreement with the de Havilland Engine Company, Limited.

A photograph of the Fiat G80 is reproduced in Fig. 1, herewith, and the general arrangement is shown in Figs. 6, 7 and 8, on page 226. It is a low-wing monoplane of all-metal light-alloy construction, with slightly swept-back wing and tail surfaces. Accommodation is provided for two pilots, seated in tandem pressurised cockpits, the layout of the controls and instruments in both cockpits being identical and arranged so as to allow for installing any special equipment that may be required for carrying out military training programmes. The wings have a span of 36 ft., an area of 270 sq. ft., and an aspect ratio of 4.82. The overall length of

the machine is 40 ft. 6 in. and the height is 13 ft. At the maximum all-up weight, 11,910 lb., the wing loading is 44 lb. per square foot and the take-off thrust loading is 3.4 lb. per pound-thrust. The disposable load is 2,960 lb. The predicted top speed of the Fiat G80 at sea level is 550 m.p.h.; at the cruising speed of 465 m.p.h. the still-air range is estimated to be 870 miles with a fuel load of 2,360 lb. The calculated take-off run of the fully-loaded aircraft is 700 yards, and it will climb to 10,000 ft. in 3½ minutes, to 20,000 ft. in 8 minutes, and to 30,000 ft. in 15½ minutes. The service ceiling, corresponding to a rate of climb of 80 ft. per minute, is 44,000 ft. With the flaps fully lowered, the stalling speed at sea level is 105 m.p.h.

In order to guard against the onset of flutter, the wings and tail surfaces of the G80 have been



FIG. 1. THE PROTOTYPE FIAT G80 AIRCRAFT.

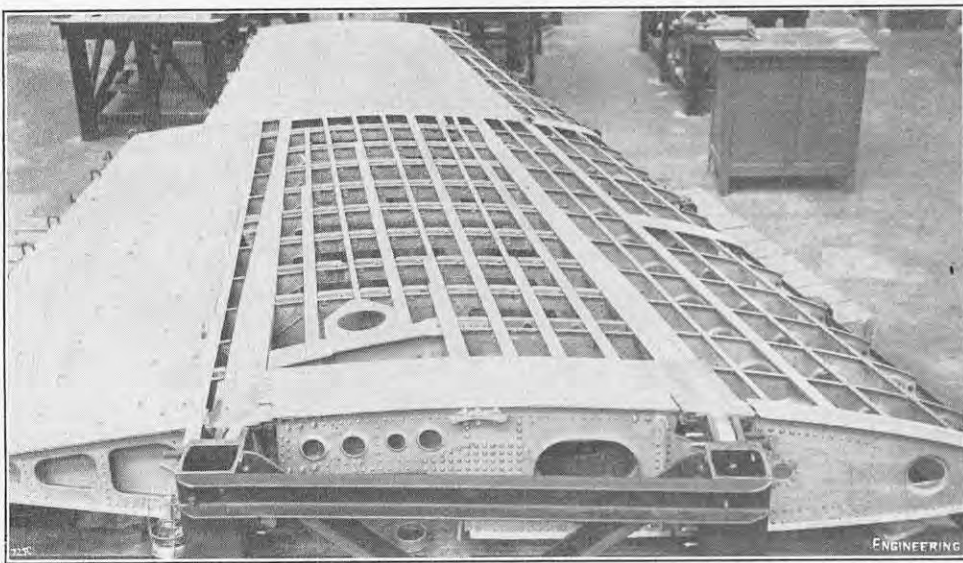


FIG. 2. OUTER WING UNDER CONSTRUCTION.

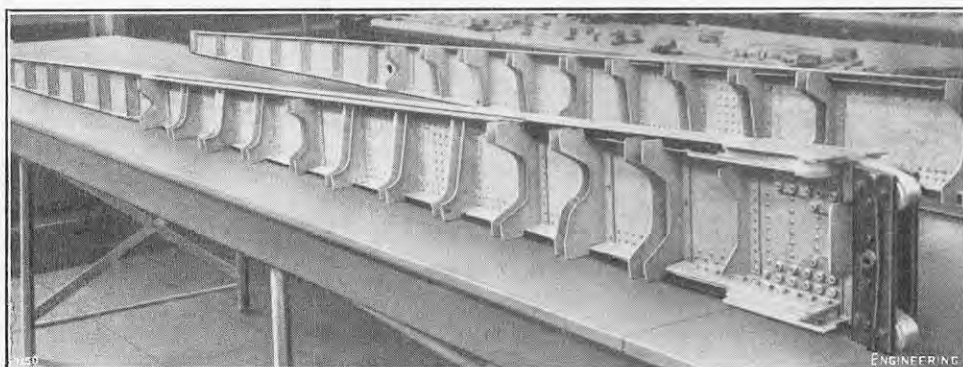


FIG. 3. WING SPARS.

made very stiff in torsion. Wherever possible, rigid transmissions to the control surfaces have been used in preference to flexible cable connections. In the case of the ailerons and the rudder, the shallow profiles used did not allow sufficient space for installing internal mass balances, and it has been necessary to resort to a system of external balance weights on lever arms.

A smooth surface for the laminar-flow wings has been obtained by the use of a thick sheet-metal skin, stiffened with longitudinal stringers, the sheets being joined by internal butt-straps and countersunk rivets. Rigorous checks were made throughout the forming and assembly operations to ensure that departures from the theoretical profile did not exceed 0.3 mm., and that the surface waviness was not greater than 0.1 mm. The wings, which consist of a centre section carried across the fuselage and two swept-back outer sections, are of orthodox two-spar torsion-box construction; Fig. 2 shows the internal structure of the port outer wing, and the outer-wing spars may be seen in Fig. 3. Owing to the thin wing section employed, only the struts of the main undercarriage units retract into the outer wings; the wheels, when retracted, are housed in the centre section. The wing tips are detachable so that later they can be replaced, if desired, by others of larger size, to increase the wing area and aspect ratio. It should be mentioned that the low aspect ratio of the prototype aircraft has been chosen, in conjunction with moderate sweep-back and thin wing section, to give a high critical Mach number. Split flaps are fitted.

To allow for converting the aircraft quickly from one role to another, the monocoque fuselage is built in three sections. The pressurised nose portion, of oval cross-section, comprises the pilots' cockpits, the front landing-wheel recess and the engine air intakes on each side. The centre part, circular in section, rests on the centre-section wing and houses the jet engine and the main fuel tanks. In Fig. 4, which illustrates the front and centre portions of the fuselage, the boundary-layer bleed for the engine air intake is clearly shown; this illustration

## ITALIAN JET-PROPELLED TRAINING AIRCRAFT.

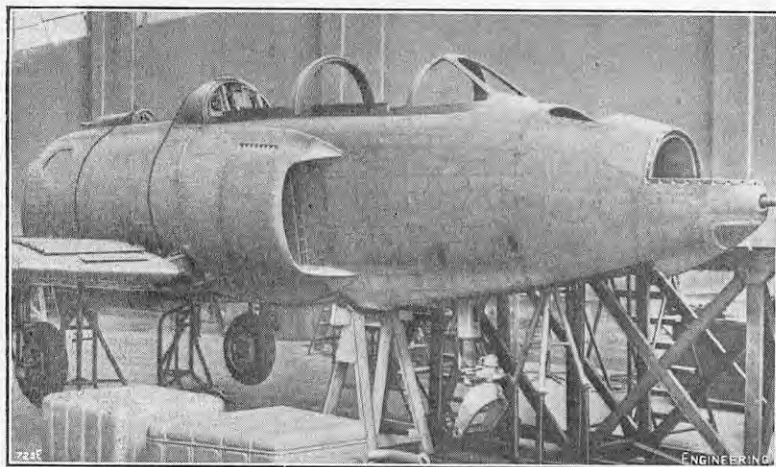


FIG. 4. FUSELAGE NOSE AND CENTRE SECTIONS.

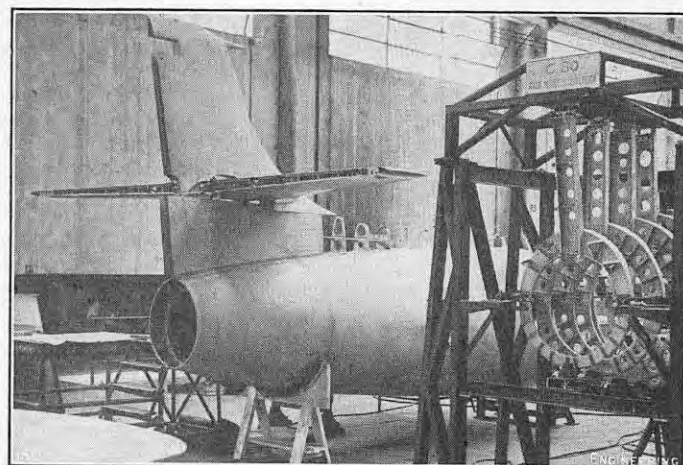


FIG. 5. REAR FUSELAGE UNITS, COMPLETE AND UNDER CONSTRUCTION.

also conveys a good impression of the high standard of finish that has been achieved. The aft end of the fuselage, illustrated in Fig. 5, also of circular cross-section, houses the tail pipe and carries the fin and the tailplane, which is mounted well above the jet exhaust. The fuselage sections are attached together by special bolts, four to each joint, so as to make them readily detachable. For the attachment of the nose section, which will require to be removed frequently in service to carry out engine overhauls, an easily-removed fastening has been designed with a new type of "worm" locking which, it is claimed, offers greater security than the ordinary lock-nut and eliminates the effect of negligence in assembly. It is also possible to replace the nose section by one suitably equipped for a different military purpose. It is, in fact, intended to develop the Ghost-powered production version of the G80 as an operational aircraft to carry out the duties of a single-seat day fighter, a night-fighter, and a photographic reconnaissance aircraft.

The engine mounting allows for the expansion of the engine when running. Inside the fuselage is fitted a rail from which the tailpipe is suspended during assembly. When assembly is complete, the tailpipe is attached to links so that it is free to expand. Wide inspection doors giving access to the engine are provided at the top and bottom of the fuselage. Graviner methyl-bromide fire-extinguishing equipment, fitted with an inertia switch which operates in the event of a crash, is provided.

The fuel system comprises six metal tanks, two of which are in the central portion of the fuselage, and two on each side in the wing tips. It is intended later to replace the metal tanks by flexible nylon-rubber tanks, which will give an increased fuel capacity. Two additional external fuel tanks can be mounted on the wing tips, which, it is claimed, reduce the induced drag of the wings; these tanks are each provided with a fin to improve lateral stability.

A retractable tricycle undercarriage with a wide track is fitted, the main wheels being provided with hydraulically-operated brakes. The castoring nose wheel can be locked in the central position by the pilot. Messier oleo-pneumatic shock absorbers are fitted on all the undercarriage units. A Messier hydraulic system provides for the operation of the undercarriage, the wing flaps, the air brake, which is fitted in the belly of the centre-section fuselage, and the wheel brakes.

The electrical services, which include most of the instruments, are supplied by a direct-current generator and two batteries connected in series. There are two external plug connections, one for testing the circuits and the other for starting the jet engine. The various circuits are controlled by circuit-breakers grouped on a switch board within reach of the pilot in the front cockpit. The radio installation consists of a very high-frequency ten-channel receiving and transmitting set. There is also provision for fitting a radio compass.

Fig. 6.

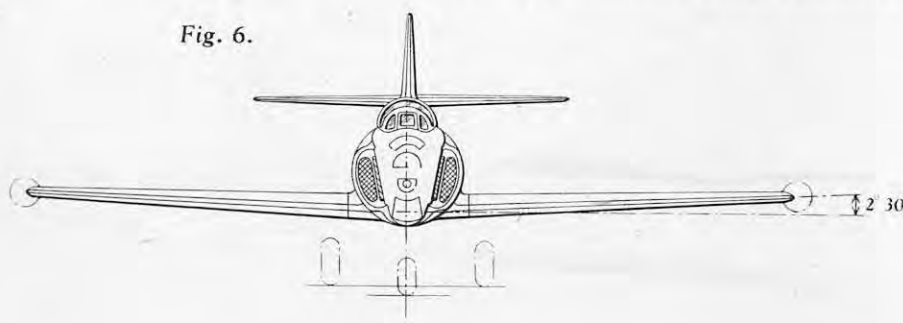


Fig. 7.

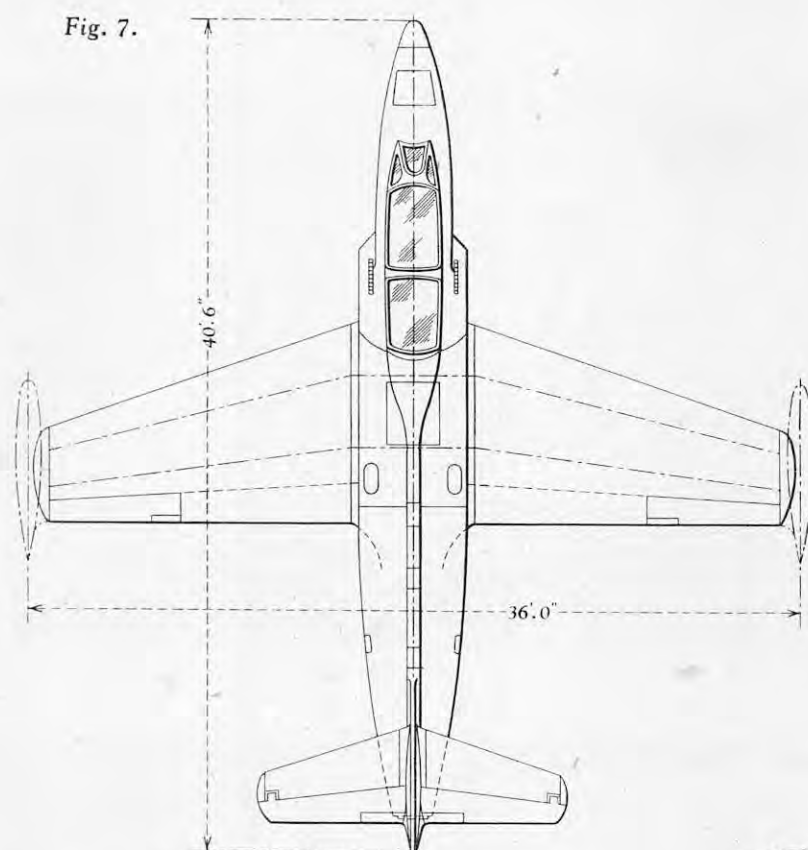
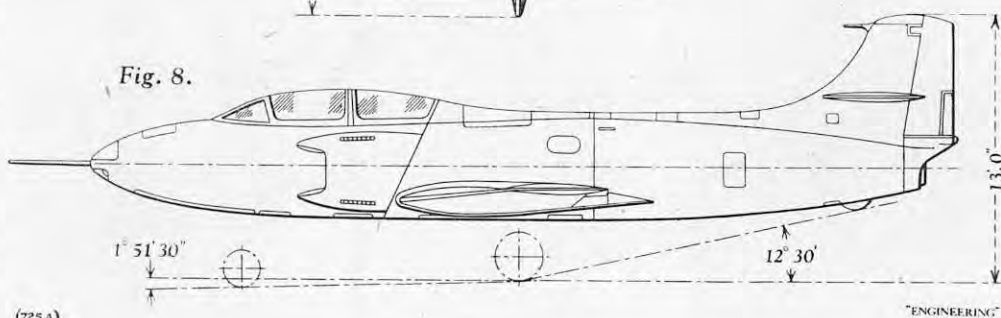


Fig. 8.



## ITALIAN JET-PROPELLED TRAINING AIRCRAFT.

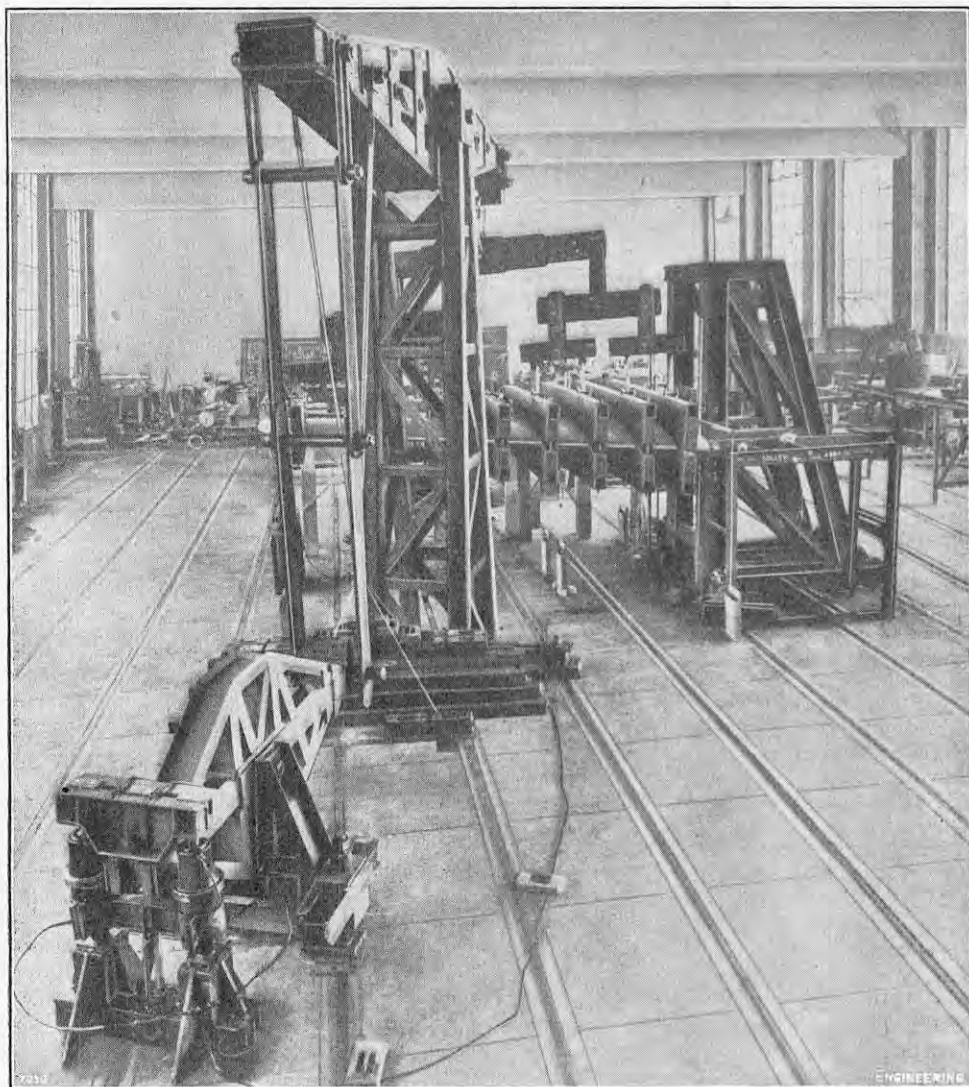


FIG. 9. STATIC STRUCTURAL-TEST RIG.

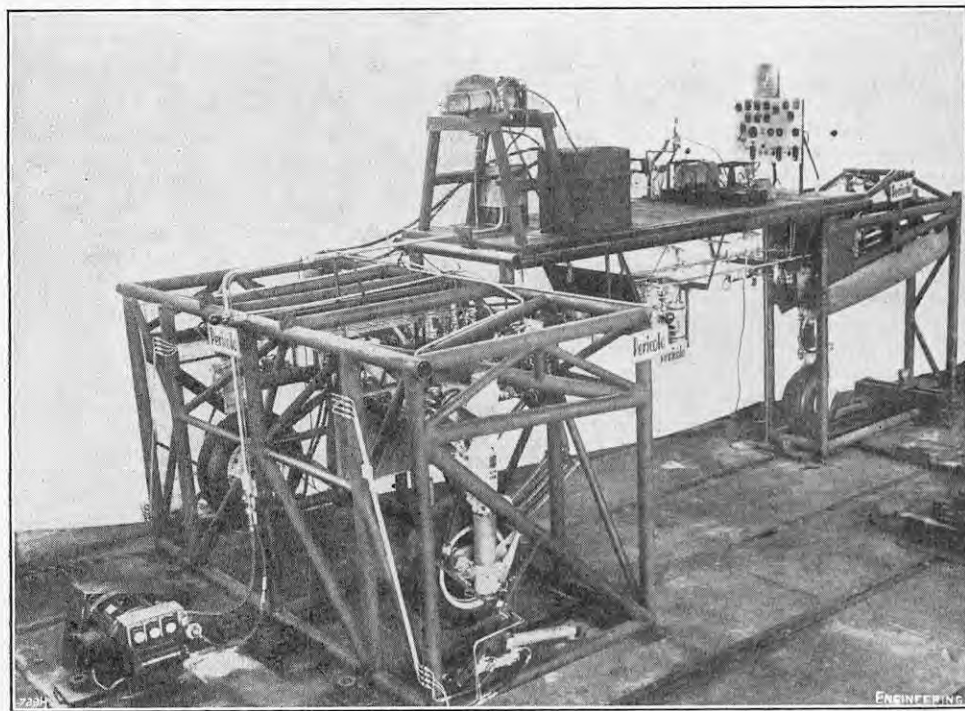


FIG. 10. TEST RIG FOR HYDRAULIC SYSTEM.

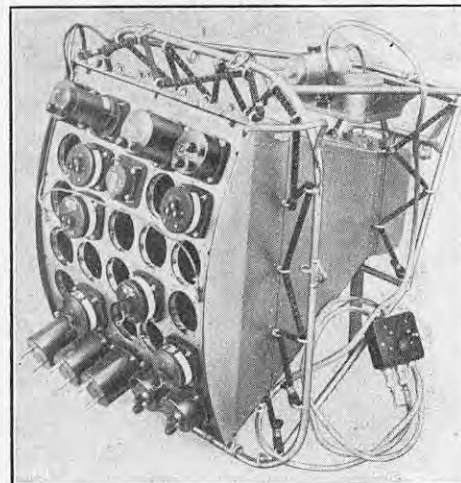


FIG. 11. AUTOMATIC OBSERVER.

ejector seats complete with dinghy, parachutes and emergency oxygen supply. The windscreen and canopy are of sandwich construction, with a dry-air space, to prevent mist formation on the inside of the screen. The windscreen is provided with a de-icing spray connected to a tank on the forward side of the front bulkhead, from which de-icing fluid may be hand-pumped by the pilot in the front cockpit.

Constructing a high-speed high-altitude aircraft calls for extensive testing of the strength and functioning of the various units. Figs. 9 and 10 illustrate some of the test rigs developed by the Fiat company. Fig. 9 shows a wing undergoing a static-strength test. In Fig. 10 can be seen the rig on which the operation of the undercarriage and the hydraulic system was tested. For carrying out flight tests, the automatic observer illustrated in Fig. 11 has been designed for installation in the rear cockpit, to photograph the instruments. The automatic observer is supplemented by a voice recorder to register the pilot's remarks during flight.

**NEW LINER FOR THE UNION-CASTLE FLEET.**—The Kenya Castle, the new one-class steamship of the Union-Castle Mail Steamship Company, Limited, has arrived at Southampton, where she will be prepared for her maiden voyage round Africa. The Kenya Castle was built by Harland and Wolff, Limited, Belfast, and is the third one-class vessel to be constructed for the Union-Castle Line, the first being the Bloemfontein Castle and the second the Rhodesia Castle. Before sailing on April 4 for East-African ports, the Kenya Castle will undertake a 14-day cruise, leaving on March 7 for Lisbon, Las Palmas, Casablanca, Malaga and Cadiz.

**THE DEVELOPMENT OF THE COUNTY OF LONDON.**—An exhibition organised by the London County Council, designed to portray "London—The Next 20 Years," was opened at the County Hall on Saturday, February 16, and will remain open until Friday, March 28 (Sundays excepted). No charge is made for admission, and the exhibition is on view daily from 10 a.m. to 8 p.m. (Saturdays, 6 p.m.). The scope of the Exhibition is broadly that of the County of London Development Plan of 1951, and its main purpose is to show, by means of diagrams, pictures and models, what are "the problems and proposals involved in what is basically a large-scale attempt to secure a proper balance between the economic use of land and the need for adequate social standards and amenities." The main exhibit is a contoured model, 6 ft. in diameter, showing London and its environs within a radius of about 36 miles—approximately the area covered by the County of London Development Plan, which is to be the subject of a public inquiry by the Minister of Housing and Local Government, later in this year. L.C.C. publications concerning the Plan—including the *Report of the Survey and Analysis*, and a series of some 415 maps (which can be purchased separately) are on sale at the exhibition. Three special afternoon visits have been arranged, to take place in February; the first was on February 20, for representatives of municipalities, and the second on February 20, for commercial undertakings and chambers of commerce. The third, for "civic, amenity and architectural societies and associations," will be on February 29.

The cockpit-pressure and air-conditioning system is supplied by air from the turbo-jet engine. Automatic Normalair valves regulate the air pressure; the temperature is controlled by the pilot. An oxygen supply is also provided for high-altitude flying. The transparent canopies, through which the cockpits are entered, are rendered airtight after entry by inflating a sealing tube with air drawn from the engine. The canopies can be jettisoned in flight, and both cockpits are fitted with Martin-Baker

## LITERATURE.

*Pipe Resistance for Hydraulic, Lubricating and Fuel Oils, and Other Non-Aqueous Liquids.*

By T. E. BEACHAM, B.Sc., M.I.C.E., M.I.Mech.E.  
E. and F. Spon, Limited, 22, Henrietta-street, London,  
W.C.2. [Price 18s.]

It is a melancholy fact that, in spite of all the hydraulic research that has been undertaken and the constant use of flowing liquids, no correct and unchallenged formulae have been evolved to answer the simple question of how much a given pipe will discharge. Water is better served in this respect than other liquids, however, since there are innumerable formulae available. Although it may be argued that none is correct, a limited number are in daily use with sufficient accuracy for practical purposes. Oil and other non-aqueous liquids are less simple to deal with, if only because of their varying viscosity. Mr. T. E. Beacham's monograph on *Pipe Resistance* is welcome, therefore, as a simple means of obtaining an approximate answer to flow problems for these liquids. It is a purely practical book for the designer or engineer who wants a quick answer of sufficient accuracy for his purpose, and who does not wish to consider the theory of the subject.

The author gives first a very brief summary of hydraulic terms and a guide to the use of the diagrams which form the major part of the book. Viscosity is one of the main factors influencing oil flow, and, consequently, comparatively little is said regarding the vexed question of pipe roughness; in fact, only three kinds of surface are considered, namely, very smooth drawn tubing, steel and wrought-iron pipes, and galvanised-iron pipes. It is a pity that the author does not use more up-to-date terms in this connection, since wrought-iron pipe is no longer in use and the galvanised pipe referred to is presumably steel. The friction factors for these pipes are then taken from Moody's diagram. Many investigators may disagree with the assumed roughness figures, but, for approximate values, such as the author's diagrams inevitably give, the friction factors that he takes are as good as any.

The author then uses D'Arcy's formula as the basis for his diagrams, ignoring the fact that most investigators agree that pressure loss in turbulent flow is proportional to some exponent of  $D$  appreciably greater than 4. Since the pipe sizes dealt with here for oil are restricted to below 6 in., however, this probably is not of much consequence. A somewhat similar system of dealing with the flow of non-aqueous liquids is available in the American *Piping Handbook*, which, in fact, goes farther in that it covers all fluids. This method, however, does involve some calculation, for example, to find the Reynolds number; and the friction factors used are, perhaps, not so up to date as Moody's. The author's system has the advantage that a wide range of viscosities and specific gravities is directly covered and there are sufficient diagrams to enable the user, if not to pick out one dealing with his exact conditions, at least to find one sufficiently close for practical purposes.

Perhaps the most serious shortcoming of the book is that nowhere is there any indication that the values obtained are in accordance with tests or observation, they being merely the result of applying certain assumptions and formulae. Nevertheless, such a system is better than pure guesswork, and will at least indicate approximately the size of pipe required. The diagrams give a direct answer in engineering units, gallons per minute, pounds per square inch, etc., to a problem set in similar units, without the user having to consider such matters as kinematic viscosity, Reynolds number, relative roughness and other matters, which usually make hydraulic problems so complicated.

*Plant Layout: Planning and Practice.*

By RANDOLPH W. MALLICK and ARMAND T. GAUDREAU.  
John Wiley and Sons, Incorporated, 410, Fourth-  
avenue, New York 16, U.S.A. [Price 7.50 dols.];  
and Chapman and Hall, Limited, 37, Essex-street,  
London, W.C.2. [Price 60s. net.]

WHEN a new Government department is set up (at least, in this country) the first step appears to be to devise for it a suitable "establishment" of prin-

cipal, deputy and assistant secretaries, directors and deputy directors, superintendents, inspectors, etc., etc. Somewhat similar is the approach of the authors of this book to the problems of plant layout. On page 3, they lead off with a diagram (Fig. 1) showing the "evolution of information for a plant layout." On page 12 is another (Fig. 5) which is described as a "specimen functional chart for a plant layout organisation"—not, be it noted, an organisation for a plant, but merely for laying out a plant—which divides "the entire field of plant layout engineering into 73 key activities inter-related among 5 sections of the organisation." On page 15 is a statement detailing the "personal characteristics required in plant layout engineers," which is followed on page 18 by Table I, occupying practically the whole page and listing, under 23 "function numbers," the "principal functions of plant layout personnel."

When it is added that the authors, like so many writers of the present day, apparently hold the opinion that a reader cannot absorb two or more ideas in one sentence unless they are itemised and numbered, it is easy to understand why so much space is occupied in expounding the comparatively simple and straightforward principles of their subject. In their preface, they remark that, apart from articles in periodicals, their preliminary "extensive research" disclosed "only sketchy passages on this subject in some books on industrial engineering," though they have contrived to assemble a fairly lengthy bibliography, covering more than seven closely-printed pages. Undoubtedly, there are opportunities for the specialist in plant layout, as in most other industrial fields; but we incline to doubt whether an intending specialist would derive as much benefit from studying in detail the elaborations of the obvious, with which this book abounds, as from visiting actual plants, keeping his eyes and ears open, and using his common sense.

*Sound Insulation and Room Acoustics.*

By PER V. BRÜEL, M.Sc., D.Sc. Translated from the  
Danish by J. M. BORUP. Chapman and Hall, Limited,  
37, Essex-street, London, W.C.2. [Price 35s. net.]

DR. BRÜEL'S work in the application of acoustics to the reduction of noise and the improvement of hearing conditions in buildings is well known, for the rules drawn up by him and enforced by the Swedish Government through its Building Department have, as the translator remarks in his foreword, "left the rest of the world a long way behind." In this book, he summarises the present position, largely in the light of his own extensive investigations carried out in Copenhagen and at the Chalmers University of Technology in Gothenburg. How different matters were a hundred years ago is well brought out by a quotation from Charles Garnier's monograph on the building of the Paris Opera House, at the end of which he concludes that the only thing to be done in respect of its acoustics was to "hope for the best."

Among the fundamental ideas covered in Chapter I are definitions of the relevant acoustic parameters, details of the tube method for measuring absorption coefficients, the Sabine-Eyring formula for reverberation time, the use of the high-speed level recorder developed by the author in determining reverberation times, and the insulation of structural components against airborne and impact sounds. In Table I, however, the international scale is based on  $A_s = 435$  and not on the present accepted value of 440; the pitch notation is antiquated; and "voice" seems to be a mistake for "frequency."

The frequency ratios corresponding to  $C^\sharp$ , F and A in Table II are incorrect and "cm." should read "cent." Unfortunately, these are by no means the only errors. A brief chapter on physiological acoustics deals mainly with the ear, in the description of which the cochlea is referred to as the "snail," and the tectorial membrane as the "pectorial" membrane.

Chapter III, on "Fields of Sound," is largely mathematical. It opens by treating plane waves, incident normally on an absorbing wall, by means of vector diagrams; and, after notes on the Rayleigh disc and the calibration of condenser microphones, goes on to consider absorption at oblique incidence, the wave equation, and the natural

modes of undamped and damped oscillations in closed rectangular rooms, which have significantly added to the understanding of the real nature of the reverberation curve. There are errors in this chapter, also. Following it is a detailed discussion of absorbents under the headings of porous materials, membranous absorbents, and resonance absorbents, in which a nomogram for the calculation of air absorption is included. Chapter V is devoted to sound insulation and the damping of noise, and deals, in turn, with sound transmission through apertures, airtight and porous partitions and compound walls, the damping of ducts, and impact sounds. The concluding chapter—roughly one-third of the text—contains an admirable account of room acoustics. All types of auditoria are considered, particular attention being given to the special requirements of broadcasting studios and to the desirable relationship between the reverberation times of the studio and the listening-in room. Valuable hints, based on wide experience, are provided concerning such matters as proper proportioning in the preliminary planning, model techniques, correct distribution of absorbent material to obviate flutter echoes and promote uniform sound distribution, the possibilities of variable absorption devices and sound-diffusing elements. Though certain of the author's conclusions, particularly in connection with cinemas, run counter to current views, they are backed by convincing evidence.

Apart from the many errors, to a few of which attention has been directed above, the text betrays itself as a translation in sundry ways; some irritating, such as the persistent use of the possessive, and others obscure, such as the use of "optimum" where "maximum" is intended, on pages 23, 56 and 66. Some typical examples are: "different inswinging conditions" (page 15); "we then plot a curve over the conveyed effect" (page 27); "a point-formed freely-arranged sound transmitter" (page 51); "a physically grounded conclusion" (page 72); "all frequencies may be touched in the duct" (page 160); and "bandwidth  $\Delta f$  can maximally be  $\frac{1}{3}$  octave" (page 189). These are the more to be regretted as they detract from the real merit of the original.

*Modern Naval Architecture.*

By W. MUCKLE, M.Sc., M.Inst.N.A., M.I.Mar.E.  
Temple Press, Limited, Bowling Green-lane, London,  
E.C.1. [Price 9s. 6d. net.]

THIS little volume is one of the publishers' Technical Trends Series, which, according to the dust jacket, "is intended to review recent developments and current practice in selected branches of technology." According to the same source, Mr. Muckle's book has for its main purpose "to survey, for the benefit of the student and the busy technical man who needs to keep his knowledge of modern technical progress in this field up to date, the major developments of recent years in naval architecture." Against this it may be argued that the student of naval architecture must, of necessity, be familiar with text-books giving all the basic information about naval architecture, and much of the general information, that this book contains; and that the "busy technical man" is not likely to provide much of a market for an elementary survey. Nevertheless, the book is one to be commended. The author knows his subject, as those who know him or have read his various contributions to the proceedings of professional institutions do not need to be told; and he writes clearly and to the point, albeit with an economy of punctuation that, while it will not confuse those who also know something of his subject, may sometimes give pause to those who do not. To the apprentice in a shipyard or marine-engine works, or to the man in a shipping office who wishes to understand something of naval architecture without himself needing to practise it, the book is likely to be particularly useful, and it is conceivable that even the complete layman might find it of considerable interest if his bent is at all towards things maritime. It is to the reader of this class that the half-tone illustrations are more likely to appeal; a majority of them have some technical interest, but pictures of cabin interiors seem a little difficult to justify.

## FLUE-DUST SAMPLING.

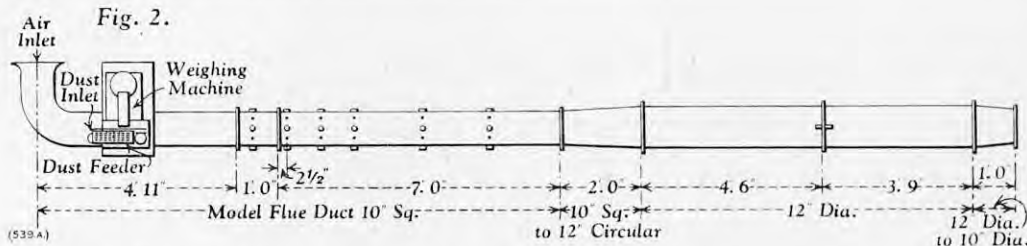
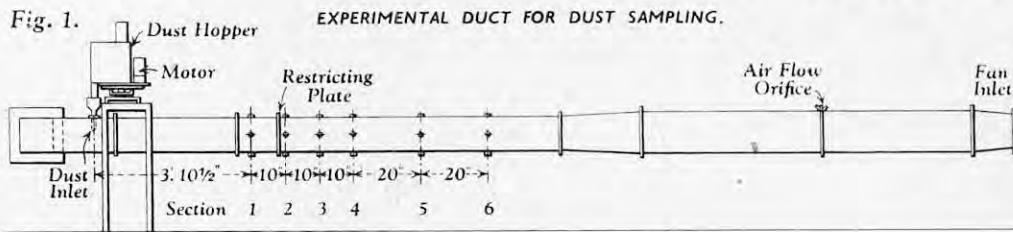


Fig. 5. INFLUENCE OF AIR INLET ON VELOCITY DISTRIBUTION.

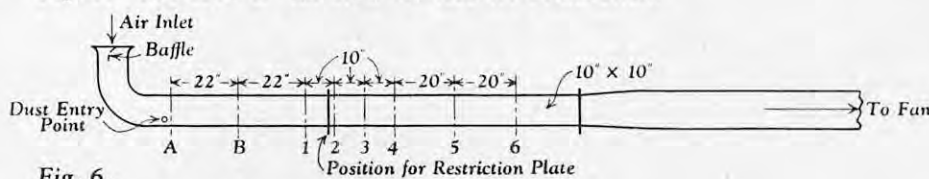
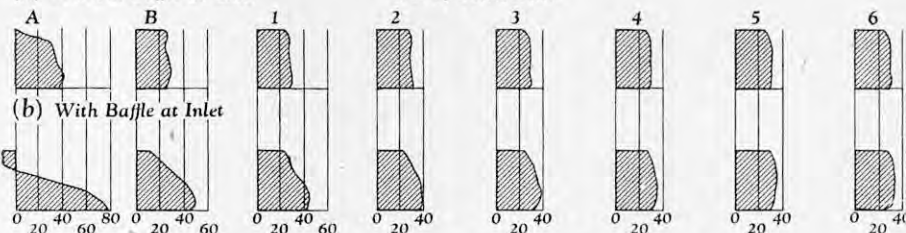


Fig. 6.

(a) Without Baffle at Inlet

No. of Test Section



(539 C)

Velocity Distribution Along Central Horizontal Axis, Ft. per sec.

## THE COLLECTION OF A REPRESENTATIVE FLUE-DUST SAMPLE.

By A. FITTON, B.Sc., A.M.I.Mech.E. and C. P. SAYLES, M.A. (Cantab).

It is well known that the problem of collecting a representative sample of dust carried by flue gases is extremely difficult owing to the uneven velocity distribution in the flue, the uneven distribution of the concentration of the dust, and the uneven distribution of the particle size of the dust. British Standard Specification No. 893, "The Method of Testing Dust Extraction Plant and the Emission of Solids from Chimneys of Electric Power Stations," calls for sampling at a large number of points, with the object of collecting a representative sample of dust. The minimum number of sampling points is given as 24. This procedure, though practicable in the case of special and acceptance tests, is unsuitable for routine work, due to the excessive time and labour involved.

The British Standards Institution Technical Committee ME/48, when reviewing the specification, recognised the desirability of a simplified test procedure. They requested the Fuel Research Station to examine the possibilities of producing a more uniform distribution of the dust so that representative samples could be collected from a single point. It was considered that, even if the technique could not be developed to a stage satisfactory for use in acceptance tests, it might prove to be suitable for routine test work where knowledge of the change of dust concentration was of more importance than accurate measurement of the true dust concentration. Further, sampling at a single point would lend itself easily to continuous recording of dust concentration, which also is under investigation by the British Standards Technical Committee.

From experience on previous work on dust sampling at the Fuel Research Station, it was known that the dust distribution could be made more

uniform by either of two methods. The first method is the insertion in the duct of a restricting device which consists of a flat plate. The plate, which may vary considerably in design, creates turbulence and thus tends to give uniform mixing of the gas and dust. In the second method, a more elaborate form of restricting device is used, such as a nozzle, which, though creating less turbulence than the flat plate, can, in some circumstances, give more uniform mixing of the gas and the dust.

As it was not considered practicable to carry out the work on full-scale plant, a small model flue was constructed in sheet metal. Provision was made to produce artificially an uneven distribution of velocity and dust concentration, so that the efficiency of different devices in bringing about uniform distribution could be assessed.

With each restricting device, it was arranged to carry out the following experimental work at two different velocities: velocity exploration at different sections throughout the length of the duct downstream from the device; dust concentration determinations at the centre of the duct at different sections throughout the length of the duct; and when promising results had been obtained with the previous experiments, to carry out a complete exploration of dust concentration at selected sections.

In the above tests, it was proposed to use two different size gradings of dust, namely, fine dust, typical of dust from boilers fired with pulverised fuel, and of any dust at the exit of a dust-extraction plant; and coarse dust, typical of dust from stoker-fired boilers at the inlet to a dust-extraction plant.

The test programme was ambitious and, in practice, it proved to be more laborious and time-consuming than was originally envisaged. Some time before it was completed, it became necessary to transfer the staff on this programme to other urgent work. At this point, only a few preliminary tests had been made with fine dust, but a considerable amount of experimental work with coarse dust had been carried out.

Fig. 3. FILTER PAPER HOLDER.

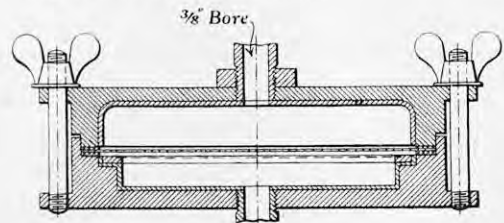
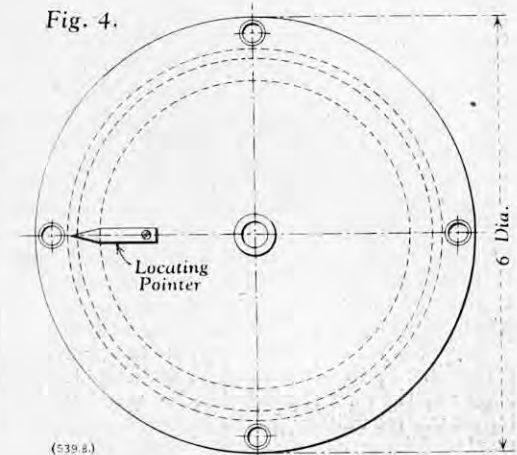


Fig. 4.



There is little doubt that coarse dusts will involve greater difficulties than fine dust, and any solution of the problem for coarse dust will probably be more than adequate for fine dust. The tests had to be terminated before any correlation which was obtained between the size distribution of the dust injected and the dust samples collected. The quantity of dust collected in each sample was inadequate for the purpose of correlation of size distribution, and it was the intention to collect larger samples at selected positions at a later period. Previous experience, however, indicates that, under conditions where a sample is collected which is approximately representative of the dust concentration, it is even more representative of the size distribution of the whole of the dust passing through the duct.

Though the programme was far from complete, a promising stage of development had been reached, and, on reviewing the work, the question whether to resume the original programme on the model flue or to proceed direct to full-scale work was considered. A summary of the progress made was communicated to the British Standards Institution Committee and the Electrical Research Association Committee and, after discussion, the Committees decided that sufficient progress had been made to justify immediate development on full-scale plant. Though these experiments with the model flue have now been abandoned, it is felt that the results obtained are worthy of publication as a guide to the various ways of attacking the general problem.

Referring to Figs. 1 and 2, herewith, it will be seen that the test duct consisted of a length of ducting, 10 in. square in section, with a short right-angle bend at the entrance to give uneven flow of the air in the test section. An orifice was fitted for measurement of the air flow at the exit end of the duct prior to connection to the inlet of an exhaust fan. A small dust feeder of the Redler conveyor type using multiple chains, was developed for feeding the dust into the test duct at a distance of 53 in. upstream of section No. 2, where the restricting devices were fitted.

Provision was made to enable velocity measurements and determinations of dust concentrations to be made across the full cross-section of the duct at six sections. The first section was 10 in. upstream of the position of the restricting device, the second at the restricting device and the remainder at 10 in., 20 in., 40 in., and 60 in. downstream of the device.

Velocity measurements were made with a standard National Physical Laboratory Pitot tube, and dust samples were drawn through stainless-steel sampling tubes,  $\frac{3}{8}$  in. inside diameter, and were collected

on Whatman filter papers clamped in the holder' as shown in Figs. 3 and 4, on page 229. An independent exhaustor was fitted which enabled six samples of dust to be collected simultaneously from different points through independently-controlled measuring systems. The orifices used in the sampling lines were calibrated against a standard wet gas-meter.

The fine dust used in the tests was obtained from the secondary collecting chamber of a multi-cyclone dust-extraction plant; over 99 per cent. of it passed through a 200-mesh B.S. test sieve. The coarse dust was obtained from the primary collecting chamber of a multi-cyclone dust-extraction plant, and the material which passed through a 72-mesh B.S. test sieve was used in the tests. This dust contained about 70 per cent. of material which passed through a 200-mesh B.S. test sieve.

For all rates of air flow, arrangements were made to feed the dust, both fine and coarse, at such rates as would give a mean dust concentration in the air of 1,000 mg. per cubic metre, which is equivalent to 0.437 gr. per cubic foot. This was achieved by means of the dust feeder already mentioned. The dust hopper and the feeder were mounted on a weighing machine. A uniform rate of feed during each test was maintained by manual adjustment of the feed control. Variations of rate during a test, and from test to test, were small and unimportant.

A velocity exploration across the horizontal centre line of the duct at eight sections along the length of the duct showed that the velocity distribution was too uniform for the purposes of the experiments. The results are shown graphically in Fig. 6(a), page 229. The velocity distribution was therefore made uneven by inserting a curved baffle plate at the air inlet of the duct, as shown by the dotted line in Fig. 5. The effect of this baffle on the velocity distribution in the duct is shown by comparing Fig. 6(a) and (b).

With the inlet baffle in position, a series of tests was carried out in which fine dust was injected into the air stream at one side of the duct, and the distribution of dust concentration was determined at Sections 1 and 5. The results for Section 1 are given in Figs. 7 and 8, herewith, which show the distribution of the dust concentration expressed in mg. per cubic metre and in mg. per minute per square inch of the cross-section of the duct.\* They show that distribution was unexpectedly uniform, with little margin for improvement.

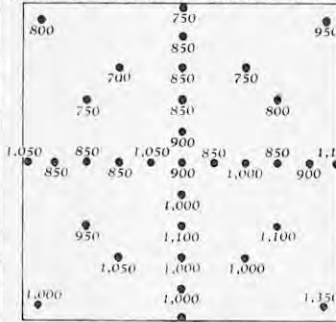
The exploration was then repeated using coarse dust. With the coarse dust the distribution was not so uniform. At the central point of the duct at Section 1, the dust concentration was 650 mg. per cubic metre, and at the bottom of the duct it was 2,100 mg. per cubic metre. The dust concentration was determined at eight positions, distributed uniformly over the section, and the lowest dust concentration measured was 470 mg. per cubic metre. Comparison of the results of tests using fine dust and coarse dust indicates that the problem of obtaining uniform distribution becomes more difficult with increase in particle size of the dust.

Incidentally, the exploration of the fine dust passing Section 1 enabled a check to be made on the accuracy of the sampling methods used. It seemed to be reasonable, from an inspection of Fig. 8, to draw contour lines showing the amount of dust passing per minute per square inch of section of the duct. From these contours, it was possible to calculate the total amount of dust passing through the duct in unit time. The amount of dust calculated in this manner was only 1.2 per cent. lower than the weighed amount of dust fed into the duct over the same period. This agreement is closer than the agreement between repeat determinations at a single point, and indicates that the sampling technique was satisfactory. The fairly uniform distribution obtained when using the fine dust is presumably the result of turbulence set up by the baffle at the entrance to the duct. In some circumstances, with large-scale plant, it may be possible to use this method to give a more uniform distribution of the dust.

\* Conversion factors:—1 mg. per cubic metre = 0.000437 gr. per cubic foot; 1 mg. per square inch per minute = 0.015432 gr. per square inch per minute; 1 mg. per square inch per minute = 0.155 mg. per square centimetre per minute.

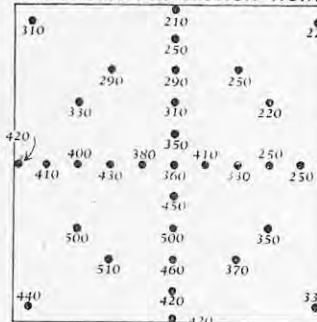
## FLUE-DUST SAMPLING.

Fig. 7. DISTRIBUTION OF CONCENTRATION AT SECTION NO.1.



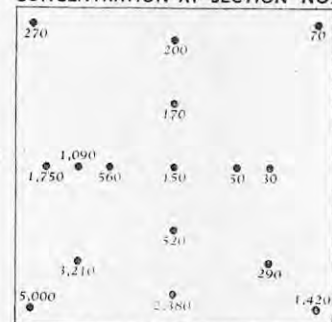
Curved Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Feed, 1,000 mg. per cub. m.  
Type of Dust, Fine

Fig. 8. DISTRIBUTION AT SECTION NO.1.



Curved Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Feed 354 mg. per min.  
per sq. in. of Section  
Type of Dust, Fine

Fig. 9. DISTRIBUTION OF CONCENTRATION AT SECTION NO.1.



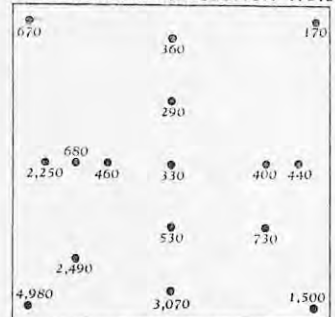
Without Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Injection, 1,000 mg. per cub. m.  
Type of Dust, Coarse

Fig. 10. DISTRIBUTION AT SECTION NO.1.



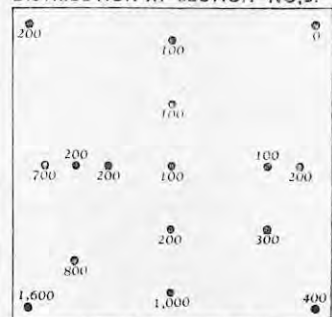
Without Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Injection, 354 mg. per min.  
per sq. in. of Section  
Type of Dust, Coarse  
(575.2)

Fig. 11. DISTRIBUTION OF CONCENTRATION AT SECTION NO.5.



Without Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Injection, 1,000 mg. per cub. m.  
Type of Dust, Coarse

Fig. 12. DISTRIBUTION AT SECTION NO.5.



Without Baffle at Air Inlet  
Mean Velocity in Duct, 30 ft. per sec.  
Rate of Dust Injection, 354 mg. per min. per sq. in. of Section  
Type of Dust, Coarse

The baffle at the entrance of the duct was then removed and the exploration of dust concentration across Section 1 was repeated, using the coarse dust. The results of this series of tests are shown in Figs. 9 and 10, herewith, which give the dust concentration in milligrammes per cubic metre and in milligrammes per minute per square inch of cross-section of the duct. Distribution of the dust was very uneven, varying from 5,000 mg. per cubic metre at the bottom left corner to 70 mg. per cubic metre at the top right corner of the duct. In this series of tests, the weight of dust passing through the duct in unit time, calculated from Fig. 10, was only 3.5 per cent. lower than the weighed amount of dust injected into the duct—again showing good agreement. The distribution of dust with this arrangement was considered to be sufficiently uneven to serve as a base line on which to assess the value of a restricting device as a possible means of enabling a representative sample of dust to be collected from a single point.

Before starting with tests on restricting devices, an exploration was carried out at Section 5, using the coarse dust. The results of this series of tests are given in Figs. 11 and 12, herewith, which show that the distribution of dust concentration was very uneven, varying from 4,980 mg. per cubic metre at the bottom left of the duct to 170 mg. per cubic metre at the top left of the duct when looking upstream.

(To be continued.)

ELECTRICAL ENGINEERS' EXHIBITION.—The central regional council of the Association of Supervising Electrical Engineers have arranged to hold their first Electrical Engineers' Exhibition at the Royal Horticultural Society's new hall, Greycoat-street, London, S.W.1, on Friday and Saturday, March 28 and 29. Exhibits will include heating, lighting and electronic equipment of various kinds, switchgear, cables and capacitors, as well as special features shown by the British Electricity Authority, the British Electrical and Allied Industries Research Association, and the Electrical Development Association. Admission to the exhibition, which will be open between 10 a.m. and 7 p.m. each day, will be by trade card, or by ticket obtainable from Mr. P. A. Thorogood, 35, Gibbs-green, Edgware, Middlesex.

## THE ENGINEERING OUTLOOK.

### VIII.—SHIPBUILDING AND MARINE ENGINEERING.

IN one respect, 1951 was a very successful year for shipbuilders and marine engineers. Orders poured in at a rate which, according to the *Lloyd's List* annual review, "assumed all-time record proportions." At the end of December, 1951, plans had been approved and materials ordered for 295 ships of 2.2 million tons gross, compared with 148 ships of 954,000 tons gross at the end of 1950. There are now contracts in hand for more than 1,000 ships, of 6.25 million gross tons, valued at 550l. millions. Even if adequate supplies of steel and raw materials had been available, a comparable increase in the rate of building would have been out of the question. The 1950 level of launchings was barely maintained (see Table I, taken from the *Shipbuilding Returns* of Lloyd's Register), but, at the end of the year, ships for which the plans were approved and materials ordered accounted for 50.2 per cent. of the total under construction, compared with 31.8 per cent. at the end of December, 1951. Orders on hand represent four years' work at the present rate of construction, but could be completed in three years if sufficient steel were available. Not all shipbuilders have participated in the general prosperity. Mr. J. Ramsay Gebbie, President of the Shipbuilding Conference, pointed out in December that "many of the medium and smaller yards are both eager and anxious to book new orders to take the place of the work currently in hand and nearing completion." To some extent, the Admiralty have helped small builders by placing re-armament orders with them whenever possible. The Navy Estimates for 1951-52 show that 41 minesweepers are on order, many of these with builders of fishing vessels. Not every small shipbuilder, however, has facilities for the construction of the type of craft required by the Admiralty.

The programme of re-armament building has turned out to be on a much greater scale than was expected. Naval work, which accounted for 2 per cent. of the labour engaged in shipbuilding and repairing in 1948 and 11 per cent. at the beginning

of 1951, is expected to account for 30 per cent. at the end of 1952. Pressure on the large builders of merchant tonnage, however, is not as great as might appear from these figures, because a large proportion of the orders have been placed with the small yards, with companies who normally specialise in naval craft, such as John I. Thornycroft and Company and Yarrow and Company, with the Royal Dockyards, and also, in some cases, with ship repairers.

A total of 218 vessels are being built for the Admiralty under the re-armament programme, of which 24 are frigates and the remainder are minesweepers or small craft. The Royal Dockyards will build two of the frigates and will also deal with the conversion to fast frigates of 45 destroyers. Much of this work, together with the refitting of the

They believed that deflationary pressure would lead to a fall in shipbuilding costs, and therefore were content to wait either until prices fell or the upward trend of freight rates was renewed. At the same time, present high earnings and the high incidence of taxation are a strong incentive to the placing of orders. At one time, it seemed that the waiting policy was justified. As the tonnage under construction in British yards fell from 2.2 million tons in June, 1948, to 1.9 million tons in March, 1950, few new orders were received, though shipbuilders were offering to build at fixed contract prices. In September, 1950, only 832,000 tons were in hand, compared with 1.5 millions in September, 1948. After Korea and the re-armament drive, it became quickly evident that it was useless to expect a fall

deferring orders for new tonnage seemed, in many cases, more costly than the purchase of ships at inflated prices. Table II, taken from the *Monthly Digest of Statistics*, shows that, at the end of 1949, tankers accounted for 48 per cent., and, at the end of 1950, for 59 per cent., of the total tonnage under construction. During 1950, there were signs that even tanker orders were being discouraged by the high price of new ships; but the prospect of even higher prices led to a sharp increase in 1951, and, at the end of the year, tankers accounted for 63 per cent. of the total tonnage in hand (see Table III, taken from the *Shipbuilding Returns* of Lloyd's Register).

The world tanker fleet, according to a report issued by John I. Jacobs and Company, shipowners and shipbrokers, has now reached 29.8 million deadweight tons, compared with 16 million deadweight tons in July, 1939. The rate of annual increase is now slightly over 2 million tons per annum. The Royal Dutch-Shell group have put in hand the biggest tanker-building programme of any oil group since the war: their subsidiary, the Anglo-Saxon Petroleum Company, placed orders with British and Dutch shipyards valued at 45l. millions, of which 30l. millions was with British yards. Altogether, 41 tankers of 18,000 tons dw. each and five of 28,000 tons have been contracted for over the next five years. This will raise the combined fleet by 900,000 tons, to approximately 3.5 million tons. Earlier in 1951, the Anglo-Iranian Oil Company had ordered 31 tankers, totalling 586,000 tons deadweight. The Esso Petroleum Company have also placed orders for six new tankers, each of 26,500 tons deadweight, valued at 7.5l. millions.

Many orders have been placed by independent tanker owners, who own 13 million tons—over 45 per cent. of the tanker tonnage afloat. London and Overseas Freighters, Limited, for example, have placed an order for three tankers, each of 25,000 tons deadweight, with Richardsons, Westgarth and Company. The former company, formed

TABLE I. UNITED KINGDOM: MERCHANT SHIPBUILDING.

| Year and Quarter. | Under Construction and in Hand. |                   | Commenced. |                   | Launched. |                   | Completed. |                   |
|-------------------|---------------------------------|-------------------|------------|-------------------|-----------|-------------------|------------|-------------------|
|                   | No.                             | 1,000 Tons Gross. | No.        | 1,000 Tons Gross. | No.       | 1,000 Tons Gross. | No.        | 1,000 Tons Gross. |
| 1948, March ..    | 721                             | 3,407             | 89         | 213               | 65        | 181               | 81         | 234               |
| June ..           | 704                             | 3,517             | 85         | 375               | 84        | 302               | 88         | 274               |
| Sept. ..          | 706                             | 3,716             | 61         | 238               | 78        | 272               | 78         | 272               |
| Dec. ..           | 682                             | 3,547             | 80         | 353               | 94        | 417               | 98         | 433               |
| Total, 1948 ..    |                                 |                   | 315        | 1,179             | 321       | 1,172             | 345        | 1,213             |
| 1949, March ..    | 645                             | 3,511             | 73         | 274               | 73        | 263               | 76         | 311               |
| June ..           | 617                             | 3,481             | 64         | 288               | 96        | 358               | 88         | 339               |
| Sept. ..          | 575                             | 3,253             | 80         | 402               | 73        | 337               | 86         | 340               |
| Dec. ..           | 524                             | 2,990             | 65         | 249               | 79        | 302               | 90         | 364               |
| Total, 1949 ..    |                                 |                   | 282        | 1,213             | 321       | 1,260             | 340        | 1,354             |
| 1950, March ..    | 495                             | 2,938             | 66         | 268               | 65        | 204               | 86         | 361               |
| June ..           | 474                             | 2,955             | 66         | 372               | 95        | 485               | 85         | 346               |
| Sept. ..          | 450                             | 2,878             | 68         | 388               | 63        | 307               | 71         | 289               |
| Dec. ..           | 478                             | 2,999             | 84         | 390               | 55        | 318               | 77         | 393               |
| Total, 1950 ..    |                                 |                   | 284        | 1,418             | 278       | 1,314             | 319        | 1,389             |
| 1951, March ..    | 549                             | 3,487             | 56         | 317               | 55        | 241               | 47         | 291               |
| June ..           | 600                             | 3,955             | 79         | 382               | 79        | 414               | 70         | 346               |
| Sept. ..          | 645                             | 4,261             | 75         | 424               | 51        | 242               | 53         | 269               |
| Dec. ..           | 655                             | 4,434             | 69         | 361               | 73        | 433               | 76         | 434               |
| Total, 1951 ..    |                                 |                   | 279        | 1,484             | 258       | 1,330             | 246        | 1,340             |

TABLE II.—UNITED KINGDOM: MERCHANT SHIPBUILDING.

Vessels of 1,600 gross tons and over (thousand gross tons).

|                  | Tankers.   |             |                                      |             |            |             | Other Vessels. |             |                                      |             |            |             |
|------------------|------------|-------------|--------------------------------------|-------------|------------|-------------|----------------|-------------|--------------------------------------|-------------|------------|-------------|
|                  | Laid Down. |             | Under Construction at End of Period. |             | Completed. |             | Laid Down.     |             | Under Construction at End of Period. |             | Completed. |             |
|                  | Total.     | For Export. | Total.                               | For Export. | Total.     | For Export. | Total.         | For Export. | Total.                               | For Export. | Total.     | For Export. |
| Annual Totals :  |            |             |                                      |             |            |             |                |             |                                      |             |            |             |
| 1946 .. .. .     | 208        | 57          | 242                                  | 57          | 314        | —           | 1,028          | 307         | 1,446                                | 350         | 601        | 91          |
| 1947 .. .. .     | 291        | 99          | 414                                  | 155         | 119        | —           | 772            | 275         | 1,451                                | 436         | 764        | 187         |
| 1948 .. .. .     | 409        | 230         | 620                                  | 326         | 203        | 59          | 710            | 212         | 1,238                                | 336         | 923        | 312         |
| 1949 .. .. .     | 608        | 293         | 855                                  | 448         | 380        | 176         | 538            | 135         | 939                                  | 225         | 880        | 262         |
| 1950 .. .. .     | 753        | 397         | 1,050                                | 580         | 563        | 255         | 549            | 119         | 761                                  | 168         | 737        | 176         |
| 1951 .. .. .     | 817        | 311         | 1,107                                | 407         | 782        | 498         | 552            | 136         | 807                                  | 178         | 508        | 128         |
| Monthly Totals : |            |             |                                      |             |            |             |                |             |                                      |             |            |             |
| 1950, Oct. ..    | 68         | 31          | 1,008                                | 566         | 34         | 16          | 40             | 5           | 770                                  | 171         | 71         | 31          |
| Nov. .. ..       | 39         | 16          | 970                                  | 559         | 78         | 24          | 56             | 11          | 757                                  | 167         | 69         | 12          |
| Dec. .. ..       | 147        | 50          | 1,050                                | 580         | 67         | 28          | 63             | 8           | 761                                  | 168         | 57         | 6           |
| 1951, Jan. ..    | 47         | 13          | 1,044                                | 554         | 56         | 40          | 29             | —           | 761                                  | 165         | 30         | 3           |
| Feb. .. ..       | 74         | 55          | 1,085                                | 599         | 34         | 11          | 45             | 5           | 755                                  | 141         | 53         | 30          |
| March .. ..      | 38         | 13          | 1,064                                | 592         | 59         | 33          | 50             | —           | 762                                  | 137         | 44         | 4           |
| April .. ..      | 81         | 48          | 1,077                                | 611         | 71         | 30          | 35             | 4           | 763                                  | 132         | 33         | 7           |
| May .. ..        | 59         | 43          | 1,082                                | 610         | 55         | 45          | 41             | —           | 711                                  | 107         | 91         | 25          |
| June .. ..       | 47         | 26          | 1,079                                | 618         | 51         | 19          | 44             | 6           | 727                                  | 97          | 28         | 17          |
| July .. ..       | 70         | 13          | 1,099                                | 587         | 52         | 29          | 16             | —           | 716                                  | 92          | 28         | 6           |
| August .. ..     | 93         | 24          | 1,128                                | 547         | 66         | 66          | 71             | 57          | 777                                  | 148         | 9          | —           |
| Sept. .. ..      | 43         | 12          | 1,094                                | 520         | 78         | 51          | 59             | 4           | 812                                  | 147         | 25         | 6           |
| Oct. .. ..       | 61         | 13          | 1,078                                | 463         | 83         | 76          | 25             | 8           | 748                                  | 142         | 89         | 12          |
| Nov. .. ..       | 53         | 19          | 1,069                                | 455         | 63         | 28          | 72             | 51          | 783                                  | 189         | 36         | 4           |
| Dec. .. ..       | 152        | 34          | 1,107                                | 407         | 114        | 71          | 63             | 2           | 807                                  | 178         | 41         | 13          |

Reserve Fleet, is being handled by the ship-repairers, who have been working under capacity for some time. There was an increase in the merchant tonnage passing through the ship-repairers' yards in 1951; 2.3 million tons were under repair at the end of November, 1951, compared with 1.9 million tons at the end of November, 1950. The flow of work was much less, however, than in 1947 and 1948, when the corresponding figures were 3.4 million tons and 3.1 million tons, respectively.

The rush of orders which began during the last quarter of 1950 is, to some extent, the result of shipowners' reluctance to place orders in 1949 and 1950 because of the high price of new tonnage.

in the price of ships, that increased wages and rising prices of steel and raw materials would drive up shipbuilding costs, and that shortages would cause costly delays. It was also reasonable to expect that, even if there were no war, freight rates would remain high enough for long enough to make the operation of the most expensive tonnage profitable. In consequence, those shipowners who had thought they could afford to wait hastened to place their orders.

Tanker owners have been much less concerned about the price of ships than owners of passenger and dry-cargo tonnage. So rapid has been the growth in world oil consumption that the loss in earning power which would have resulted from

in 1948 to build and operate a modern fleet of tankers, will have 16 ships when the present programme is completed, aggregating over 300,000 tons. The North American Shipping and Trading Company, Limited, managed by Mr. Stavros S. Niarchos, ordered two more tankers from Vickers-Armstrongs Limited, in July, and, as stated on page 147, *ante*, have since increased the tonnage of these vessels from 32,000 to 44,000 tons each. Contracts placed by these interests with Vickers-Armstrongs Limited are valued at over 10l. millions and cover ten ships aggregating 272,000 tons deadweight. A substantial volume of tanker and other tonnage is now being operated by Greek interests. The tonnage block under Greek control, operating mainly under the

Panamanian, United States, British, Liberian and Honduran flags, is estimated to be fourth in importance, being exceeded only by the fleets owned in the United States, the United Kingdom and Norway.

As lately as the beginning of 1950, it was possible to make out a fairly convincing case showing that, at the rate of new construction being undertaken at that time, there was likely to be a surplus of tanker tonnage by 1953 or 1954. Such is the rate of increase in world petroleum consumption that it now seems clear that the present extensive building programme is by no means excessive in relation to the future demand for tankers. Since 1946, the world demand for petroleum has increased by 70 per cent. Mr. J. W. Platt, managing director of the Anglo-Saxon Petroleum Company, on the occasion of the launch of the 28,000 tons tanker *Velletia* at Wallsend-on-Tyne, drew attention to the very large increase in petroleum consumption. The United States and the Soviet Union apart, he said, the consumption of petroleum in the world, which amounted to 165 million tons in 1950 and was expected to reach 185 million tons in 1951, is now expected to rise to 245 million tons by 1956. The tanker tonnage available at present—and all but two large tankers have now been withdrawn from the United States reserve fleet—is said to be quite unable to cope with the current demand.

There was some slackening of tanker freight rates in the summer, due mainly to seasonal influences, but, according to the Petroleum Press Service, the London spot rate in December was 300 per cent. above the Ministry of Transport war-time rate, compared with 60 per cent. above at the end of July. The shutting down of oil production in Persia, and the consequent release of many tankers from the long haul round the Arabian Peninsula and through the Mediterranean, affected the situation only momentarily, for these vessels have now been absorbed elsewhere, often on longer hauls. The Trans-Arabian pipeline, which was opened in 1950, has also failed to ease the tanker shortage. On the other hand, 12·5 per cent. of the total world tanker fleet, or 3·45 million deadweight tons, is more than 20 years old and over half of this is over 25 years old. By 1956, tankers aggregating over 4 million tons deadweight will be over 25 years old and must be replaced, since the corrosive action of oil cargoes makes it impracticable to operate them beyond that age. The extra tonnage required to carry the additional 60 million tons of oil, which Mr. Platt estimates will be consumed by the world outside the United States and the Soviet Union between 1952 and 1956, is estimated at 6 million deadweight tons. Leaving out of account any increase in demand from the United States upon overseas supplies of petroleum, an extra 10 million deadweight tons of tanker tonnage—or 2 million tons per annum—will be required by 1956.

Building tankers on this scale requires a heavy capital outlay. The price of a new tanker of 16,000 tons deadweight is now about 53l. per ton. Moreover, new storage and distribution facilities will be required to handle the extra oil, and the cost of these at 5l. per ton for the extra tonnage to be distributed will be 300l. millions. The total investment outlay required is, therefore, 830l. millions. Not all of this will have to be met from British sources, for the share of the British oil companies in the world trade in oil outside the United States and the Soviet Union is only about 40 per cent. Even so, it means that the United Kingdom, with resources already heavily strained by re-armament and heavy investment in the coal mines and the electrical supply industry, is required to find an additional 330l. millions to bring in essential supplies of oil, if Mr. Platt's prophecy is fulfilled.

At present prices, the future profitability of dry-cargo and passenger tonnage is rather less certain than that of tankers, but orders increased sharply over 1951. As will be seen from Table III, here-with, 83 cargo liners, of 595,770 gross tons, were in hand at the end of December, 1951, compared with 50 of 312,700 tons at the end of June, and there was also some increase in the tonnage of colliers and miscellaneous vessels in preparation. The tonnage of passenger, and passenger and cargo, vessels in hand declined, but some important orders

have been placed recently. The Cunard Steamship Company announced in December that arrangements have been made with John Brown and Company, Limited, for the construction of two liners, each of about 20,000 gross tons, with a speed of 20 knots. They will have first-class and tourist-class accommodation and are scheduled to go into service on the Canadian run in 1954 and 1955. The value of the contracts has not been announced, but at current prices the cost of the new liners would be between 3·5l. and 4l. millions each.

Shipping earnings are very high at present. The Chamber of Shipping index of freight rates (1948 = 100) averaged 164 in 1951, compared with 84 in 1950. War-time Liberty ships are said to be earning from 500l. to 600l. per day, or about 177,000l. per annum after meeting operating costs, including repairs, but making no allowance for depreciation. As a result, the price of secondhand vessels has risen rapidly. In November, a Liberty ship fetched 575,000l., and several others have sold at about 600,000l. Even at present freights, the margin of profit on a vessel at this price is comparatively

five years' time, though only modern vessels can be run at a profit in times of falling freights.

Rates are maintained at present at a very high level partly because it has been found necessary to bring into commission large numbers of ships with high operating costs. Before the outbreak of war in Korea and the impact of world re-armament, about 14 million tons of Liberty-class shipping were laid up in the United States reserve fleet. Since then, about 450 vessels have been withdrawn, leaving only 11 million tons. A relatively small reduction in the volume of goods to be carried, or a speed-up in the turn-round of shipping in ports, might bring about a very sharp fall in freight rates. This would be particularly serious for owners of the less efficient tonnage, because operating costs, notably wages and fuel prices, have been advancing rapidly of late. Some weakening of freights is already apparent. The peak was reached in May, when the Chamber of Shipping index stood at 203·8. Although it still stood at 168·5 in December, 1951, compared with 115·7 in December, 1950, it has been falling since October, whereas, in the

TABLE III.—UNITED KINGDOM: SHIPBUILDING ANALYSIS BY TYPES OF VESSEL  
(MARCH TO DECEMBER, 1951).

| Type of Vessel.                               | Quarter. | Commenced. |           | Launched. |           | Completed. |           | Under Construction. |           | In Hand.* |           |
|-----------------------------------------------|----------|------------|-----------|-----------|-----------|------------|-----------|---------------------|-----------|-----------|-----------|
|                                               |          | No.        | Tons.     | No.       | Tons.     | No.        | Tons.     | No.                 | Tons.     | No.       | Tons.     |
| Passenger and Passenger-Cargo                 | June ..  | 3          | 50,300    | 3         | 39,600    | 5          | 67,826    | 20                  | 220,900   | 8         | 95,100    |
|                                               | Sept. .. | 3          | 36,500    | 2         | 10,900    | 2          | 17,623    | 20                  | 236,983   | 6         | 81,250    |
|                                               | Dec. ..  | 3          | 43,710    | —         | —         | 4          | 44,158    | 19                  | 236,610   | 5         | 53,250    |
|                                               | Total .. | 9          | 130,510   | 5         | 50,500    | 11         | 129,607   |                     |           |           |           |
| Cargo Liner ..                                | June ..  | 9          | 54,600    | 10        | 65,300    | 8          | 51,753    | 69                  | 491,350   | 50        | 312,700   |
|                                               | Sept. .. | 10         | 51,750    | 10        | 77,150    | 3          | 14,061    | 76                  | 529,750   | 60        | 373,290   |
|                                               | Dec. ..  | 7          | 42,070    | 16        | 109,228   | 12         | 85,999    | 71                  | 486,038   | 83        | 595,770   |
|                                               | Total .. | 26         | 148,420   | 36        | 251,678   | 23         | 151,813   |                     |           |           |           |
| Cargo Tramp ..                                | June ..  | 9          | 58,300    | 5         | 30,530    | 3          | 17,468    | 23                  | 141,300   | 22        | 122,830   |
|                                               | Sept. .. | 8          | 46,700    | 2         | 6,000     | 4          | 26,947    | 27                  | 160,720   | 18        | 98,850    |
|                                               | Dec. ..  | 5          | 24,650    | 2         | 11,770    | 5          | 25,717    | 27                  | 159,820   | 21        | 116,900   |
|                                               | Total .. | 22         | 129,650   | 9         | 48,300    | 12         | 70,132    |                     |           |           |           |
| Oil Tanker ..                                 | June ..  | 21         | 198,950   | 22        | 257,511   | 17         | 176,359   | 101                 | 1,181,755 | 103       | 1,247,020 |
|                                               | Sept. .. | 23         | 267,200   | 11        | 129,358   | 16         | 194,509   | 108                 | 1,255,754 | 106       | 1,348,920 |
|                                               | Dec. ..  | 19         | 228,060   | 25        | 292,982   | 22         | 253,707   | 105                 | 1,239,497 | 108       | 1,391,290 |
|                                               | Total .. | 63         | 694,210   | 58        | 679,851   | 55         | 624,575   |                     |           |           |           |
| Collier ..                                    | June ..  | 2          | 3,600     | 2         | 3,656     | 5          | 12,104    | 7                   | 13,770    | 11        | 26,854    |
|                                               | Sept. .. | 2          | 4,820     | 3         | 7,564     | 2          | 3,653     | 7                   | 15,105    | 15        | 36,009    |
|                                               | Dec. ..  | 3          | 5,064     | 2         | 3,653     | 3          | 7,933     | 7                   | 12,516    | 12        | 30,945    |
|                                               | Total .. | 7          | 13,484    | 7         | 14,873    | 10         | 23,690    |                     |           |           |           |
| Coaster ..                                    | June ..  | 16         | 9,610     | 6         | 4,990     | 3          | 1,622     | 39                  | 30,415    | 23        | 16,566    |
|                                               | Sept. .. | 11         | 9,850     | 6         | 5,893     | 6          | 3,637     | 44                  | 36,523    | 28        | 15,226    |
|                                               | Dec. ..  | 14         | 9,646     | 11        | 7,860     | 9          | 9,863     | 49                  | 36,472    | 22        | 14,830    |
|                                               | Total .. | 41         | 29,106    | 23        | 18,743    | 18         | 15,122    |                     |           |           |           |
| Miscellaneous ..                              | June ..  | 19         | 7,118     | 31        | 12,551    | 29         | 19,079    | 86                  | 34,829    | 38        | 19,781    |
|                                               | Sept. .. | 18         | 6,782     | 17        | 5,581     | 20         | 8,208     | 86                  | 36,805    | 44        | 36,161    |
|                                               | Dec. ..  | 18         | 8,059     | 17        | 7,871     | 21         | 7,038     | 82                  | 38,059    | 44        | 22,419    |
|                                               | Total .. | 55         | 21,949    | 65        | 26,003    | 70         | 34,325    |                     |           |           |           |
| Grand Total                                   | ..       | 223        | 1,167,339 | 203       | 1,089,948 | 199        | 1,049,264 |                     |           |           |           |
| Total under construction at December, 1951 .. |          |            |           |           |           |            |           | 360                 | 2,209,012 | 295       | 2,225,404 |

\* Plans approved or material ordered.

small. A correspondent of the *Financial Times*, in an article published on January 7, 1952, pointed out that, after allowing for depreciation, the profit was likely to be about 126,000l. a year, or about 23 per cent. on the outlay. After deducting profits tax and income tax, what remains is a poor recompense for a somewhat risky venture. Most of the Liberty ships afloat to-day, of course, were bought at prices well below the current level. At the end of the war, the United States War Shipping Administration disposed of over 100 at about 137,000l. each, and in June, 1950, the market price was about 150,000l.

The rise in secondhand ship prices is, of course, a reflection of the cramped state of shipbuilders' order books as well as of the increased cost of new building. Delivery cannot be promised on most orders given to-day until 1955 or 1956, and, because of increases in wages and in the price of steel and components, building costs have risen by 15 per cent. over the past six months. A secondhand ship, however old and expensive to run, which can take advantage of the present high freights, may be a far better investment than a new vessel which, however efficient, will pay for itself only on the assumption that high freight rates will still obtain in four or

same period of 1950, it was rising. There was strong evidence in 1950 that the world dry-cargo fleet was more than adequate to deal with the world's seaborne trade.

Freight rates fell continuously from 1948 onwards. In May, 1950, the index stood at 71·4, compared with 99·7 in May, 1949. Since then (mid-1950), the world dry-cargo fleet has increased by 1·2 million tons gross to 69·0 million tons. A return to more normal conditions of trade—and the possibility of a slump cannot be dismissed—must, therefore, mean a large volume of surplus tonnage. This surplus, moreover, would be all the more serious if the larger and faster modern ships could be used to full advantage. At present, much valuable sailing time is lost in ports. In some cases, as of late in Australia and New Zealand, labour difficulties have been responsible for delays; in others, a changing pattern of world trade has caused serious congestion, as, for example, at the Port of London; and in others it has not been possible to undertake the capital investment necessary to keep the facilities in good repair. An attempt to attack the problem on an international basis was made in October, when representatives of many maritime countries met to discuss provisional articles of association for

an International Cargo Handling Co-ordination Committee. The object is to study the practical details of port operation as well as any factors which influence the loading and unloading of ships, such as the design of cargo-handling equipment on ship and shore, and the feeding of the ports by complementary transport systems.

British shipowners, though obviously optimistic about the future, have taken precautions against the return of hard times and have formed the Tonnage Stabilisation Association. The object of this Association, to which 23 leading owners of tramp tonnage are subscribers, is to relieve the pressure of tonnage on the market when freights are weak by laying up surplus vessels instead of leaving them to fight for unremunerative freights. A levy on the gross tonnage of vessels still employed would provide compensation for owners of laid-up tonnage. Such a scheme is not new to the shipping world, for the International Tanker Pool operated before the war with similar objects. Insurance of this sort is valuable enough, but, to some extent,

because of inadequate depreciation allowances, the industry has not been able to build up reserves large enough to finance new building on the scale required. A ship which cost 100,000*l.* in 1930 costs 400,000*l.* to replace to-day. It might have earned an average profit of 10 per cent. per annum before amortisation between 1930 and 1945, and 40 per cent. from 1946 to 1950; total gross profits, therefore, would have amounted to 350,000*l.* With depreciation allowances calculated on the basis of the purchase price, income tax and profits tax would amount to 125,000*l.*, so that, even if no dividends were paid, only 225,000*l.* would be available to buy a new ship. The high prices obtaining in the second-hand market are of little assistance, since any owner disposing of obsolescent tonnage is liable to "balancing charges," which tax the amount by which the selling price exceeds the permitted written-down value. The Council have thus a case for urging the abolition of the balancing charges and that a wide discretion should be permitted to shipping companies to amortise ships as

for new Mexican shipyards at Vera Cruz. The biggest threat to British yards is, however, the revival of shipbuilding in Japan, Germany and Italy. For some time, these countries will be mainly concerned with building for their own national fleets; but this is serious enough, since it will increase the tonnage of ships afloat, depressing freights and consequently the demand for ships.

Japanese shipowners, who lost almost 9 million tons of shipping during the war, are now making great efforts to regain their former place on the high seas. Controls on ship operation have been eased and the Japanese Government hope to have 2.7 million tons of shipping in service at the end of 1952, compared with 2.2 million tons at present and 1.8 million tons a year ago. Japanese shipyards, which had 521,000 tons of shipping under construction at the end of June, 1951, were planning to increase their capacity to 800,000 tons. At the end of December, however, the tonnage under construction had fallen to 60 ships of 295,000 tons, of which 227,000 tons were for Japanese owners. High costs are proving a serious obstacle to the revival of shipbuilding in Japan; for, despite low wages, their relatively inefficient methods, combined with the higher prices to be paid for coal and iron ore brought from the United States instead of from China as formerly, have raised Japanese building costs above the British. According to the Shipbuilders' Rationalisation Deliberative Council, the cost of building an 18,000-ton tanker in Japan is 63*l.* a ton, compared with 50*l.* in the United Kingdom and 72*l.* in the United States. The United States Government have advised so far against subsidising shipbuilding in Japan, but the Deliberative Council, a semi-Government body, have recommended that a subsidy should be paid on steel. They point out that a heavy burden is being imposed on the Japanese steel industry, with serious repercussions in the shipbuilding industry, since the policy of the United Nations forbids Japan, a non-member, to buy coal and iron ore from China. It is considered, therefore, that "the Government should indemnify the steel manufacturers by subsidy payments." A subsidy which would reduce the price of rolled steel

TABLE IV.—UNITED KINGDOM: REGISTRATION OF SHIPS UNDER CONSTRUCTION.

|                                              | December 31, 1949. |           | December 31, 1950. |           | December 31, 1951. |           |
|----------------------------------------------|--------------------|-----------|--------------------|-----------|--------------------|-----------|
|                                              | No.                | Tons.     | No.                | Tons.     | No.                | Tons.     |
| British Dominions and Colonies               | 31                 | 96,400    | 21                 | 90,559    | 32                 | 86,705    |
| Argentina                                    | 14                 | 96,403    | 5                  | 70,000    | 1                  | 12,000    |
| Belgium                                      | —                  | —         | 2                  | 1,200     | —                  | —         |
| Brazil                                       | 4                  | 1,368     | 7                  | 35,968    | 7                  | 35,968    |
| Denmark                                      | 5                  | 24,332    | 2                  | 9,623     | —                  | —         |
| France                                       | 2                  | 17,300    | 5                  | 40,250    | 2                  | 16,150    |
| Holland                                      | 8                  | 42,410    | 4                  | 25,550    | 1                  | 6,050     |
| Iceland                                      | 6                  | 4,215     | 8                  | 5,660     | 2                  | 1,400     |
| Liberia                                      | —                  | —         | 5                  | 74,940    | 4                  | 64,250    |
| Norway                                       | 36                 | 324,166   | 38                 | 391,618   | 23                 | 248,430   |
| Panama                                       | 7                  | 75,080    | 1                  | 13,070    | 6                  | 67,140    |
| Poland                                       | 1                  | 3,200     | 3                  | 18,400    | —                  | —         |
| Portugal                                     | 6                  | 15,105    | 3                  | 16,700    | —                  | —         |
| Sweden                                       | 5                  | 35,750    | 3                  | 27,400    | 3                  | 22,608    |
| United States                                | —                  | —         | 1                  | 13,070    | 1                  | 12,000    |
| Other countries                              | 4                  | 22,750    | 10                 | 20,630    | 23                 | 122,218   |
| Total for registration abroad                | 129                | 758,479   | 118                | 794,638   | 105                | 694,919   |
| Total for registration in the United Kingdom | 239                | 1,235,712 | 212                | 1,250,050 | 255                | 1,514,093 |
| Total under construction                     | 368                | 1,994,191 | 330                | 2,044,688 | 360                | 2,209,012 |

TABLE V.—UNITED KINGDOM: SHIPBUILDING AND MARINE ENGINEERING EXPORTS.

|                             | 1938.   |                 | 1939.  |                 | 1945.  |                 | 1946.  |                 | 1947.   |                 | 1948.   |                 | 1949.   |                 | 1950.   |                 | 1951.    |                 |
|-----------------------------|---------|-----------------|--------|-----------------|--------|-----------------|--------|-----------------|---------|-----------------|---------|-----------------|---------|-----------------|---------|-----------------|----------|-----------------|
|                             | Tons.   | Value (£1,000). | Tons.  | Value (£1,000). | Tons.  | Value (£1,000). | Tons.  | Value (£1,000). | Tons.   | Value (£1,000). | Tons.   | Value (£1,000). | Tons.   | Value (£1,000). | Tons.   | Value (£1,000). | Tons.    | Value (£1,000). |
| Ships for breaking up       | 13,002  | 32              | 22,772 | 47              | —      | —               | 9,342  | 14              | 4,400   | 22              | 10,528  | 53              | —       | —               | —       | —               | —        | —               |
| War vessels                 | 9,967   | 2,022           | —      | —               | —      | —               | —      | —               | —       | —               | —       | —               | —       | —               | —       | —               | —        | —               |
| Steam vessels               | 134,470 | 4,063           | —      | 7,034           | 14,552 | 1,165           | 33,678 | 2,565           | 108,015 | 9,668           | 212,888 | 20,384          | 124,120 | 14,120          | 124,245 | 14,179          | 142,100  | 15,915          |
| Motor vessels               | 891     | 1,959           | —      | —               | 553    | 34              | 15,518 | 1,349           | 94,000  | 8,639           | 202,987 | 17,536          | 324,697 | 26,626          | 333,094 | 26,864          | 491,911  | 35,256          |
| All other vessels           | 11,574  | 447             | —      | —               | 581    | 24              | 24,673 | 565             | 16,470  | 668             | 19,951  | 1,203           | 18,705  | 1,274           | 8,524   | 780             | —        | 1,948           |
| Internal-combustion engines | 2,661   | 617             | 2,206  | 476             | 52     | 23              | 5,392  | 1,707           | 7,592   | 3,061           | 10,175  | 4,299           | 10,283  | 4,804           | 10,844  | 5,124           | 9,314    | 4,908           |
| Steam reciprocating engines | 1,229   | 151             | 561    | 73              | —      | —               | 944    | 260             | 1,453   | 282             | 1,864   | 438             | 1,932   | 498             | 2,219   | 655             | 2,522    | 755             |
| Turbines                    | 993     | 234             | 473    | 171             | —      | —               | 1,854  | 837             | 2,435   | 1,390           | 3,377   | 1,610           | 5,267   | 2,575           | 5,164   | 3,095           | 5,942    | 3,649           |
| Total                       | 171,787 | 9,525           | —      | 7,801           | 15,738 | 1,246           | 91,401 | 7,297           | 234,365 | 23,730          | 461,770 | 45,523          | 485,004 | 49,897          | 484,090 | 50,697          | 651,789* | 62,431          |

\* Excluding tonnage of "All other vessels."

it lessens the incentive to acquire and operate faster and more up-to-date ships. An efficient fleet may, in fact, be the best defence against a shipping slump.

Shipping earnings are of vital importance to the British balance of payments; an inquiry in 1947 showed that they contributed foreign currency to the value of 60.3*l.* millions. In 1951, it is unofficially estimated that net earnings of foreign exchange will be 150*l.* millions, excluding the earnings of the tanker fleet. These earnings, however, will not be maintained in face of falling freight rates unless more is done to replace the high proportion of over-age tonnage on the British register. The General Council of British Shipping, in a memorandum submitted to the Royal Commission on the Taxation of Profits and Income, pointed out that the British merchant fleet must hold its own in international markets. Nevertheless, over 40 per cent. of the dry-cargo fleet on British and Colonial registers was built in 1939 or earlier, and more than 23 per cent. is over 20 years old. The need to replace ships over 20 years old is urgent, but at present prices it would cost about 310*l.* millions. This imposes a very considerable burden upon the shipping industry and on the national economy. An example is given by the Council to show that,

quickly as possible in good times so that the arrears of unabsorbed depreciation allowances are not allowed to accumulate in bad times.

However inadequate the rate of replacement of British shipping may still be, orders for new tonnage from British shipowners have been reviving. As will be seen from Table IV, taken from Lloyd's Register's shipbuilding returns, the tonnage under construction for British owners at the end of 1951 was 21 per cent. higher than at the end of 1950. On the other hand, the tonnage under construction for registration in overseas countries fell, though, as will be seen from Table V, taken from the *Trade and Navigation Accounts*, exports of ships and their engines were somewhat higher in 1951 than in 1950. The fall in export demand is not at present of grave concern to British shipbuilders, as their order books are full, but the rapid rise in world shipbuilding capacity is one of the most serious threats they have to face. Economic nationalism is bringing into being shipbuilding industries, in many countries, which cannot hope to be competitive. The latest example is the announcement that the Fiat Company of Turin are negotiating with the Argentine Government for the building of new yards at Rio Santiago, on the River Plate. The Fiat Company are already providing equipment

by 30 per cent. would cut the price of ship construction by 10*l.* per ton.

The tonnage under construction in German yards more than doubled over 1951, from 198,000 tons at the end of 1950 to 430,000 tons at the end of 1951. All but a few of the restrictions on German shipbuilding were lifted in April, and, as a result, there was a rush of orders from German shipowners, mainly for dry-cargo vessels. Important foreign orders were also received, however, mainly from Norway, Panama, Sweden and Switzerland, after the removal of all restrictions on shipbuilding for export in September, 1950. Export orders received during the first six months of 1951 were valued at 38*l.* millions, and, at the end of December, 249,000 tons were under construction on foreign account. Orders on home account are being stimulated by Government loans. Dr. Schaeffer, the Federal Minister of Finance, announced in April that DM. 100 millions have been earmarked for shipbuilding loans. The North German Länder are also making available considerable funds. As a result, the German merchant fleet is increasing rapidly. In the year to July, 1951, before the removal of restrictions on shipbuilding in Germany could have had any effect, it rose by 571,000 tons to 1.0 million tons, still less than a quarter of its

pre-war size. The main obstacle to German building at present is the shortage of raw materials, mainly steel plate. The shipbuilding industry, however, has high priority and the situation is expected to ease considerably in a year's time, when the new 3-m. plate mill at Hoerde, financed by the European Co-operation Administration, comes into operation with an output of 18,000 tons a month. The present capacity of German yards is about 400,000 tons, or 50 per cent. of the pre-war capacity, and cannot be extended without Allied permission. German pressure for the removal of this, the most important of the few remaining restrictions on their shipbuilding industry, must be expected, however, as soon as the supply of raw materials improves.

Shipbuilding in Italy is heavily subsidised. The largest liner built since the war, the Andrea Doria of 25,000 tons, was launched in the summer, and work has now been started on a sister ship. The Italian merchant fleet increased by 337,000 tons to 2.9 million tons, or only 500,000 tons less than in 1939. The tonnage under construction for Italian owners declined from 261,000 tons in December, 1950, to 211,000 tons in December, 1951. So far, this has not been offset by any increase in foreign orders, largely because Italian shipbuilding costs are high. The tonnage under construction for foreign account amounted to 19 vessels, of 52,000 tons. Shipbuilding costs are perhaps higher in the United States than in any other country, but the United States Government find it worth while to keep the yards going by placing Government orders and by paying subsidies to some shipowners. At present, the Maritime Administration has on order 35 cargo vessels at seven shipyards. The total tonnage under construction in United States yards amounts to 52 vessels, of 377,000 tons.

British yards have held their own so far in competition with foreign builders, though the increase of 11.5 per cent. in tonnage under construction in the United Kingdom, to 2.2 million tons in the year to December 31, 1951, compares with an increase of 13.5 per cent., to 5.5 million tons, in the tonnage under construction in the world over the same period. In harder times, surplus capacity abroad, possibly benefiting from subsidies, may accentuate the difficulties with which the shipbuilding industry has been only too familiar in the past. Despite all the difficulties, British shipbuilding has seldom, if ever, enjoyed such a period of continuous prosperity as at present; for example, Harland and Wolff, Limited, who again in 1951, when they launched 155,388 tons of shipping, had the largest output of any single shipbuilding concern in the United Kingdom, have now launched over 100,000 tons per annum in 12 successive years. For some of the smaller yards, prosperity does not appear to extend quite so far ahead as for the larger, but most of them have a sufficiency of work on hand. At Leith, there was a reduction in the tonnage under construction from 31,900 tons in December, 1950, to 26,600 tons in 1951, but most other districts recorded increases. At Aberdeen, the tonnage under construction increased from 7,000 to 13,600. At Selby, Cochrane and Sons, Limited, launched 8,900 tons in 1951, compared with 8,100 in 1950. In December, 1951, orders on hand, mainly for trawlers, amounted to 16 vessels of 7,600 tons.

Steel is the main problem confronting shipbuilders in 1952. At the end of 1950 shipbuilders were anxiously considering the possibility of obtaining supplies of plate from Japan. Norway and Sweden have already made extensive purchases, but British shipbuilders found the price demanded, nearly two and a half times as much as that of British-produced steel, more than they were prepared to pay. It has been announced recently that, after lengthy negotiation, some Japanese steel has been obtained at more reasonable prices, but the quantity involved is relatively small. By the second quarter of 1952, however, as American supplies become available, the shortage should ease considerably for most steel users, including shipbuilders. If so, 1952 will be yet another year of high output. Thereafter, as far ahead as shipbuilders may care to look, there is a prospect of continuing prosperity.

## LIGHT-WEIGHT BUILDING.

CAMBRIDGE ENGINEERING AND STRUCTURAL DEVELOPMENTS, LIMITED, CAMBRIDGE.

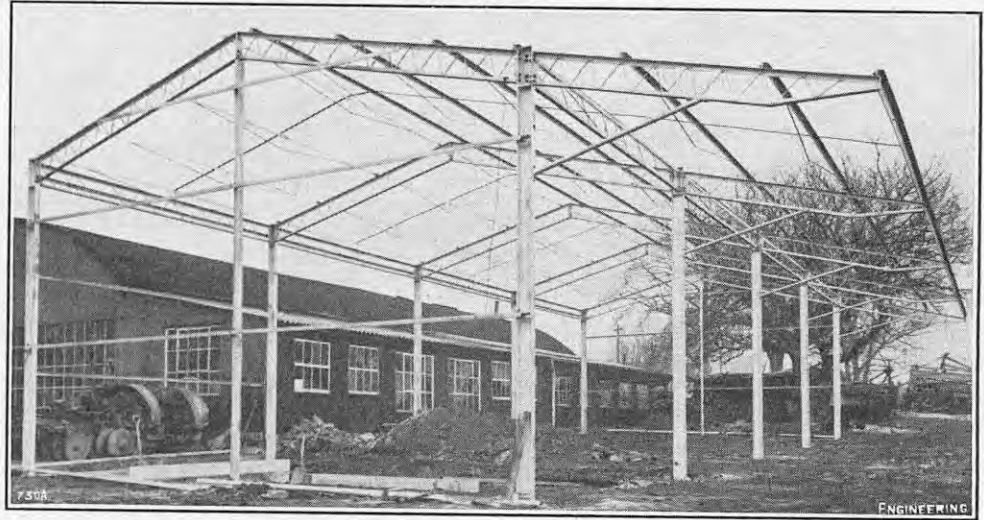


FIG. 1.

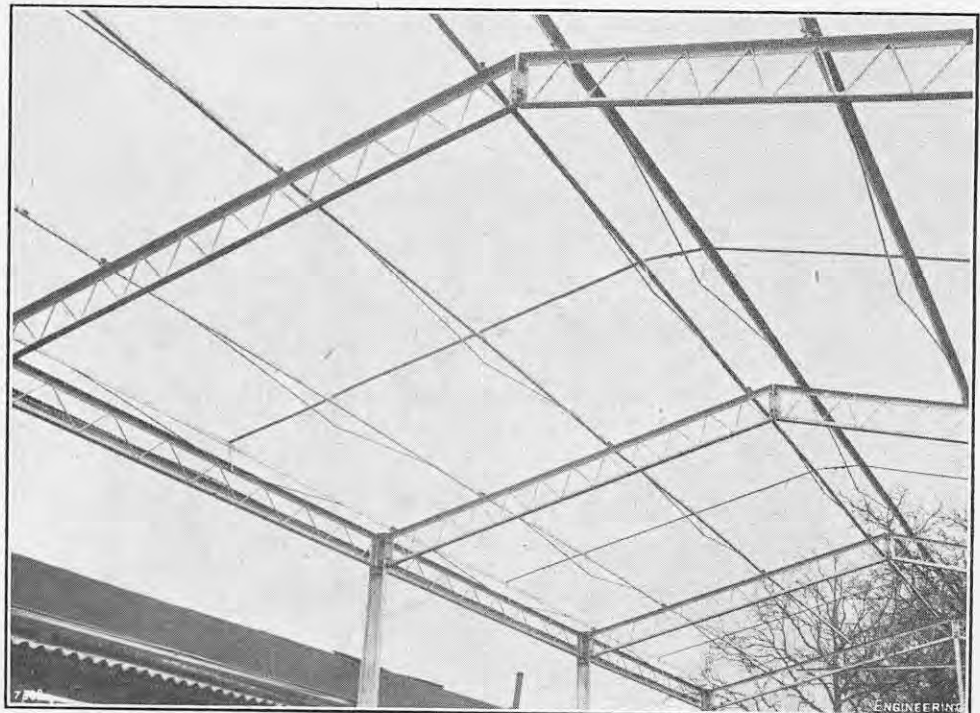


FIG. 2.

### THE C.E.S.D. LIGHT-WEIGHT BUILDING.

THE light-weight steel building illustrated in Fig. 1, on this page, which has been developed by Cambridge Engineering and Structural Developments, Limited, 85, Regent-street, Cambridge, incorporates several interesting features. The design is aimed at obtaining lightness combined with strength and rigidity without increasing the cost over similar but heavier structures. To achieve this, a portal construction has been chosen for the main arches, which are used in conjunction with longitudinal wind beams arranged at the height of the eaves. This forms a stiff structure in planes both parallel and at right angles to the main arches and capable, therefore, of withstanding both side and end wind loadings as well as the normal dead loads.

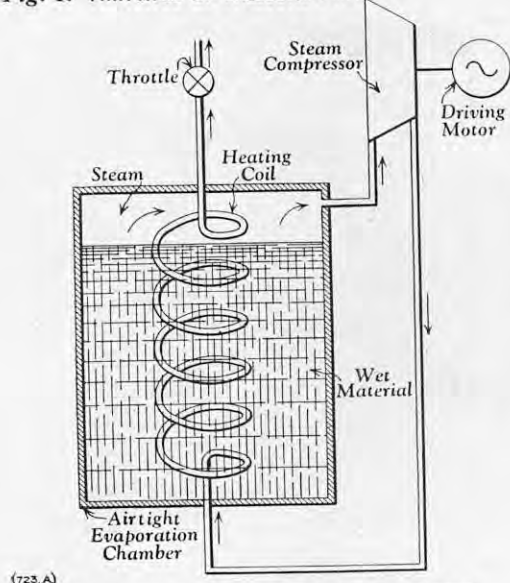
The rafters and wind beams are made from parallel angles held apart by diagonal bracing. They are 12 in. deep and the bracing rods are arranged to have included angles of 60 deg. and 90 deg. for the rafters and wind beams, respectively. A general idea of this form of construction can be gained from an examination of Fig. 2, which shows part of the roof structure separately. Both rafters and beams are tack-welded in a jig designed to locate the angles at the correct distance apart and the end-bolting angles either at right angles for the beams or at the required angle for the rafters. The bracing rods are also tack-welded to the inner flanges of the angles, being held by short pins incorporated in the jig.

Channels set at 15-ft. centres are used for the stanchions, tie webs welded above and below the bolt groups preventing the flanges from opening under load. Braced-angle purlins are employed in conjunction with the rafters and wind beams, the angles being of the same size as those used for the beams and the bracing rods having the same diameter as the diagonal bracing. The bracing wires are welded to the angles in a jig designed to give the purlins an upward deflection of 1 in. so that, on loading, they are straightened, thereby avoiding cracking of the roof sheeting due to excessive deflection. It has been estimated that this form of purlin can carry twice the load that can be carried by a plain-angle purlin 50 per cent. heavier. As the braced purlins are not sufficiently rigid in the transverse direction, they are joined to each other at the centres of their spans by light straps made from strip steel to prevent transverse sagging when the roof sheeting is placed in position.

Provision is made for additions to be made to the basic structure, such as canopies, lean-to rafter extensions or further ridged bays at each side of the initial structure, the stanchions being jig-drilled to accept these, regardless of whether they are required. The building illustrated in Fig. 1, for example, has a canopy along one side and it will be noted that this is built up from braced-angle rafters and purlins and is supported from the stanchions by tubular struts. Owing to the light weight of the various components, the building is exceptionally easy to erect; that illustrated in Fig. 1 took four men only 15 hours to erect.

## PRESSURE STILL WITH DILUENT AIR.

Fig. 1. PRINCIPLE OF PRESSURE STILL.

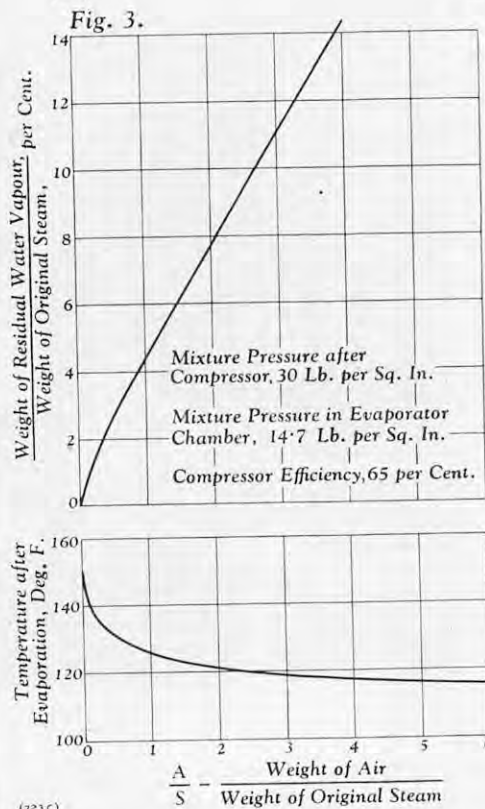
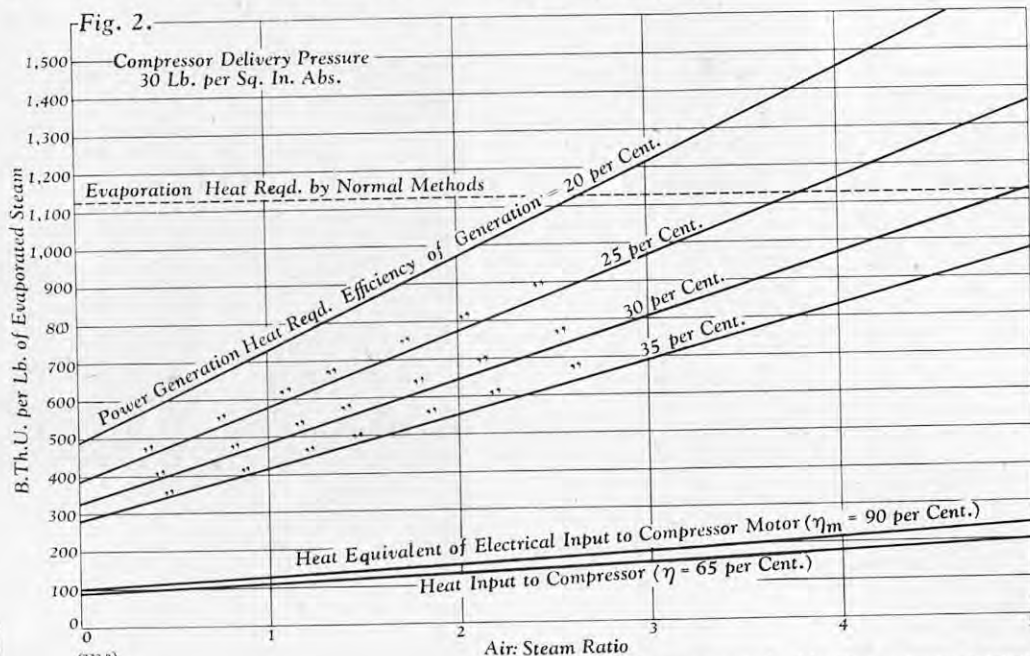


## THE PRESSURE STILL WITH DILUENT AIR.\*

By J. C. BARR.

THE principle of the pressure still is often limited in its applications owing to the fact that the technique involves an airtight chamber in which the material to be dried is placed. This causes difficulty in making adjustments when the drying is carried out in a continuous process such as the drying rolls of a paper mill. If the chamber can operate at approximately atmospheric pressure and be only roughly sealed off by means of hoods and side plates, then the applicability of the pressure-still principle will be considerably improved. In what follows, the effect of air leakage into the drying chamber has been assessed at one compression pressure on the assumption that there are no heat losses by radiation, convection or conduction from the system.

The principle of the pressure still is shown diagrammatically in Fig. 1, herewith. The purpose is to dry material that is admixed with, or dissolved in, a considerable quantity of water. The material to be dried is placed in the airtight chamber. If one assumes, in order to get the system moving, that heat is temporarily supplied from an outside source, then the water in the wet material will commence to evaporate and the resultant steam will pass out of the chamber, as indicated by the arrows, to the steam compressor. The pressure of the steam is raised to some arbitrary pressure, and is then fed back through a heating coil traversing the airtight chamber. In order to hold the pressure in the system at the compressor delivery pressure, a throttle valve is placed in the line of the exhaust water following the heating coil. Owing to the rise in pressure in the compressor, the condensing temperature of the steam passing through the coil is raised, consequently it will condense at a temperature higher than the boiling point of the liquid outside the coil. Thus, the latent heat of the compressed steam, plus its sensible heat down to the condensation point, is transmitted through the surfaces of the heating coil to the material that it is required to dry. Consequently, the latent heat of the steam derived from the evaporation chamber is continuously returned to the system and the temporary heat from the outside source can be cut off, no heat being required for the drying other than the heat equivalent of the work supplied by the compressor. In general, and depending on the compression pressure, the heat equivalent of the work applied to the compressor is considerably less than the heat that would be required to evaporate the liquid by normal means, even taking into account the efficiency of the compressor and the efficiency at which the work is generated for driving the compressor. Of course, as the pressure ratio across the compressor rises, the work input per pound of steam evaporated also rises and a point is finally reached where the system ceases to be thermally economic, but there is a considerable range of pressures where the system can show very large economies. Taking, for example, a system in which the evaporation chamber is working at about atmospheric pressure (14.7 lb. per square inch absolute) and the steam is compressed to 30 lb. per square inch, a compressor of 65 per cent. efficiency



will require an equivalent input of about 90 B.Th.U., in the form of compressor work, for each pound of water evaporated. If the compressor is driven by a Diesel engine of 35 per cent. thermal efficiency, then this corresponds to a heat input to the fuel of 257 B.Th.U., whereas by normal evaporation methods a heat input of 1,124 B.Th.U. would be required for water initially at 59 deg. F. (15 deg. C.).

If the evaporation chamber is no longer airtight, then air will leak into the chamber and will be picked up along with the steam and compressed in the compressor. Thus, in addition to the steam, extra work will be required to compress the air. The system thus becomes less economic. However, provided the proportion of air does not become too high then it can still be more economic than the normal method of drying. The effect of the addition of various proportions of air has been calculated for one set of pressure conditions, the assumptions being as follows: evaporating chamber pressure, 14.7 lb. per square inch absolute; compressor delivery pressure, 30 lb. per square inch absolute; compressor isentropic efficiency, 65 per cent.; efficiency of driving motor (electric) for compressor, 90 per cent.; inlet temperature of water to be evaporated, 15 deg. C. (59 deg. F.); inlet temperature of leakage air, 15 deg. C. (59 deg. F.). To allow the assessment of the thermal economy at various power generation efficiencies, the heat input to the generator

to supply the power required by the compressor driving motor has been calculated for various generation efficiencies rising from 20 per cent. to 35 per cent.

The results of this examination are presented in Fig. 2, herewith. It will be observed that the break-even point of thermal economy, even for a generation efficiency as low as 20 per cent., is not reached until the air: steam ratio rises to approximately 2.6:1. At higher generation efficiencies the ratio is correspondingly raised. Provided the air: steam ratio can be kept reasonably low, i.e., about 0.5:1, then the loss of economy due to the leakage air is not prohibitive. Thus, at a power generation efficiency of 20 per cent. with an air: steam ratio of 0.5:1, the heat input required per pound of evaporated water is 610 B.Th.U. as against 1,124 B.Th.U. for evaporation by normal methods. Thus, the fuel economy is about 45 per cent. It is true that the heat losses from the system, by conduction, convection and radiation, have not been allowed for, but neither have they in the case of normal evaporation, so that these two factors should balance out to some extent. It should be noted that, with the assumptions made, the heat available in the compressed steam down to its condensation point and after surrender of latent heat, is not quite sufficient to balance the heat required to evaporate the water, and that the system will only be self-running if the heat can be abstracted from the resulting condensed water down to some considerably lower temperature than the boiling point. This can be achieved in some type of contra-flow heat-exchange system, the cold wet material being first heated up in a preliminary chamber, or chambers, by the hot water exhausting from the coils of the still. The final temperature of the water after passing through the system in order to maintain balance is shown in Fig. 3, on this page.

The conclusions are as follows. The usefulness of the pressure-still principle can be enlarged to cover cases where leakage air is admitted to the drying chamber, provided the amount of leakage air is limited. For any given set of conditions, there is a ratio of leakage air to water evaporated which marks the thermal economic limit of usage. With air present in the system, the heat transmission surface will be considerably increased by reason of the poor heat transfer from a stream of air and steam mixture as compared with pure steam or water. This may limit the application of the system in certain instances, since the interest and depreciation on the extra capital cost involved may not offset the value of the fuel saved. By reason of the very large saving in heat or fuel, however, there must be many applications where the system would prove to be economic. The effect of heat losses will be to reduce the amount of air that it is permissible to allow in the system. No attempt has been made in this report to allow for these since they will depend largely on the specific application. It was found that, provided a contra-flow heat-exchange system can be arranged, the still will operate without auxiliary heat (other than that supplied by the compressor).

CONFERENCE ON INFORMATION IN INDUSTRY.—A one-day conference on "Information and Industry," to be held in London on March 18, is being organised jointly by the Federation of British Industries and Aslib. It is intended mainly as a guide to those firms who have no information service of their own.

\* Report No. 2105/X25 issued by Power Jets (Research and Development) Limited, 25, Green-street, London, W.1. Abridged.

## THE INSTITUTE OF METALS.

THE 1952 annual general meeting of the Institute of Metals will be held in London from Monday to Thursday, March 24 to 27, at the Park Lane Hotel, Piccadilly, W.1. The May Lecture will be delivered by Dr. J. J. P. Standinger on "The Place of Plastics in the Order of Matter," at the Royal Institution, Albemarle-street, London, W.1, at 6 p.m. on March 24.

On Tuesday, March 25, at 10.30 a.m., the reports of Council and of the honorary treasurer will be presented, after which the new President, Dr. C. J. Smithells, will be inducted and will deliver his presidential address. Following a luncheon at 1 p.m., the Institute of Metals Platinum Medal will be presented to Mr. W. S. Robinson, the Rosenhain Medal to Professor André Guinier, and the W. H. A. Robertson Medal to Mr. C. E. Davies. In the afternoon, at 2.45, four papers will be presented, on "Production and Properties of Oxide-Reduced Copper Powder," by Dr. E. C. Ellwood and Mr. W. A. Weddle; "Interdiffusion and Sintering in Copper-Nickel Composts," by Dr. J. M. Butler and Dr. T. P. Hoar; and "Sintering of Copper-Zinc Powder Composts," by Dr. D. D. Howat, Mr. R. L. Craik and Dr. J. P. Cranston. The fourth paper is "Creep and Softening Properties of Copper for Alternator Rotor Windings," by Mr. N. D. Benson, Dr. J. McKeown, and Mr. N. D. Mends. In the evening, at 7 for 7.30, the dinner will be held at the Park Lane Hotel.

On Wednesday, March 26, two concurrent technical sessions will be held, both commencing at 9.30 a.m. Session "A" will comprise an all-day symposium on "Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," comprising seven papers, namely, "Electric Furnaces for Thermal Treatment," by Mr. C. J. Evans, Mr. P. F. Hancock, Dr. F. W. Haywood, and Mr. J. McMullen; "Gas Equipment for Thermal Treatment," by Mr. J. F. Waigh; "Batch and Continuous Annealing of Copper and Copper Alloys," by Mr. E. Davis and Mr. S. G. Temple; "Bright Annealing of Nickel and its Alloys," by Mr. H. J. Hartley and Mr. E. J. Bradbury; "Batch Thermal Treatment of Light Alloys," by Mr. C. P. Paton; "Flash Annealing of Light Alloys," by Mr. R. T. Staples; and "Continuous Heat-Treatment of Aluminium Alloys of Duralumin Type," by Mr. M. Lamourdedien.

At Session "B" on March 26, ten papers will be discussed, the first being "Hardness and Strength of Metals," by Dr. D. Tabor. The remaining nine papers, all of which are concerned with titanium, will be discussed jointly; they are "The  $\alpha$ - $\beta$  Transformation in Titanium," by Dr. A. D. McQuillan; "Application of Hydrogen Equilibrium-Pressure Measurements to Investigation of Titanium-Alloy Systems," by Dr. A. D. McQuillan; "Constitution of Titanium-Iron Alloys," by Mr. H. W. Worner; "Titanium-Hydrogen System for Magnesium-Reduced Titanium," by Dr. A. D. McQuillan; "Provisional Constitutional Diagram of Chromium-Titanium System," by Mrs. M. K. McQuillan; "X-ray Study of Phases in Copper-Titanium Systems," by Mr. N. Karlsson; "Structure and Some Properties of Titanium-Oxygen Alloys," by Mr. A. E. Jenkins and Mr. H. W. Worner; "Heat-Treatment of Titanium-Iron Alloys," by Mr. H. W. Worner; and "Effect of Elements of First Long Period on the  $\alpha$ - $\beta$  Transformation in Titanium," by Dr. A. D. McQuillan.

In the afternoon of March 26 four papers will be discussed at Session "B," namely, "Mechanism of Precipitation on Aluminium-Magnesium Alloys," by Mr. E. C. W. Perryman and Mr. G. B. Brook; "Reaction of Aluminium-Magnesium Alloys with Steam," by Mr. A. J. Swain; and "Mechanism of Stress-Corrosion in Aluminium-Magnesium Alloys," by Dr. C. Edeleanu. The fourth paper is "Ageing Characteristics of Binary Aluminium-Copper Alloys," by Dr. H. K. Hardy. In the evening of March 26, at 8 p.m., an informal conversation and exhibition will be held at the offices of the Institute, 4, Grosvenor-gardens, S.W.1.

On Thursday, March 27, there will again be two programmes, the first ("A") consisting of visits to the works of the Ford Motor Company, Dagenham, and J. Stone and Company (Charlton), Limited, Charlton.

Programme "B" will consist of a morning metal-physics session, commencing at 9.45 a.m., when five papers will be considered. The first two papers deal with "Fatigue" and are: "New Observations on Mechanism of Fatigue in Metals," by Dr. W. A. Wood and Mr. A. K. Head; and "Metallographic Observations on Fatigue of Metals," by Mr. P. J. E. Forsyth. The last three papers will deal with "Plastic Deformation"; they are "Slip and Polygonisation in Aluminium," by Dr. R. W. Cahn; "Inhomogeneities in Plastic Deformation of Metal Crystals," by Dr. R. W. K. Honeycombe; and "Slip Bands and Hardening Processes in Aluminium," by Dr. A. F. Brown. In the afternoon, there will be visits to the Physics Department of B.I.S.R.A., at Battersea; the G.E.C. Research Laboratories at Wembley, and the precious-metal refinery of the Mond Nickel Company, at Acton.

## INFRA-RED DRYING OVENS.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.



FIG. 1. MOISTURE-DRYING OVEN.

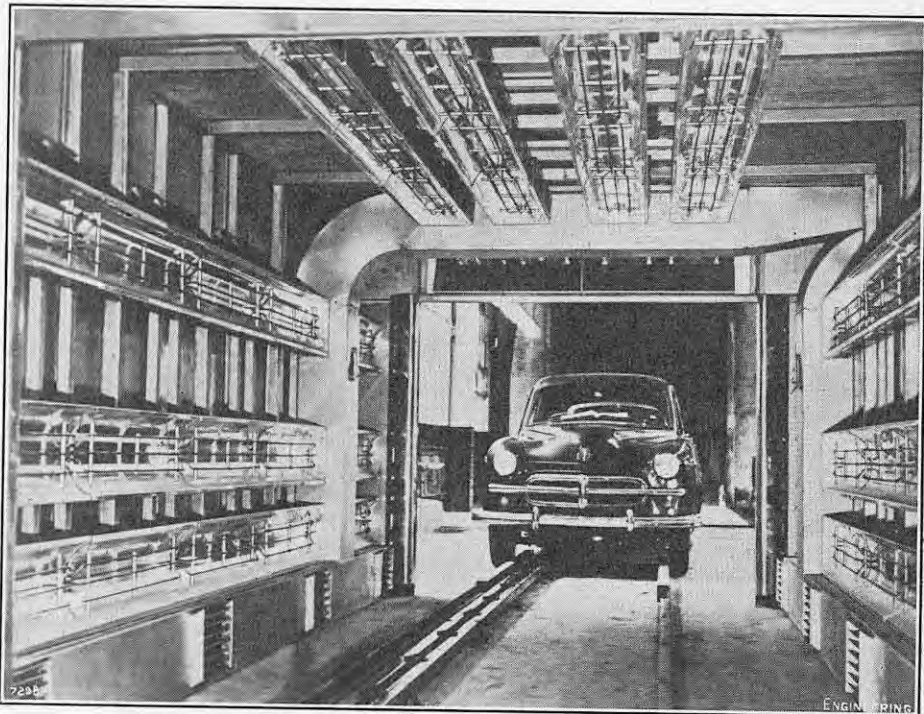


FIG. 2. SPOT-DRYING OVEN.

## INFRA-RED OVENS FOR DRYING MOTOR-CARS.

FOUR infra-red tunnel ovens, through which motor-cars are passed for drying moisture and paint, have recently been installed at the Luton factory of Vauxhall Motors, Limited. They were built by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, and are arranged in two pairs, one of which is shown in Fig. 1, herewith. Two of the four are used for drying moisture off the car after cleaning, and the others for drying any touching-up of cellulose paint that may be necessary before the cars leave the factory. Air is circulated through each oven at a rate of 4,000 cub. ft. per minute.

The completely-assembled car is driven on to a floor-level chain conveyor which draws the car through a washing booth, where jets of water thoroughly test for leaks in the screen and back-light. After spraying, it is leathered down by hand, leaving the car with a thin film of moisture to be dried off. This is done in the first oven (Fig. 1), through which the car passes in four minutes; the infra-red radiation is controlled at a level which ensures that no part of the car exceeds a temperature of 180 deg. F. during its passage through the oven. After emerging from this oven the car travels 50 ft., by which time it is completely dry, before entering the spray booth, where spotting and touching-up are carried out with cellulose paint. A further travel of 20 ft. gives a "flash-off" period of about five minutes before the car enters the cellulose-

drying oven, which is traversed in 3 minutes 20 seconds, when the car emerges ready for final polishing.

The first infra-red plant, comprising two ovens side by side as shown in Fig. 1, is 17 ft. long, 24 ft. wide and 10 ft. high, with a total electrical loading of 300 kW. Each oven is fitted with 50 infra-red element projectors mounted in ten rows of five projectors per row. The infra-red element consists of a spiral of high-grade heat-resisting wire, tightly embedded by a special process in magnesium oxide and enclosed solidly in an outer sheath of a non-scaling non-corrodible alloy. The trough reflector is made of aluminium sheet, anodised to give maximum heat reflection and protection from atmospheric corrosion. A separate air-circulating system, consisting of a centrifugal fan driven by a 2½ h.p. motor and displacing 4,000 cub. ft. per minute, drives air into each oven through ducts mounted at floor-level in the sides of the oven. Hot air is exhausted from the oven roof through three hoods extending the full length of the oven and connected by ducts to the suction side of the fan. The apertures in the lower ducts are louvred to direct the air stream on to the sides of the car, and to reduce the amount of floor dust entrained. Dampers in each main duct enable a correct balance to be obtained between the recirculated air and the fresh air. The fans are mounted in separate structures housed in the central compartment between the ovens.

Complete safety is ensured by electrical interlocking of the conveyor motors and fans with the infra-red projectors, and, in addition, air-flow switches, similarly

## "DRI-POR" METHOD OF REPAIRING CONCRETE PILES.

METROPOLITAN RESURFACING AND CONSTRUCTION CO., INC., CURTIS BAY, MARYLAND, U.S.A.

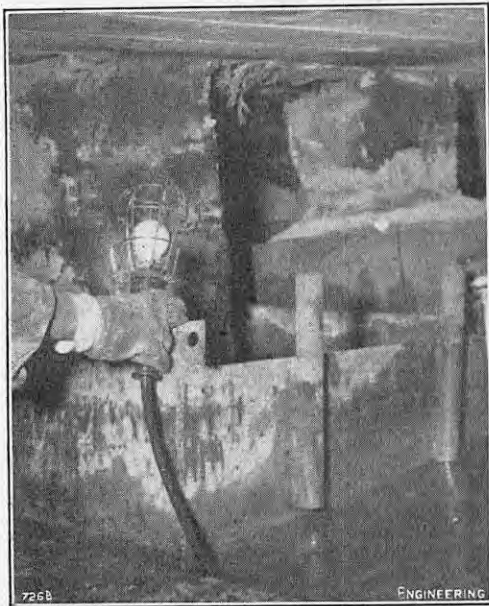


FIG. 1. SETTING CAISSON ROUND PILE.



FIG. 2. PILE READY FOR TREATMENT.

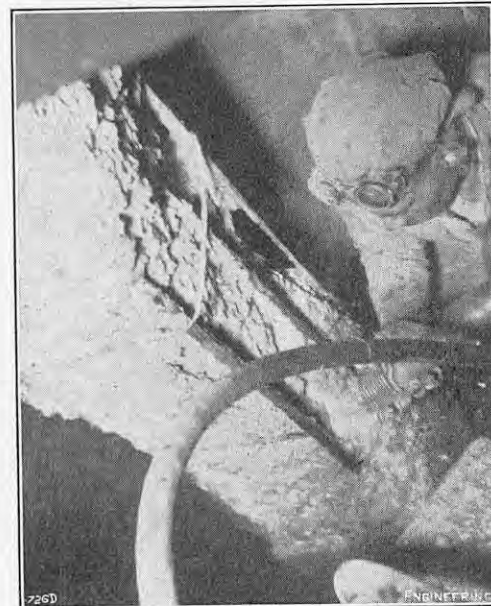


FIG. 3. CHIPPING DETERIORATED CONCRETE.

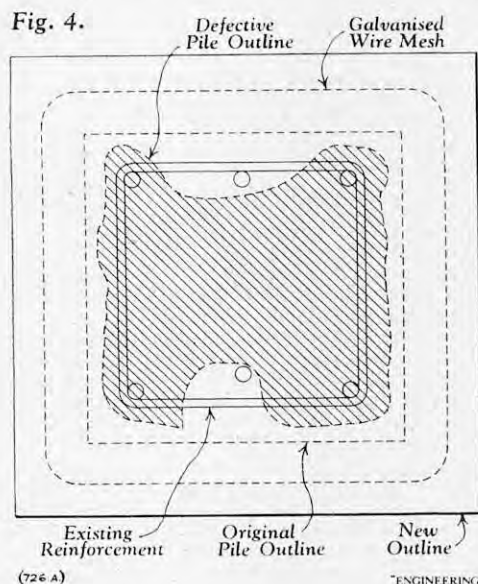


FIG. 5. PLACING WIRE MESH ROUND PILE.

### "DRI-POR" METHOD OF REPAIRING CONCRETE PILES.

THE photographs reproduced on this page and page 240 illustrate the "Dri-Por" method of repairing deteriorated concrete piles, which has been developed by the Masonry Resurfacing and Construction Company, Incorporated, B. and O. Coal Pier, Curtis Bay 26, Maryland, U.S.A. The method is applicable to those zones of marine piles, between mean low water and mean high water, where deterioration is most severe. The affected part is enclosed in a small caisson, which is then pumped dry. After the inferior concrete has been chipped away and the existing reinforcement made good (if necessary), high-quality concrete, reinforced with wire mesh, is placed round the pile; this concrete is held by a galvanised-iron form, which is allowed to remain *in situ* after the job has been finished. As the form is larger in section than the original pile, the repaired zone is also larger and is therefore better able to withstand subsequent erosion and deterioration. Fig. 4, on this page, shows the relative sizes of the various sections. The method also includes guniting of the pile above the repaired part.

The cyclic variation of the conditions at the water line of a pile results in deterioration after, perhaps, 15 or 20 years. Necking of the pile due to disintegration of the concrete causes a reduction in the effective section of the pile, and the steel reinforcement may rust. The company point out that other methods of

pile repair, in which a diver removes the marine growths and disintegrated concrete, suffer from certain disadvantages. In particular, the diver has to work under difficult conditions; his equipment is bulky and often he cannot see the work clearly, especially if the pile is in the polluted water which is found in most present-day harbours. There is therefore a risk that the affected area of the pile is not properly cleaned and that the new concrete will not bond efficiently. Difficulty can also be experienced in draining all water from within the form that is used in placing the concrete. Moreover, between the time the pile is prepared and the form is fixed in position, the rising and falling tide is liable to deposit a scum which will later diminish the effectiveness of the bond.

The "Dri-Por" system, however, achieves a good bond between the old and new concrete; it gives a longer life, owing to the greater section of new concrete which covers the reinforcement; and it employs a durable concrete, with an air-entraining agent, which is better able to resist the effects of the cyclic conditions. The successive stages of the method are illustrated in the photographs reproduced on this page, and on Figs. 6 to 9, on page 240. A small open-top caisson just large enough to allow a man to work in it, is erected round the affected zone of the pile (Fig. 1). The joint at the base of the caisson is sealed and the caisson is pumped dry; the pump continues working, if necessary, while the repair is in progress. Fig. 2 shows the pile inside the caisson at this stage. All deteriorated concrete is then chipped off (Fig. 3), the chipping being continued, if required, behind the reinforcement and even right through the section of the pile. An examination of the prepared zone will show whether it is necessary to make good the reinforcement at this stage.

Wire mesh is then fixed round the pile (Fig. 5) and the galvanised form is placed in position. The form is designed to resist bulging while the concrete is poured, and it is set independently of the caisson, and about 6 in. above the floor of the latter, so that it cannot be distorted by movement of the caisson or be affected by a slight leakage of water. The concrete is then poured; a pile after this stage is shown in Fig. 6, which also shows the upper part of the form. Above the repaired zone of the pile, the exposed original concrete is chipped, wire mesh is placed (Figs. 7 and 8), and guniting is carried out to restore the original dimensions. This part of the work is usually done when a bent of piles is ready, as shown in Fig. 8. A pile completely restored by the method described is shown in Fig. 9. The only limitation of the "Dri-Por" method arises when the piles are too close together to allow the small caisson to be erected. The method can also be applied to timber piles.

interlocked with the projectors, ensure that the air velocity has reached a safe minimum value before the projectors can be switched on. Heat loss from the ovens is reduced by the use of heat-insulating panels of mild steel, lagged with glass wool and finished on the inside with asbestos hard-board. The panels are easily removed to give access to the infra-red projectors and wiring. Access to the central compartment is by means of a hinged door fitted with a tumbler lock to prevent unauthorised entry. The heat output of the oven is controlled by Sunvic energy regulators which operate on the well-known Simmerstat energy regulator principle, as used on electric cookers for controlling the boiling plates. Each regulator also provides automatic compensation for voltage fluctuations up to 15 per cent. The second plant, which is shown in Fig. 2, is generally similar to the first, except that it is 3 ft. shorter in length and has a total electrical loading of 240 kW, provided by 40 Metrovick infra-red projectors which are mounted in each oven in ten rows of four projectors per row.

**PRODUCTION OF PIG IRON AND STEEL IN UNITED KINGDOM.**—Statistics issued by the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, indicate that the production of steel ingots and castings in January was at an annual rate of 15,234,000 tons, compared with a rate of 14,953,000 tons in December and of 15,907,000 tons in January, 1951. The output of pig iron in January was at an annual rate of 10,319,000 tons, compared with a rate of 10,281,000 tons in December and of 9,520,000 tons in January, 1951.

**WEEK-END COURSE FOR FOREMEN ON MANAGEMENT.**—A week-end residential course for foremen and supervisors on "The Practice of Management" will be held at Dillington House, Ilminster, Somerset, from February 29 to March 2. The course is being organised by the Institute of Industrial Supervisors, Bank Chambers, 47, Temple-row, Birmingham, 2, and will be conducted by Mr. D. H. Bramley, head of the Industrial Administration Department, College of Technology, Birmingham.

## NOTES FROM THE INDUSTRIAL CENTRES.

### SCOTLAND.

**SCOTTISH STEEL AND IRON PRODUCTION.**—Despite higher pig-iron outputs, a shortage of metal for furnace charges, resulting from reduced scrap imports, caused steel production last month to drop to an annual rate of 1,671,500 tons, as compared with 1,836,700 tons in January, 1951. The production of pig iron was equivalent to a rate of 827,500 tons against 740,700 tons last year. The actual output in 1951 totalled 789,800 tons.

**SHORT-TIME WORKING AT ROLLING MILLS.**—The position of steel re-rolling firms in Scotland is giving rise to some concern. Steelworks are striving to distribute equitably their reduced output from the furnaces, but the supply of semi-manufactured steel to re-rollers of bars and sheets is inadequate to keep the mills working to anything like capacity. One firm, at present operating a double-shift, are reported to be almost certain to adopt single-shift working in the near future, and others are reducing their working shifts. Last week, the number of shifts at the Hallside Steelworks, Newton, of the Steel Company of Scotland, were reduced from 15 to 13, but it is hoped that the curtailment will be only temporary.

**SCOTTISH COAL EXPORTS.**—Coal exports from Scottish ports during January totalled 37,821 tons, compared with 37,136 tons in the corresponding month in 1951, 70,343 tons in 1950, and 73,373 tons in 1949. The pattern of shipments last month showed little change from a year ago, the only notable difference being the inclusion of Belgium and Germany among consignees. This arose from their acceptance of cargoes of silt.

**EARTH-MOVING OPERATIONS IN DAER VALLEY.**—Four heavy American tractors were landed on February 3 at Glasgow docks. These 275-h.p. Diesel-engined machines, which cost 13,000l. each, will be used for earth-moving operations in connection with the Daer Valley water scheme in South Lanarkshire.

**RESEARCH AT ROYAL TECHNICAL COLLEGE.**—The salaries offered in industry were tending to discourage some of the best students of the Royal Technical College, Glasgow, from staying on for training in research methods, particularly in engineering, according to Dr. D. S. Anderson, the director, speaking at a meeting of the governors of the College on February 14. An offer by the Belmos Co., Ltd., to establish a research scholarship in electrical engineering to the value of 300l. per annum for six years, with an additional annual sum of 100l. for disbursement to aid research projects, was accepted.

### CLEVELAND AND THE NORTHERN COUNTIES.

**SHORTAGE OF WATER ON TEES-SIDE.**—At a meeting of the Tees Valley Water Board, held on February 11, the chairman, Alderman C. W. Allison, referred to the inadequacy of the Board's present filtration plant to meet the increased weekly consumption of 12,000,000 gallons, which had arisen during the past 12 months. Of this quantity 9,000,000 gallons are taken by industrial consumers. To ease the present situation, two emergency schemes are being prepared, the one being the conversion of a cooling pond at Broken Sear, Darlington, into an additional filter bed, at a cost of 11,000l. The second scheme involves the laying of a pipeline, 4,000 yards in length, from Lartington to Barnard Castle. This, it was pointed out, would cost some 90,000l. and could be completed in from four to six months, provided that Government sanction was granted in respect of the quantity of steel needed, which lay between 700 and 1,000 tons. Meanwhile, an appeal has been made to the Board's domestic and industrial clients in Middlesbrough and adjoining districts to reduce their consumption of water by 7½ per cent. during the next five months.

**OVERCROWDING AT KING'S COLLEGE, NEWCASTLE-ON-TYNE.**—Lord Eustace Percy, Rector of King's College, Newcastle-upon-Tyne, in the course of his report to the College Council, referred to the inadequacy of the buildings of the student centre and assembly rooms, in relation to the number of students. He added that there is no prospect of any material addition to the premises before the second stage of the College development plan, during 1957-62. The Rector stated, moreover, that the social accommodation available for members of the College staff was even less adequate and equally difficult to expand in the near future. Lord Eustace Percy's comments have been prompted by the fact that the present number of students, 3,226, is expected to increase

to 3,500 during the next five years, the latter figure being nearly three times the pre-war total. He concluded that the only justification for pressing a policy of accepting further students in circumstances of overcrowding was if such a policy was forced upon the College authorities by a natural demand.

**SEARCH FOR NATURAL GAS IN NORTH YORKSHIRE.**—Permission to sink an experimental borehole at Fairhead Farm, Grosmont, some six miles from Whitby, in the North Riding of Yorkshire, has been applied for by Imperial Chemical Industries Ltd., Wilton Division, Middlesbrough. The company, who addressed their application to Whitby Rural Council, hope to find natural gas in sufficient quantity to make the scheme a commercial proposition. It appears that the presence of natural gas was revealed when borings for petroleum were sunk in the vicinity in 1938 and 1939. The Rural Council are now considering the application.

**DOCK IMPROVEMENTS AT WEST HARTLEPOOL.**—William Gray & Co., Ltd., the West Hartlepool ship-builders, are to increase the width of their Graythorp basin from 150 ft. to 450 ft., to improve the approach for ships and give greater freedom of movement within the basin. The material removed will be deposited on the west side of the dock as a preliminary to a scheme for building a new quay.

### LANCASHIRE AND SOUTH YORKSHIRE.

**SHEFFIELD STEEL PRODUCTION.**—In January, Sheffield and district produced an average of 1,000 tons of steel a week less than in January, 1951. The total was 44,400 tons a week, compared with 45,400 tons in January last year. A continued shortage of scrap and other melting materials was the reason and it is believed that the scarcity is likely to continue until the second half of the present year.

**ECONOMIES IN STEEL CONSUMPTION.**—The Sheffield Public Works Department is economising in the use of steel by reverting to an old form of building construction, namely, by spanning the basements of temporary shops with brick arches resting on brick pillars. It had originally been intended to utilise reinforced-concrete beams between the pillars.

**STEEL RESEARCH STATION.**—At the research station of the British Iron and Steel Research Association at Sheffield a scale model, one-twelfth full size, of an open-hearth furnace has been built and is to run on a shift basis like its full-scale counterparts. The object is to test various designs of furnaces, the effect of design on output, and the influence of the composition of the fuel used. The furnace design can be altered daily if necessary, and component parts, such as bricks, will be altered so that their effects may be studied. One object of the experiments is to reduce the time employed for making steel.

**FOREMEN IN CONFERENCE.**—Following the recent success of conferences of steelworks foremen in Derbyshire, six representative foremen have attended a two-days conference at Birmingham, organised by the National Association of Drop Forgers and Stampers. The chairman of the conference was Mr. W. E. A. Redfearn, a special director of the English Steel Corporation Ltd., Sheffield, who is now in his second year as President of the Association.

**MANUFACTURE OF CUTLERY BY ENGINEERING PROCESSES.**—A Sheffield firm, Fiberloid, Ltd., have applied engineering methods to cutlery manufacture and are producing an all-steel knife which weighs less than an ounce. The knife has a hollow handle and is welded without flux or solder. Eighteen months of research have been needed to perfect the welding method. Since September, 1950, some 200,000 articles of cutlery have been made and the Air Ministry has taken the major part of the output.

### THE MIDLANDS.

**FURNACE RELINING AT BILSTON.**—No. 2 blast furnace at the Bilston steelworks of Stewarts and Lloyds, Ltd. has been blown out for complete relining. As soon as No. 2 furnace has been relined, No. 4 will be blown out for the same purpose. The only other furnace at the plant, No. 5, was relined a few months ago, as we reported at the time. It is probable that none of the furnaces will be relined again, as the plant is to be reconstructed, when new furnaces will be built. The existing ones will then be dismantled.

**OUTPUT OF TRACTORS.**—The output of Ferguson tractors at the Banner Lane Works, Coventry, of the Standard Motor Co., Ltd., in the past five years has

exceeded 250,000. About three-quarters of the total has been exported to 72 countries. Since the prototype first appeared in 1935, more than 620,000 Ferguson tractors have been made, and the company claim that this is probably the largest production of a single model of tractor ever achieved.

**"FLATTED" FACTORIES AT WALSALL.**—The Town Council of Walsall has commenced the erection of the first of its "flatted" factory buildings in Red Lion-street. The factory is of two storeys and is designed to accommodate four separate firms, but it will be taken over on completion by a Walsall firm whose existing premises are to be acquired by the Council. The cost of erection will be about 17,000l.

**THE EMPLOYMENT OF THE ELDERLY.**—At a conference of the Birmingham Branch of the Institute of Personnel Management on February 13, Mr. A. G. B. Owen, chairman and managing director of Rubery Owen & Co., Ltd., Darlaston, gave some details of his firm's scheme for retaining employees who have passed the normal age of retirement. The company have a special workshop at their Darlaston works, where these older employees, whose average age is 75½, are engaged on production work. They work a 37½-hour week, and are allowed special privileges in time-keeping and general working conditions, if they wish. Mr. Owen said, however, that of 18,421 hours available for work last year, only 811½ were lost, and this time was accounted for by unavoidable causes. A rest room was provided, but was never used. The scheme has been adopted in Denmark, and at least six American firms have followed suit.

**WATER CONSUMPTION IN BIRMINGHAM.**—The Water Committee of the Birmingham Corporation have reported another increase in water consumption in the city's supply area. Water is now being used at the rate of 47,400,000 gallons a day, an increase of 1,800,000 gallons over the figure for the corresponding period of last year.

### SOUTH-WEST ENGLAND AND SOUTH WALES.

**UNREST IN SOUTH WALES COLLIERIES.**—South Wales faces the threat of a coalfield strike. This follows the decision of 36 miners' lodges, representing 25,000 miners in the Swansea, Dulais, Rhondda, Neath, Aberdare and Gwendraeth Valleys, recommending the lodges to tender 14 days' notice in protest against the abolition of workmen's fares on local omnibuses. Already, men at pits in the Dulais Valley have tendered notices, following a decision they reached on the same point last week. The area executive of the National Union of Mineworkers called a coalfield conference on Wednesday, February 27, to discuss the matter and also the proposed ban on Saturday work suggested by the Parc and Dare miners. The response, on the first Saturday, to the call for a boycott, intended as a protest against the cuts in the social services, was disappointing, for men at 136 pits in South Wales ignored the appeal and continued at work in response to the advice given by the union officials. The following Saturday, February 16, however, there was a much greater response, and fewer pits worked than on any Saturday this year.

**WELSH STEEL INDUSTRY.**—Steel production in South Wales in January showed a slight reduction over the figures for the corresponding month of last year. Weekly average output of ingots and castings was 67,340 tons this year against 67,740 tons last year. Pig iron production, however, increased, from a weekly average of 25,090 tons in January, 1951, to 28,190 tons this year.

**TOWER FOR LLANDARCY REFINERY.**—A 65-ton tower, 105 ft. long, is to be brought from London to Swansea for installation at the Llandarcy Oil Refinery. It is 12 ft. in diameter and will be towed by sea-going tugs from Woolwich Wharf to Swansea. It will take five days to reach Swansea and, on arrival, will be taken by rail to the refinery.

**THE FUTURE OF CARDIFF AIRPORT.**—The City Corporation of Cardiff have been informed that, if the development of Rhoose Aerodrome, near Barry, is carried out as proposed, it would mean the transfer there of all Ministry of Civil Aviation flying activities now at Cardiff Airport. This was because the Ministry would not be able to operate two aerodromes in the Cardiff area. The Ministry has informed the Cardiff Airport Committee that the Rhoose Aerodrome is to be brought back into flying use as from June 1 next. This is because the proposed new South Wales to Dublin air service would be operated with Dakota aircraft. A final decision by the Ministry on the future development of Rhoose and the consequent giving up by the Ministry of the present Cardiff Airport would be made later in the year, when the South Wales to Dublin service had been in operation for a month or two.

## 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.

**INSTITUTE OF PETROLEUM.**—Monday, February 25, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Air and Vapour Release from Aviation Fuels," by Mr. L. D. Derry, Dr. E. B. Evans, Mr. B. A. Faulkner and Mr. E. C. G. Jelfs.

**INSTITUTE OF ELECTRICAL ENGINEERS.**—*Radio Section:* Monday, February 25, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Debate: "That the Lone Worker Can No Longer Make a Major Contribution to Radio Development." *Mersey and North Wales Centre:* Monday, February 25, 7 p.m., Carter's Café, Bridge-street, Warrington. "Earthing," by Mr. P. W. Cave. *Scottish Centre:* Tuesday, February 26, 7 p.m., 39, Elmbank-crescent, Glasgow. "The Inductor Compass," by Mr. A. Hine. *London Students' Section:* Tuesday, February 26, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. "High-Voltage Air-Blast Circuit-Breakers," by Mr. D. J. Kingsbury and Mr. D. B. Johnston. *North-Western Centre:* Tuesday, February 26, 7 p.m., Engineers' Club, Manchester. Annual Lecture: "Why Bother About Poetry?" by Professor H. B. Charlton. *Supply Section:* Wednesday, February 27, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Joint Meeting with the *Steam Group*, INSTITUTION OF MECHANICAL ENGINEERS. "Performance of Natural-Draught Water-Cooling Towers," by Mr. H. Chilton. *Southern Centre:* Wednesday, February 27, 6.30 p.m., Technical College, Weymouth. "Review of British Underground Railway Practice," by Mr. T. S. Pick and Mr. R. Dell.

**INSTITUTE OF WORKS MANAGERS.**—*Manchester Branch:* Monday, February 25, 6.30 p.m., Grand Hotel, Manchester. "Foremanship," by Mr. T. E. A. Verity.

**INSTITUTE OF STRUCTURAL ENGINEERS.**—*Midland Counties Branch:* Monday, February 25, 7 p.m., Merchant Hall, Albion-street, Derby. "Some Aspects of Mechanics with Reference to Foundations," by Dr. G. Meyerhof. *Institution:* Thursday, February 28, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Torsional Strength of Structural Members," by Dr. W. B. Dobie.

**ILLUMINATING ENGINEERING SOCIETY.**—*Leeds Centre:* Monday, February 25, 7 p.m., Lighting Service Bureau, 24, Aire-street, Leeds, 1. Joint Meeting with the ELECTRICAL CONTRACTORS' ASSOCIATION. "Electric Lighting: A Contractor's Viewpoint," by Mr. J. Ashmore.

**ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.**—*Bournemouth Branch:* Monday, February 25, 7.30 p.m., Grand Hotel, Bournemouth. "Germanium Crystals," by Mr. S. A. Bell.

**INCORPORATED PLANT ENGINEERS.**—*West and East Yorkshire Branch:* Monday, February 25, 7.30 p.m., The University, Leeds. "Further Advances in Metallurgy," by Dr. A. Irvine. *London:* Tuesday, February 26, 7 p.m., Royal Society of Arts, John Adam-street, W.C.2. Joint Meeting with the INSTITUTE OF WELDING. "Modern Practice in the Welding of Pipes," by Mr. E. Fuchs. *Birmingham Branch:* Friday, February 29, 7.30 p.m., Imperial Hotel, Birmingham. "Costing and the Plant Engineer," by Mr. E. E. Mitchell.

**INSTITUTE OF FUEL.**—*Midland Students' Section:* Monday, February 25, 7.30 p.m., The University, Edmund-street, Birmingham. "Modern Trends in Coal Preparation," by Dr. G. F. Eveson.

**ROYAL INSTITUTION.**—Tuesday, February 26, 5.15 p.m., 21, Albemarle-street, W.1. "Dusts and Powders in Nature and Industry.—I. Occurrence and Properties of Particulate Materials," by Dr. H. Heywood. Thursday, February 28, 5.15 p.m., "Interference and Diffraction as General Wave Properties.—II. Applications in X-Ray Analysis," by Sir Lawrence Bragg, F.R.S.

**INSTITUTE OF REFRIGERATION.**—Tuesday, February 26, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Mechanical Handling Applied to Refrigeration," by Mr. L. R. Meyer.

**INSTITUTE OF HEATING AND VENTILATING ENGINEERS.**—*Scottish Branch:* Tuesday, February 26, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. "Automatic Controls," by Mr. R. Russell.

**INSTITUTE OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.**—Tuesday, February 26, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.1. "On the Acceleration of Ships," by Mr. H. Lackenby.

**INSTITUTE OF ROAD TRANSPORT ENGINEERS.**—*North-East Centre:* Tuesday, February 26, 7 p.m., Dunelm Hotel, Durham. "Paint: Its Application and Maintenance on Road-Transport Vehicles," by Mr. G. S. Metcalfe.

**INSTITUTE OF PRODUCTION ENGINEERS.**—*Luton Section:* Tuesday, February 26, 7.15 p.m., Town Hall, Luton. "Drop Forging," by Mr. J. C. Sharnan. *Luton*

*Graduate Section:* Tuesday, February 26, 7.30 p.m., Staff Canteen, Messrs. W. H. Allen and Co., Ltd., Queen's Engineering Works, Bedford. Debate: "That Design is More Important Than Production." *Shrewsbury Section:* Wednesday, February 27, 7.30 p.m., Walker Technical College, Oakengates, Salop. "Pattern for Progress: The Production of Steel Sheet and Tin Plate," by Mr. A. S. Huxley. *South Wales and Monmouthshire Section:* Thursday, February 28, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Manufacture of Ball and Roller Bearings," by Mr. R. K. Allan. *London Section:* Thursday, February 28, 7 p.m., Messrs. Creed and Co., Telegraph House, Colston-road, East Croydon, Surrey. "Modern Electroplating and Metal-Finishing Processes," by Mr. H. Cann. *Cornwall Section:* Thursday, February 28, 7.15 p.m., Cornwall Technical College, Trevenson Park, Pool. "An Assessment of Production Engineering Training," by Mr. T. B. Worth. *North-Eastern Graduate Section:* Friday, February 29, 7 p.m., Neville Hall, Newcastle-upon-Tyne. "Press-work," by Mr. J. M. Phillips.

**ROYAL AERONAUTICAL SOCIETY.**—*Graduates and Students Section:* Tuesday, February 26, 7.30 p.m., 4, Hamilton-place, W.1. "Meteorology from the Pilot's Point of View," by Mr. L. Welch; and "Gravity as an Aid to Soaring," by Dr. R. S. Scorer.

**ROYAL SOCIETY OF ARTS.**—Wednesday, February 27, 2.30 p.m., John Adam-street, W.C.2. "The Work of the National Research Development Corporation," by the Earl of Halsbury.

**INSTITUTE OF MARINE ENGINEERS.**—Wednesday, February 27, 5.30 p.m., King's College, Strand, W.C.2; and Thursday, February 28, 7 p.m., Wandsworth Technical College, S.W.18. "Marine Diesel Engines," by Mr. C. C. Pounder.

**LIVERPOOL ENGINEERING SOCIETY.**—Wednesday, February 27, 6 p.m., 24, Dale-street, Liverpool. "Some Aspects of Refrigeration Practice," by Mr. J. Douglas.

**MANCHESTER ASSOCIATION OF ENGINEERS.**—Wednesday, February 27, 7 p.m., Engineers' Club, Manchester. Students' Meeting. "Manufacture of Propellers," by Mr. H. J. Nixon.

**INSTITUTE OF MECHANICAL ENGINEERS.**—*Yorkshire Branch:* Wednesday, February 27, 7 p.m., The University, Sheffield. "Principles of Continuous Gauge Control in Sheet and Strip Rolling," by Mr. W. C. F. Hessenberg and Mr. R. B. Sims. *Institution:* Friday, February 29, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Gear-Tooth Stresses and Rating Formulae," by Dr. H. E. Merritt. **AUTOMOBILE DIVISION.**—*Birmingham Centre:* Tuesday, February 26, 6.45 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting. "Experiences During Twenty Years' Oil Engine Development," by Mr. C. B. Dicksee. *North-Western Centre:* Wednesday, February 27, 7.15 p.m., Engineers' Club, Manchester. Annual Meeting. *Western Centre:* Thursday, February 28, 6.45 p.m., Royal Hotel, Bristol. "Brake Linings," by Mr. J. G. Remington.

**INSTITUTE OF BRITISH FOUNDRYMEN.**—*Birmingham Branch:* Wednesday, February 27, 7.15 p.m., Grand Hotel, Birmingham. "Experiences with Investment Casting Process," by Mr. D. F. B. Tedds. *London Branch:* Wednesday, February 27, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Investment Casting," by Mr. G. A. Tomlinson. *Falkirk Section:* Friday, February 29, 7 p.m., Temperance Café, Lint Riggs, Falkirk. Annual Meeting. "Time and Motion Study in the Foundry," by Mr. D. W. Provan. *Wales and Monmouth Branch:* Saturday, March 1, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Synthetic Resins as Core Binders," by Mr. G. L. Harbach.

**ROYAL STATISTICAL SOCIETY.**—*Sheffield Industrial Applications Group:* Thursday, February 28, 6.30 p.m., Grand Hotel, Sheffield. "Experimental Designs in Technological Research," by Mr. N. L. Franklin.

**INSTITUTE OF METALS.**—*Birmingham Local Section:* Thursday, February 28, 7 p.m., James Watt Memorial Institute, Birmingham. "Metallurgical Research in the United States," by Professor C. S. Barrett. Friday, February 29, 10.30 a.m., College of Technology, Birmingham. Whole-Day Symposium on "New Techniques of Metallurgical Research."

**ROYAL METEOROLOGICAL SOCIETY.**—*Scottish Centre:* Friday, February 29, 5.15 p.m., The University, Drummond-street, Edinburgh. Annual Meeting.

**INSTITUTE OF CIVIL ENGINEERS.**—*Yorkshire Association:* Friday, February 29, 6.15 p.m., Electricity Showrooms, Ferensway, Hull. "Tunnelling Plant and Equipment," by Mr. G. P. Archer.

**INSTITUTE OF CHEMICAL ENGINEERS.**—*North-East Graduates' and Students' Section:* Friday, February 29, 6.15 p.m., Chemical Engineering Department, Stephenson Building, Claremont-road, Newcastle-upon-Tyne. "The Place of Instrumentation in Chemical Plant," by Mr. A. H. Isaac.

**JUNIOR INSTITUTION OF ENGINEERS.**—Friday, February 29, 6.30 p.m., 39, Victoria-street, S.W.1. "The Use and Abuse of Concrete," by Mr. A. E. Taigel.

## PERSONAL.

SIR JOHN KENNEDY, O.B.E., M.I.C.E., M.I.E.E., informs us that shortly he will be severing all connection with the Uganda Electricity Board. All future communications should be sent to Woodstock, Chinthurst-lane, Shalford, near Guildford, Surrey.

MR. JOHN KEIR, manager of the Service Division of the Marconi International Marine Communication Co. Ltd., Marconi House, Chelmsford, Essex, has now been appointed assistant general manager of the Marconi Marine Companies, these comprising also the Radio Communication Co. Ltd., and the Marconi Sounding Device Co. Ltd.

PROFESSOR H. H. READ, A.R.C.Sc., M.Inst.M.M., D.Sc., F.R.S., Professor of Geology in the University of London, has been awarded the Wollaston Medal of the Geological Society of London.

MR. R. B. W. BOLLAND has been appointed general manager of Head Wrightson Aluminium Ltd.

MR. P. B. R. GIBSON, M.A. (Cantab.), A.M.I.Mech.E., has relinquished his appointment as lecturer in engineering production at the University of Birmingham, to take up the position of senior instructor, Department of Management Studies, Officers' Training Centre, Royal Electrical and Mechanical Engineers, Arborfield, Berkshire.

The Council of the University of Sheffield have approved the full-time appointments of Mr. R. SHEPHERD, B.Sc. (Eng.) (Lond.), A.M.I.Min.E., F.G.S., as senior lecturer in the post-graduate school of mining and of Dr. E. O. HALL, M.Sc. (New Zealand) as lecturer in physics. The part-time appointment of Dr. B. A. BILBY, B.A. (Cantab.) (Sorby Research Fellow) as honorary lecturer in physical metallurgy has also been approved.

MR. A. R. NORTHOVER, M.I.P.E., has been elected President of the South Wales and Monmouthshire section of the Institute of Industrial Supervisors for 1952.

DR. G. J. KYNCH, hitherto lecturer in mathematical physics, University of Birmingham, has been appointed Professor of Applied Mathematics at University College, Aberystwyth.

MR. C. D. B. WILLIAMS, of Walton, Warwick, who has been associated with the interests of the Van der Horst Co. in the United Kingdom for the past 15 years and, we understand, was largely instrumental in bringing about the agreement between the Birmingham Small Arms Co. Ltd., Monochrome Ltd., Redditch, and the Van der Horst Co., of Hilversum, Holland, announced on page 691 of our issue of June 8, 1951, will continue to represent not only the Dutch and American Van der Horst interests in this country, but also those of Monochrome Ltd.

MR. L. E. MASHETER, tyre technical superintendent, Dunlop Rubber Co. Ltd., Fort Dunlop, has been appointed technical manager of tyre production there under Mr. F. G. W. KING, technical director.

MR. PAUL ZINNER, formerly regional director of the United States Bureau of Mines at Minneapolis, has been made head of the Minerals Division of the Bureau at Washington, in succession to Mr. L. B. MOON, who has resigned to take up a position in industry.

MR. W. M. KELLER has been appointed to the new position of director of mechanical research, Association of American Railroads, Operations and Maintenance Department, Mechanical Division, 59, East van Buren-street, Chicago 5, U.S.A. Mr. J. R. JACKSON, the former mechanical engineer to the Division, retired on December 31, 1951, after 40 years of railway service.

DAVIDSON & CO. LTD., Sirocco Engineering Works, Belfast, Northern Ireland, announce that their Manchester depot, which is under the management of Mr. C. G. Huntley, A.M.I.Mech.E., A.M.I.E.E., M.I.H.V.E., will be moving to more commodious premises at the end of this month. On and from March 3, the address will be 42, Deansgate, Manchester, 3. (Telephone: BLACKfriars 6218.)

ROBERT JENKINS and Co. LTD., "Ivanhoe" Works, Wortley-road, Rotherham, advise us that Mr. S. MCGONIGAL, who represented them in Lancashire and Cheshire, has severed his connection with them as from February 1, and that a new representative will be appointed as soon as possible.

FULLER, HORSEY, SONS AND CASSELL are leaving 10, Billiter-square, and their new address will be 10, Lloyd's-avenue, Fenchurch-street, London, E.C.3.

We are asked to state that the announcement, on page 175, *ante*, that Denbigh machine tools will be sold overseas, excluding Australia and New Zealand, by FENTER, LTD., Birmingham, does not affect existing Denbigh sales arrangements with the machine-tool trade in the United Kingdom.

BAKELITE LTD., 18, Grosvenor-gardens, London, S.W.1, announce that their northern sales office has been moved to more spacious premises at the Royal Exchange, Manchester, 2. (Telephone: BLACKfriars 5174-7.)

"DRI-POR" METHOD OF REPAIRING CONCRETE PILES.  
METROPOLITAN RESURFACING AND CONSTRUCTION CO., INC., CURTIS BAY, MARYLAND, U.S.A.  
(For Description, see Page 237.)

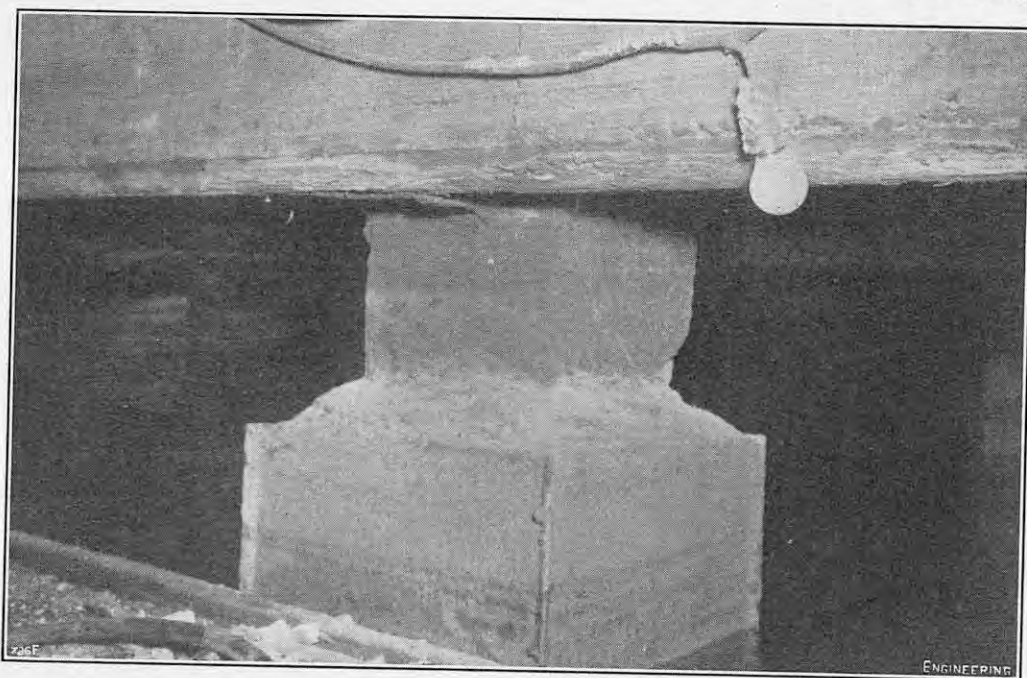


FIG. 6. REPAIRED PILE.

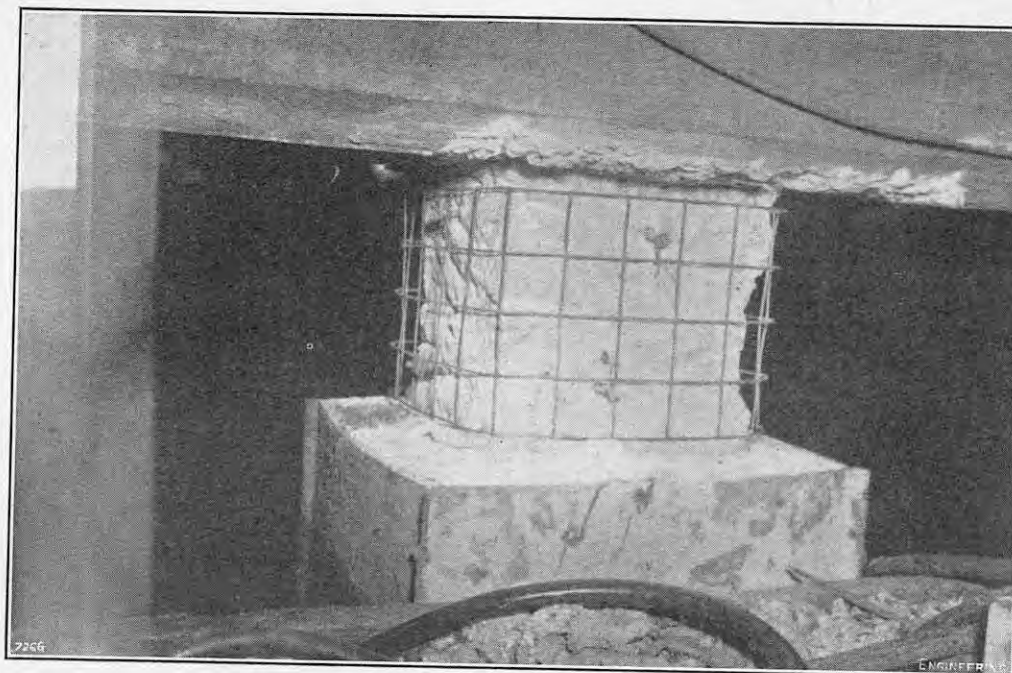


FIG. 7. WIRE MESH PLACED ROUND CAP.



FIG. 8. PILE BENT BEFORE GUNITING.

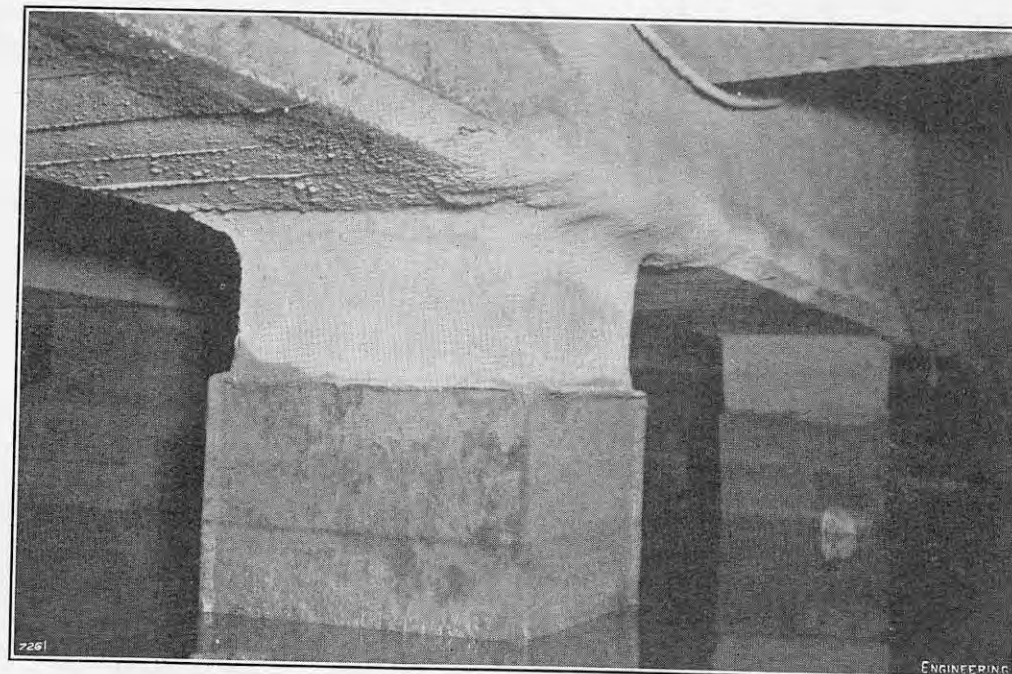


FIG. 9. COMPLETED PILE ENCASEMENT AND GUNITE CAP.

## 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.

Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

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

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

## SUBSCRIPTIONS.

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

|                                                                                  |         |
|----------------------------------------------------------------------------------|---------|
| For the United Kingdom and all places abroad, with the exception of Canada ..... | £5 10 0 |
| For Canada .....                                                                 | £5 5 0  |

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2s. 3d. post free.

## ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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

## TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

## CONTENTS.

|                                                                                                                                                                                                                | PAGE |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Italian Jet-Propelled Training Aircraft ( <i>Illus.</i> ) .....                                                                                                                                                | 225  |
| Literature.—Pipe Resistance for Hydraulic, Lubricating and Fuel Oils, and Other Non-Aqueous Liquids. Plant Layout: Planning and Practice. Sound Insulation and Room Acoustics. Modern Naval Architecture ..... | 228  |
| The Collection of a Representative Flue-Dust Sample ( <i>Illus.</i> ) .....                                                                                                                                    | 229  |
| The Engineering Outlook—VIII .....                                                                                                                                                                             | 230  |
| The C.E.S.D. Light Weight Building ( <i>Illus.</i> ) .....                                                                                                                                                     | 234  |
| The Pressure Still with Diluent Air ( <i>Illus.</i> ) .....                                                                                                                                                    | 235  |
| The Institute of Metals .....                                                                                                                                                                                  | 236  |
| Infra-Red Ovens for Drying Motor-Cars ( <i>Illus.</i> ) .....                                                                                                                                                  | 236  |
| "Dri-Por" Method of Repairing Concrete Piles ( <i>Illus.</i> ) .....                                                                                                                                           | 237  |
| Notes from the Industrial Centres .....                                                                                                                                                                        | 238  |
| Notices of Meetings .....                                                                                                                                                                                      | 239  |
| Personal .....                                                                                                                                                                                                 | 239  |
| The World's Navies .....                                                                                                                                                                                       | 241  |
| Safety in Mines .....                                                                                                                                                                                          | 242  |
| Notes .....                                                                                                                                                                                                    | 243  |
| Letter to the Editor.—Pulverised-Coal Feeder for Uniform Flow ( <i>Illus.</i> ) .....                                                                                                                          | 243  |
| Obituary.—Mr. W. S. Graff-Baker ( <i>with portrait</i> ) .....                                                                                                                                                 | 244  |
| Standard Nominal Diameters for Metric and Inch Units .....                                                                                                                                                     | 244  |
| Contracts .....                                                                                                                                                                                                | 246  |
| Malleable Cast-Iron Manhole Cover ( <i>Illus.</i> ) .....                                                                                                                                                      | 246  |
| Technology and History .....                                                                                                                                                                                   | 246  |
| Labour Notes .....                                                                                                                                                                                             | 248  |
| Fuels for Marine Auxiliary Oil Engines ( <i>Illus.</i> ) .....                                                                                                                                                 | 249  |
| Courses in Gas-Turbine Technology .....                                                                                                                                                                        | 251  |
| Noise in Private Cars ( <i>Illus.</i> ) .....                                                                                                                                                                  | 252  |
| Fluids for Hydraulic Power Transmission .....                                                                                                                                                                  | 254  |
| Guillotine for Sheet Metal ( <i>Illus.</i> ) .....                                                                                                                                                             | 255  |
| Trade Publications .....                                                                                                                                                                                       | 255  |
| British Standard Specifications .....                                                                                                                                                                          | 256  |
| Cleaning Telephone Wires on the London Underground ( <i>Illus.</i> ) .....                                                                                                                                     | 256  |
| Books Received .....                                                                                                                                                                                           | 256  |

## ENGINEERING

FRIDAY, FEBRUARY 22, 1952.

VOL. 173.

No. 4491.

## THE WORLD'S NAVIES.

To those who remember the pace of naval construction during the two world wars, or even the normal rate of warship building in the days when the advocates of the battleship used to chant in chorus "We want eight and we won't wait," the present progress of the navies of the world seems to verge upon the somnolent. In the case of many of the smaller fleets, of course, it always did, for they were instituted, as often as not, largely on the principle of "keeping up with the people next door" and were maintained for reasons of political expediency rather than necessity. Such fleets were augmented as much by the purchase of second-hand craft as by *ad hoc* new construction, though the amount of tonnage that changed hands in this way over long periods of years was no more than the ordinary student of naval affairs could memorise.

The fever of naval shipbuilding that broke out in the 1914-18 war seemed hectic enough, though it was probably surpassed in "hecticity" (to coin a word) by that of the second world war; more so in the United States than in this country, considered in relation to the pre-war tempo, but sufficiently notably in the United Kingdom by comparison with the almost complete stagnation in the British shipbuilding industry between the wars. There was, however, a fundamental difference between the conditions of late 1914 and 1939 in that, when the first world war broke out, hardly any preparations had been made for a rapid expansion of the British naval forces, whereas in 1939 the process of re-armament had gathered already a considerable momentum. On the other hand, in 1914 there were under construction in this country a number of very useful ships ordered by foreign navies, including battleships, cruisers and destroyers, enough to

constitute in themselves quite a formidable and fairly well-balanced fleet; these, of course, the British Admiralty promptly appropriated. There was no corresponding advantage in 1939; in fact, Britain had begun to feel rather acutely the competition of various Continental countries in the business of supplying and refitting the ships of the smaller navies which were not backed by home industries capable of undertaking such work.

How very different are the conditions at the present time is well brought out in the foreword to the 1951-52 edition of *Jane's Fighting Ships*\*—the 53rd edition of this unique naval compendium, in which the editor, Mr. Raymond V. B. Blackman, A.M.Inst.N.A., has probably introduced more changes than have been effected in any one edition previously issued. Perhaps the most striking paragraph of his lengthy introduction is the one in which he surveys the extent to which the surplus warships of the principal navies of the 1939-45 war have been distributed over the world. He does not specifically enumerate the number of new navies that have come into being as a result of the wave of rather self-conscious nationalism that has swept over the world in recent years, though that has greatly expanded the possible markets for second-hand naval tonnage; but, even without those new markets, the number of changes of flag undergone by surplus warships is truly remarkable.

Former British aircraft carriers are now serving in the fleets of Australia, Canada, France and the Netherlands; ex-British cruisers are to be found under the flags of Australia, Canada, India and New Zealand; destroyers have been transferred from the British flag to Australia, Canada, India, Pakistan, South Africa, Dominica, Greece, Indonesia, the Netherlands, Norway and Turkey; British submarines have gone to Denmark, France, Greece, the Netherlands, Norway and Portugal, and fleet minesweepers to India, Pakistan, Belgium, Egypt, Persia, Portugal and Turkey. The most widely distributed class of former British warships, however, is that of frigates, which, in the recent war, largely succeeded to the "maid of all work" role assumed by the destroyer in the 1914-18 war; they are now to be found in the navies of Australia, Canada, New Zealand, India, Pakistan, South Africa, Argentina, Burma, Denmark, Egypt, France, Greece, the Netherlands, Norway, Persia, Portugal and Thailand. The re-distribution of former ships of the United States Navy is almost equally striking; for example, 14 other countries now possess escort destroyers or frigates obtained from the United States. Many of the ex-United States ships have gone to the navies of Central and South America, but France has two American aircraft carriers and Greece, Italy and Turkey have former United States destroyers.

The foreword to *Jane* comments, in this connection, on the consequent "degree of uniformity which has been achieved or can be attained in inter-fleet operations." So far as the fleets of the North Atlantic Treaty Organisation are concerned, this may be so; but there is little doubt that, in many cases, the ships thus distributed may be "written off" for all practical purposes, even if another global war were to break out forthwith. Uniformity in type of *matériel* undoubtedly there is, but uniformity in "inter-fleet operations" requires much more than that. There is, however, a very real advantage to any belligerent in knowing fairly intimately the quality of the weapons in the possession of an opponent, though this is an advantage hardly to be enjoyed by any one of the Western Powers in any naval conflict that can be envisaged at present. Casual observation would suggest that the principal problem that is likely to bemuse, in such a case, any of the smaller navies, comprising

\* Published by Sampson Low, Marston and Company, Limited, 25, Gilbert-street, London, W.1. (Price 4 gns. net.)

mainly vessels acquired from major Powers, will be that of ammunition supply, particularly for the anti-aircraft armament. Hardly any of the minor navies which have been re-formed with second-hand ships possesses the necessary plant to manufacture dependable ammunition in any quantity, if at all; and the expenditure of shells has increased enormously with each successive war. All the indications are that this tendency will be accentuated in any future conflict, so that the countries which can control the supply of ammunition, either at its source or in transit, can control also, with only a small time delay, the activities of many of the smaller navies.

There is nothing in the latest edition of *Jane's Fighting Ships* to shake the conviction that, at last, the days of the battleship are definitely numbered; not so much because of the vulnerability of the battleship to serious damage as because there is not now the same reason for its continued existence. Fifty years ago, when French naval opinion favoured the torpedo boat so strongly, it was held by many that battleships were no longer worth their heavy cost in construction and upkeep. Then the German policy of building heavy warships gave them a new lease of life. Now, however, the conditions have changed radically; at first, as a result of the improvement of piloted aircraft, and latterly because of the advent of new types of submarines, underwater weapons and guided missiles. The aircraft carrier has succeeded the battleship as the capital ship, and it is by no means certain that the aircraft carrier also has not passed the peak of its ascendancy. Cruisers may still be necessary for a number of years to come, but their former position, which once seemed so unassailable, now appears much less so. It is significant that, while the British Admiralty are showing considerable activity in refitting former destroyers for anti-submarine duties and are pressing on with the completion of the aircraft carriers left unfinished at the close of the recent war, they are still taking no obvious action to complete the three cruisers *Tiger*, *Defence* and *Blake*, which were laid down ten full years ago and on which work was suspended in 1946.

Reading between the lines, it would seem that it is in submarine design, and especially in submarine propulsion, that the main advances are being made from a technical standpoint; apart, that is, from developments in weapons and missiles, most of which are almost equally applicable to surface ships. A point that is not so clear is whether future war-time policy will continue to favour the convoy system for the protection of merchant ships, to the same extent as in the recent war. In any future naval war—or, for that matter, in any future war, whether predominantly naval or not—the maintenance of fuel supplies will certainly be more crucial than ever before; but the tendency in tanker design appears to be towards a sea speed high enough to justify independent voyaging. If so, the protecting forces will probably not sail in company with the vulnerable tankers, but will seek to keep danger at a safe distance from them—preferably by preventing an enemy from breaking out into deep water at all. The development of radar should greatly aid such a policy, but, even so, it does not appear that the British naval programme is on a sufficient scale to maintain indefinitely the close-mesh anti-submarine screen that security requires. The slower cargo vessels will continue to sail in convoys, no doubt, but probably in smaller convoys, more widely dispersed than in the late war, and depending to a greater extent on radar in keeping their formation. It would seem, indeed, that the pattern of a future naval conflict in the North Atlantic might follow more closely that of the recent naval operations in the Pacific than that of any that have been carried out in the North Sea and the Western Approaches since the time of Nelson.

## SAFETY IN MINES.

STATISTICS of coal-mine accidents must be considered over a number of years if a correct idea of the general trend is to be obtained. The curves showing the total deaths and the total cases of reportable injury, from 1930 to 1950, both show a progressive fall, with, however, serious set-backs in individual years; this is particularly the case for the curve of total deaths. The curve for reportable injuries shows a reasonably consistent downward tendency. The reason for this difference is illustrated by the figures for 1950, now made available by H.M. Chief Inspector of Mines in his report for that year. Falls of ground and haulage accidents cause the largest numbers of fatalities, though in 1950 the deaths were respectively 52 and 17 less than in 1949. In spite of this improvement, the total number of deaths in 1950 was 33 greater than in 1949, because of two major disasters which did not fall into either of these classes of accident. The serious fire at Creswell Colliery in North Derbyshire, resulting in 80 deaths, was due to a belt conveyor; the accident at Knockshinnoch Castle Colliery, Ayrshire, in which 116 men were trapped underground, of whom all but 13 were ultimately rescued, was due to an inrush of peat and water.

In every year from 1930 to 1950, falls of ground were responsible for more deaths and reportable accidents than any other type of incident. The prevention of such accidents is to a considerable extent within the control of the individual, though many accidents are caused by failure of judgment rather than carelessness. In 1950, the figure for fatal and reportable non-fatal accidents due to falls of ground was 902. This total is 129 less than that for 1949. Considerably more than half the accidents, 539 in 1950, occurred at the working face. It is stated in the report that in many of these accidents there was evidence of delay in spragging or propping. The number attributed to broken supports was low and were mostly due to overloading of wood props or the breaking of the overhanging part of wood bars extending over the cutter track. There is a gradual movement towards the use of steel supports in place of wood; the consumption of round timber in 1948 was 2.76 standards per 1,000 tons of coal, in 1949, it was 2.62 and in 1950, 2.52 standards.

Haulage, the second major cause of accidents, was responsible for 609 cases of death or reportable injury, an increase of 17 over 1949. Derailments and the coupling or manipulation of tubs showed the highest figures. It is emphasised that the maintenance of both track and tubs should be of a higher standard than is always attained. For man-riding haulage, standards of design, construction—operation, inspection and maintenance should not be inferior to those necessary for winding apparatus in vertical shafts. There were twelve fatalities due to belt conveyors; of these six were caused by persons crossing over, passing under falling on, or riding on conveyors. In connection with the latter cause, it may be remembered that the productivity team which visited the United States recommended consideration of "the desirability of allowing the transport of men by belt conveyor under suitable safeguards."

Apart from the possibility of mechanical accidents, underground conveyors have introduced a fire-hazard which the report refers to as "alarming." This matter was referred to in the 28th annual report\* of the Safety in Mines Research Establishment. It is there stated that experiments in Holland and in this country were undertaken to study the circumstances in which a jammed conveyor belt could be ignited by the frictional heat from a

spinning driving roller, and that the use of steel instead of timber in conveyor roads undoubtedly reduced the risk of fires. It is added that experiments are planned on the use of sprinkler systems for fighting conveyor fires. As this report deals with the year 1949, although it was only published in February of this year, it may be assumed that by now some progress has been made in this matter. The Chief Inspector's report describes conveyor fires as "by far the greatest fire hazard in coal mines to-day." During the years 1940-1950, when the percentage of coal conveyed mainly by belt increased from 61.1 per cent. to 85 per cent., there were at least 100 conveyor fires. A table, covering 11 years, listing the causes of these, is given; six were due to electrical defects, but by far the majority were caused by seized bearings, heating due to stalling or other mechanical defect.

Locomotive haulage is rapidly being extended in British mines and apparently without any unfavourable effect on the accident rate. During the year 1950, the number of locomotives in use underground increased from 331 to 385, of which 58 were of the electric-battery type and 325 Diesel machines. There were two fatal accidents, both occurring because the clearances between the vehicles and the sides of a ventilation door and a road were inadequate. The necessary clearances were specified in the Coal Mines (Locomotives) General Regulations, 1949, and the places at which the two accidents happened did not conform with the regulations. There were two fires on Diesel locomotives during the year. One of these was due to deposits of oil-soaked dust on the top of the hot exhaust-gas conditioner and on the inside of the locomotive frame; the other was caused by the breakage of a pump V-belt which became fast between the pulley and casing. The friction set it on fire. It is stated that the design of V-belts is being considered by the makers of the locomotive. A passage in the research report refers to the escape of hydrogen from the battery of electric-battery locomotives, but, as the matter is not mentioned in the Inspector's report, it presumably does not constitute a serious inconvenience or danger.

In his report for the year 1949, the Chief Inspector stated that the position in relation to diseases of occupation, particularly pneumoconiosis, was less satisfactory than in relation to accidents, and in a lecture delivered at a meeting of the Royal Society of Arts on April 25, 1951, Sir Andrew Bryan said "perhaps the greatest danger that has arisen from the increased mechanisation of mines is the additional fine dust produced, which magnifies the explosion hazard, and also gives rise to the lung disease, pneumoconiosis." The amount of flying dust produced may be reduced by water infusion at the working face, wet cutting and the use of pneumatic picks fitted with a water source. It is reported that, though there has been some advance in all divisions, "progress has not been fast enough." It is added that "at too many mines, among management and men alike, there is still a lack of awareness of the seriousness of the air-borne dust problem."

## THE LATE DR. H. W. DICKINSON.

As we go to press, we have learned with great regret of the death on Thursday, February 21, of Dr. H. W. Dickinson. An obituary notice of Dr. Dickinson will appear in next week's issue of *ENGINEERING*, but, by a coincidence, a tribute to him is to be found on page 248 of this issue, at the end of the lecture on "Technology and History," by Professor Charles Singer, who describes Dr. Dickinson as "the leading authority on the history of technology."

\* Report of H.M. Chief Inspector of Mines under the Coal Mines Act, 1911, for the Year 1950. H.M. Stationery Office. [Price 1s. 9d. net.]

\* 28th Annual Report on Safety in Mines Research 1949. H.M. Stationery Office. [Price 2s. 6d. net.]

## NOTES.

## THE INSTITUTION OF MECHANICAL ENGINEERS.

THE James Clayton Prize for 1951, amounting to 1,550L., has been awarded by the Institution of Mechanical Engineers to Dr. H. Roxbee Cox, B.Sc.(Eng.), M.I.Mech.E., for "his contributions to engineering science and practice, particularly in the fields of aeronautics, power generation and fuel utilisation, communicated in part in a Thomas Hawksley Lecture to the Institution in November, 1951." That Lecture, entitled "Some Fuel and Power Projects," revealed the wide range of significant developments with which he has been associated, as Chief Scientist to the Ministry of Fuel and Power since 1948, and especially in gas-turbine work prior to that date. The prize, accompanied by a certificate, was handed to Dr. Roxbee Cox by the President, Mr. A. C. Hartley, C.B.E., at a meeting of the Institution held on Friday, February 15. The other prizes for the year were also presented, the Council nomination and retiring lists were read, and a paper on "The Allocation of Machines to Operators," by Mr. T. F. O'Connor, B.Eng., was discussed. The following prizes were awarded: the Thomas Hawksley Gold Medal to Mr. J. L. Norton, A.M.I.Mech.E., for his paper on "The Design and Development of the Twin Centaurus Power Plant for the Bristol 'Brabazon'"; a George Stephenson Prize to the value of 30L. to Mr. D. Downs, B.Sc.(Eng.), A.M.I.Mech.E., and Mr. J. H. Pignéguy, A.M.I.Mech.E., for their paper on "An Experimental Investigation into Pre-ignition in the Spark-ignition Engine"; a George Stephenson Prize, to the value of 15L., for the paper on "The Automatic Hydraulic Ram," to Mr. J. Krol, Ph.D., A.M.I.Mech.E.; the Water Arbitration Prize, to the value of 25L., to Mr. F. Koenigsberger, M.I.Mech.E., for his paper on "Design Stresses in Fillet Weld Connections"; the Starley Premium, to the value of 21L., to Dr. J. R. Bristow, B.Sc., A.M.I.Mech.E., Mr. P. Metcalf, B.A., B.Sc., and Mr. C. H. G. Mills, B.Sc.(Eng.), for their paper on "The Use of Wire-Resistance Strain-Gauges in Automobile Engineering Research"; the Herbert Akroyd Stuart Prize, to the value of 30L., to Dr. A. E. W. Austen, B.Sc., and Mr. B. E. Goodridge, B.Sc.(Eng.), G.I.Mech.E., for their paper on "Wear of Fuel Injection Equipment and Filtration of Fuel for Compression-Ignition Engines"; Thomas Lowe Gray Prizes to Commander (E.) J. H. Joughin, D.S.C., R.N., A.M.I.Mech.E., for his paper on "Naval Gearing—War Experience and Present Development"; and to Mr. S. Archer, M.Sc., A.M.I.Mech.E., for his paper on "Contribution to Improved Accuracy in the Calculation and Measurement of Torsional Vibration Stresses in Marine Propeller Shafting"; the T. Bernard Hall Prize, to the value of 18L., to Mr. L. N. Thompson, B.Sc.(Eng.), G.I.Mech.E., for his paper on "Fundamental Dynamics of Reaction-Powered Space Vehicles"; Engineering Applied to Agriculture Award, to the value of 20L., to Dr. A. W. Jenike, A.M.I.Mech.E., for his paper "On the Calculation of Forces in Power-Shovels"; the Joseph Whitworth Prize, to the value of 35L., to Mr. E. A. Cooke, A.M.I.Mech.E., for his paper on "Form Grinding by Mechanical and Optical Methods"; and the Ludwig Mond Prize, to the value of 35L., to Mr. J. F. Peck, B.Sc.(Eng.), Wh.Ex., M.I.Mech.E., for his paper on "Investigations Concerning Flow Conditions in a Centrifugal Pump, and the Effect of Blade Loading on Head Slip." The Council nomination list includes the following: President, Dr. D. R. Pye, C.B., F.R.S. (who was included as a Knight Bachelor in the New Year Honours List); vice-president, Mr. A. H. Lloyd, B.Sc.; and, as members of Council, Dr. H. Roxbee Cox, B.Sc.(Eng.), Mr. P. T. Fletcher, B.Sc.(Eng.), Mr. A. T. Holman, O.B.E., Mr. R. A. Riddles, C.B.E., Mr. G. A. Wauchope, Mr. A. D. S. Carter, B.Sc., and J. W. Lawrence. The latter two are associate members of the Institution.

## THE GAUGE AND TOOL MAKERS' ASSOCIATION.

Four certificates of craftsmanship were presented to apprentices in gauge and tool making at a luncheon of the Gauge and Tool Makers' Association which was held at the Savoy Hotel, London, W.C.2, on Wednesday, February 20. The recipients were Mr. Charles David Morton, Mr. Philip Keith Wain-

wright and Mr. Alan John Wright, all of whom were received or are receiving their training with Messrs. B.S.A. Tools, Limited; and Mr. Archie Eglese, who was apprenticed to Messrs. Wickman, Limited. The presentations were made by the Rt. Hon. Duncan Sandys, M.P., Minister of Supply, following his address to the members. The President of the Association, Mr. F. W. Halliwell, M.I.Mech.E., in introducing Mr. Sandys, stressed the fundamental importance of the gauge and tool industry as the basis of effective re-armament, pointing out that the production of munitions could not be increased without an adequate provision of gauges, jigs and precision tools and instruments. This provision could not be made, however, unless a sufficient quantity of steel was available; and the allocations of steel that had been made were far from being sufficient. The Minister, in his reply, admitted that the allocations for the first period of steel control had aroused criticism, but stated that those for the second period, shortly to be notified to the firms, would represent "a substantial overall increase" and would include "a very much higher proportion of alloy steel." It was quite impossible, Mr. Sandys continued, to provide all that the industry would like to have at their disposal, but he could say that the allocations for the third and fourth periods "should provide enough for all essential needs"; a statement which was received with prolonged applause.

## BRITISH ELECTRICAL POWER CONVENTION.

The British Electrical Power Convention, which, as already announced, will take place at Bournemouth from Monday, June 16 to Wednesday, June 18, is to be devoted to the subject of research. The first meeting will be held in the Town Hall on Monday morning, when a civic welcome by the Mayor will be followed by an address from the President (Mr. P. V. Hunter). In the afternoon a paper entitled "A Survey of Research in the Electrical Industry" will be presented by Sir Arthur Fleming; and there will also be papers on "Co-operative Research in the Industry," by Dr. S. Whitehead; on "Research in the Electricity Supply Industry," by Dr. J. S. Forrest; on "The Nature of Research in the Manufacturing Industry," by Dr. K. J. R. Wilkinson; on "Researches into Some Problems Associated with Steam Generation," by Mr. W. F. Simonson; and on "The Influence of Research on the Electric Lamp Industry," by Dr. J. N. Aldington. A sixth paper will be presented on behalf of the Cable Makers' Association. In the evening a reception will be given by the Mayor and Mayoress of Bournemouth. On Tuesday morning a meeting will be held at the Pavilion at which a lecture and demonstration will be given by Dr. R. S. Vincent on "High Performance Dielectrics with Special Reference to Power Factor Improvement," and at a meeting in the afternoon four papers on "The Merits of the Electric Water Heating, Electric Cooking and Heating Loads on an Integrated Supply System" will be presented by Mr. R. Y. Sanders, Mr. C. H. Smith, Mr. J. A. Fraser and Mr. R. Berry. The annual dinner will be held in the evening at the Pavilion, and on Friday morning an electrical forum will be conducted by a panel selected by the Council to answer questions which have been submitted prior to the meeting. This will be followed by the annual general meeting.

## LIVERPOOL OBSERVATORY AND TIDAL INSTITUTE.

The annual report for 1951 of the Liverpool Observatory and Tidal Institute, which is situated on Bidston Hill, outside Birkenhead, shows that steady progress was made during the year with the various fundamental researches which have been in progress for some years under the direction of Dr. A. T. Doodson, F.R.S., and his deputy director, Dr. R. H. Corkan, in addition to the large volume of routine work on tide prediction and weather observation. The staff was increased during the year to enable more research work to be done, and, with the aid of additional financial assistance provided by the University of Liverpool, it was possible to devote more time to research work towards the close of the year. The programme included a further study of the tides in oceans bounded by meridians between certain latitudes, in which the application of finite-difference methods

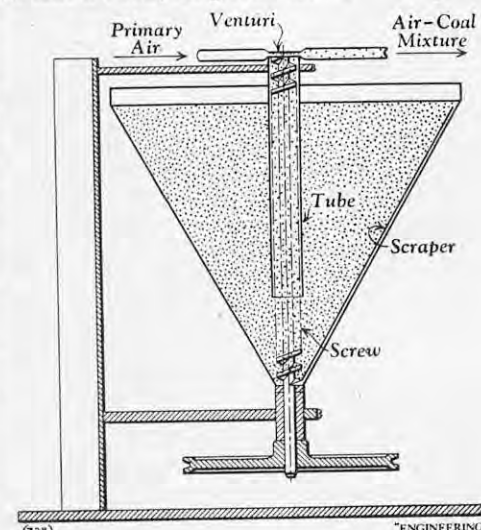
led to some progress, though not to a complete solution; the object was to establish the behaviour of the tides in an open-water area such as the North Atlantic Ocean. Another research, by Dr. Corkan, related to the oscillations in a rotating square area of sea. Dr. Corkan used the methods of relaxation to investigate free periods and modes of oscillation, with the object of applying such methods to the free and forced tides in actual seas. Five weeks were spent during the summer, off the coast of Anglesey, on the problem of relating tidal streams to the gradient of the sea surface and to the friction on the bottom. A Doodson current meter was used to measure the streams, and pressure gauges of the Favé type to record the tidal elevation. Considerably improved accuracy was achieved with these gauges as a result of a modification to the method of making time marks on the record. The observations showed that bottom friction did have an appreciable influence on the tidal streams. The report illustrates the method adopted to overcome a difficulty encountered in using the Institute's tide-predicting machine to compute the tides in shallow water. Previously, the procedure had been to predict the tides directly with the machine and then, using certain components of it, to evaluate separately the shallow-water corrections necessary. This involved a certain amount of rather tedious computation, and it was decided, therefore, to attach supplementary dials to the component angle-dials. The correction dial is held by frictional clamps to the angle-dial, so that the two rotate together, once the initial correction has been made to the setting. The corrections for about a month can then be read directly from the machine. The number of tidal predictions prepared for 1953 was 157, an increase of four over the number of 1952 and approaching double the annual number computed before the recent war.

## LETTER TO THE EDITOR.

## PULVERISED-COAL FEEDER FOR UNIFORM FLOW.

TO THE EDITOR OF ENGINEERING.

SIR,—The feeding of pulverised coal has been accompanied by bridging, holing or packing of the coal in the hopper and the screw feeder, and the finer the coal, the greater the troubles, especially



when it is not very dry. While investigating a pulverised-coal combustion problem in a laboratory (burning about 12 lb. of coal per hour), a coal feeder was developed in which these troubles were overcome and a continuous metered supply was provided. An accuracy of 1 per cent. in feeding rate by weight was attained.

The apparatus, shown diagrammatically herewith, consists of a vertical screw 15 in. long, rotating in a tube, of 1½ in. internal diameter, which is suspended from a bracket in the centre of a conical coal hopper. The lower end of the screw passes through a bearing at the bottom of the hopper and is power driven. The tube is 11 in. long, thus exposing the screw for a length of about 4 in. at the bottom, where the coal is picked up. A spring-

steel blade brazed to the lower end of the screw rotates with the screw and scrapes the inner surface of the hopper over its full height. This prevents any tendency of the pulverised coal to build up on the hopper wall and keeps the coal in a fluid condition in the hopper.

In the standard horizontal type of screw feeder, the coal has a tendency to settle at the bottom half of the screw while travelling in the screw from the hopper bottom to the delivery end. Thus the screw does not run full, the delivery is intermittent and, to stop air leakage over the empty top half of the screw, a minimum possible clearance between the screw and its tube is required. In this new type of vertical screw feeder, however, the screw must always run full as it is pushing coal upwards against gravity, thus giving a continuous supply.

The coal delivery rate depends upon the level of the pulverised coal in the hopper. The reduction in delivery rate with head of coal was found, within working limits, to be proportional. At the start of each test the delivery rate is slightly erratic, becoming steady when the coal settles down into the hopper pattern and following the linear relation. The delivery rate can, however, be made constant by automatically speeding up the motor driving the screw or by keeping the coal head approximately constant by a secondary feeder, which may be of the intermittent type, such as a star feeder. The raising or lowering of the tube was found to affect the delivery. Too short an exposure of the screw at the bottom, where the coal is picked up, reduces the delivery rate of the coal. Two different types of screws were tried, one with a rectangular-section groove and the other with a semi-circular groove. The former gave a more uniform delivery.

The coal is delivered at the top by the feeder into the primary air line. A Venturi arrangement at the junction accelerates the air stream, with a consequent drop in pressure, thus lifting the coal continuously from the feeder top. The air-coal mixture is then conveyed to the burner nozzle. Since this feeder is successful with a "sticky" material like pulverised coal, it may well be applied where a uniform flow of a powdered material from a storage bin or hopper is required.

Yours faithfully,

R. SINGH, B.E.,

Unesco Research Fellow.

Department of Mechanical Engineering,

The University of Adelaide,

South Australia.

February 7, 1952.

## OBITUARY.

### MR. W. S. GRAFF-BAKER.

WITH the sudden death of Mr. W. S. Graff-Baker, on February 15, which we record with much regret, the London Transport Executive have lost their chief mechanical engineer (railways). He was the foremost authority in this country on the rolling stock of underground railways; apart from a year during the last war, when he was seconded to the Ministry of Supply as Director of Tank Production, he had served the system for over 40 years, and at the time of his death he had been longer in the grade of officer—since 1922, in fact—than any other officer or chief officer of London Transport.

William Sebastian Graff-Baker, like some others who took part in the development of London's railways, was an American by birth; he was born at Baltimore, Maryland, on November 14, 1889, but was subsequently British by naturalisation. His father was a pioneer of electric tramway development in this country, and his grandfather was an American builder of electric street railway trucks. His general education was Anglo-American: first at Colet Court and St. Paul's, Hammersmith, then at Clebury Mortimer College, and at Johns Hopkins University. From 1908 to 1910 he studied at the City and Guilds Central Technical College, London, leaving with second-class honours as a B.Sc. (Eng.), and thereupon entering the Ealing Common works of the Metropolitan District Railway as an "engineering cadet." There, for two years, in the electric rolling-stock maintenance and construction shops, and in the operating and civil-

engineering departments, he gained practical experience of the type of equipment for which, in later years, he was responsible. In October, 1912, he was given his first appointment—as junior technical assistant in the office of the mechanical engineer of the Underground Group. Six months later he was made assistant to the mechanical engineer of the District Railway and associated lines, with responsibility for the maintenance and construction of lifts and escalators, and in 1919 the design of electrical equipment for new rolling stock was added to his duties. In 1921, for a few months, he was "personal assistant" to the mechanical engineer, prior to becoming car superintendent.

At the end of 1921, when he was 32, he was appointed an officer of the Underground Group of Companies, with the title of assistant mechanical engineer and with responsibility for all work in connection with the design and construction of new rolling stock and the maintenance and construction of lifts, escalators and pumps. This position he



THE LATE MR. W. S. GRAFF-BAKER.

continued to hold until after the formation of the London Passenger Transport Board in 1933. In February, 1935, Mr. Graff-Baker reached his ultimate position, as chief mechanical engineer (railways) to the Board, to whom he was responsible, through the engineer-in-chief, for the design, construction, maintenance and overhaul of all London Transport's railway rolling stock, lifts and escalators. During his term of office he introduced the latest types of rolling stock now running on, or on order for, the tube and surface lines, including the light-weight District Line stock, of which deliveries have recently been commenced.

Mr. Graff-Baker was President of the Institution of Locomotive Engineers for 1944-45 and for 1945-46, and a member of Council of the Institute of Transport from 1937 to 1940 and from 1945 to 1948. The technical papers he contributed to institutions included one on multiple-unit trains to the Institution of Electrical Engineers' Convention on Electric Traction (1950), and one on bogie design, delivered as recently as January 4, 1952, to the Institution of Mechanical Engineers, of which he was made a member in 1944.

COURSE ON HIGH-VOLTAGE CIRCUIT-BREAKERS.—A special course of six lectures on "High-Voltage Circuit-Breaking and Allied Problems," by members of the staff of the British Electrical and Allied Industries Research Association, will be given at 6.30 p.m., on Fridays, commencing on February 29, in the Electrical-Engineering Department at the Polytechnic, 307-311, Regent-street, London, W.1. Each lecture will be of about 1½ hours' duration and will be followed by a discussion. The fee for the course is 20s.

## STANDARD NOMINAL DIAMETERS FOR METRIC AND INCH UNITS.

By J. J. EDEN, Dipl.Ing.

THE necessity for standardising products as a whole has generally been accepted by designers, producers and consumers. This is clearly shown in, for example, shoe sizes, engine capacities, fractional horse-powers of motors, etc. One or two general dimensions are chosen as governing the capacity, use or output of the product, and these are standardised in such a manner as to satisfy sufficiently all normal requirements throughout a range, without using every available dimension. The principle of using an economic number of preferred sizes has thus been applied with beneficial consequences both for producers and consumers. On considering detail design, however, it will generally be found that the designer is allowed free choice in respect of detail size, provided the main or governing dimension referred to above is maintained. He is allowed complete freedom to dimension component lengths, widths, radii of curves, distances between holes, and even hole and shaft diameters. In this article, consideration is given to the reduction in variety of diameter of gauged holes in the range from 0 to 1 in. Although this is only a limited sector of the whole field of dimensions where profitable reduction in choice would be attained by standardising to preferred nominal sizes, it is the sector in which the greatest savings may be attained in the easiest manner.

It may appear that some automatic limiting control is attained by the available range of raw material sizes or standard tool dimensions. In fact, material of any dimension, within the scope of manufacture, is generally available, and even where the exact required dimension may not be obtained, a close alternative is offered. Since usually a machining operation has to be carried out on the raw material, its overall dimension does not strictly limit the designer. In respect of drill sizes, a survey of the British Standard on "Twist Drills and Centre Drills" (B.S. 328-1950) will reveal that, even under the heading of "Parallel Shank Jobber Series Twist Drills," in the limited range from 0.0138 in. to 0.5119 in. (from 0.35 mm. to 13 mm.), there are 232 standard drills available. These give average dimensional steps of approximately 0.002 in. The tolerance on these drills is as follows: in the range 0 to ¼ in., +0.0000 in., -0.0005 in.; and from ¼ in. to 1 in., +0.0000 in., -0.0010 in. The diameter of hole actually obtained from the drill will further vary with the degree of skill used in its sharpening, the properties of the material being drilled and the method of lubrication used. Moreover, the designer usually finds by experience that the expert user of drills is able to contrive methods to obtain further variations of final diameter.

Thus, it is apparent that, even where the new standard drills are used, the designer is in no way restricted in the choice of his nominal hole dimension. By making available too large a selection of standard drills, no effective standardisation has been achieved. When considering reaming of the drilled hole, it is found that the British Standard on "Milling Cutters, and Reamers" (B.S. 122-1938), under "Parallel Machine Reamers," provides 21 standard reamers in the range from ⅛ in. to 1 in. diameter. To designers working in this dimensional range it will be apparent that average steps of approximately 0.042 in. are quite insufficient in the lower part of the range. In the course of time, therefore, the majority of reamers in a works will be non-standard; thus, standardisation, by not allowing sufficient variety, defeats its objects. In the case of pierced holes, the number required will in itself warrant the construction of a special tool. The manufacture of such a tool is controlled by manual fitting and any practical diameter may be achieved without causing additional expense. The designer is therefore again in no way limited in the choice of diameter when designing holes for piercing. In all the above methods of hole production, no effective limiting control on the choice of nominal diameter has been imposed on the designer.

In small firms, with one drawing office covering design as well as production drawing and layout, under unified control, a measure of reduction of variety will easily be achieved. Where there are several drawing offices, however, and individual contact between them on matters of detail design is impossible, design, unless controlled by clear standard instructions to all designers, will produce a great variety of nominal dimensions, causing uneconomic variation in required raw-material sizes and drill and reamer diameters. Wherever the components produced have to be gauged, increasing numbers of expensive gauges have to be obtained to cover the ever-increasing requirements. In such cases it is found that designers are unable to keep account of the gauges already

mentioned report (B.S. 1638), as its name implies, deals with preferred numbers and not sizes. To obtain a preferred number series, the range from 1 to 10 is divided into equal logarithmic steps. The natural numbers corresponding to these logarithms form the required series. By dividing the logarithmic range by 5, 10 or  $n$ , a 5 series, 10 series or  $n$  series, respectively, will be obtained. Once a number has been derived it will remain a preferred number of that series, whatever its decimal size. Thus, 0.28, 2.8, 28, 280, etc., all correspond to one preferred number, and when multiplied by a unit become preferred sizes. It has been found more practical, when dealing with the fractional-inch and metric systems, to attribute dimensional limits to the preferred number series, rather than attempt

columns. Where an important inch fraction appears near to a number in the preferred number series, that fraction is included in the proposed series. The inch fractions are listed in sections *b* of the columns and their millimetre conversion is given in section *a*.

The closeness of the figures in the proposed series to the numbers in the preferred series should be noted. In four cases two sizes have been used to correspond to one number in the preferred series. In these cases it is suggested that the sizes in ordinary Roman type be chosen as first preference. In Table I some dimensions above 1 in. have also been included as a guide to a possible "first choice" in this range.

From Table I, Table II has been constructed

TABLE I.

| 1.<br>20<br>Series. | 2.<br>I.S.A.<br>Series. | 3.        |           | 4.        |                | 5.        |                 | 6.        |                 |
|---------------------|-------------------------|-----------|-----------|-----------|----------------|-----------|-----------------|-----------|-----------------|
|                     |                         | <i>a.</i> | <i>b.</i> | <i>a.</i> | <i>b.</i>      | <i>a.</i> | <i>b.</i>       | <i>a.</i> | <i>b.</i>       |
|                     |                         | mm.       | in.       | mm.       | in.            | mm.       | in.             | mm.       | in.             |
| 10000               | 100                     | 0.010     | —         | 0.10      | —              | 1.00      | —               | 10.00     | —               |
| 11220               | 112                     | 0.011     | —         | 0.11      | —              | 1.191     | $\frac{3}{8}$   | 11.113    | $\frac{7}{16}$  |
| 12589               | 125                     | 0.012     | —         | 0.12      | —              | 1.25      | —               | 12.70     | $\frac{1}{2}$   |
| 14125               | 140                     | 0.014     | —         | 0.14      | —              | 1.40      | —               | 14.288    | $\frac{9}{16}$  |
| 15849               | 160                     | 0.016     | —         | 0.16      | —              | 1.588     | $\frac{1}{8}$   | 15.875    | $\frac{5}{8}$   |
|                     |                         |           |           |           |                |           |                 | 17.463    | $\frac{11}{16}$ |
| 17783               | 180                     | 0.018     | —         | 0.18      | —              | 1.80      | —               | 19.05     | $\frac{3}{4}$   |
| 19953               | 200                     | 0.020     | —         | 0.20      | —              | 2.00      | —               | 20.638    | $\frac{13}{16}$ |
| 22387               | 224                     | 0.022     | —         | 0.22      | —              | 2.381     | $\frac{3}{32}$  | 22.225    | $\frac{7}{8}$   |
| 25119               | 250                     | 0.025     | —         | 0.25      | —              | 2.50      | —               | 25.40     | 1               |
|                     |                         |           |           |           |                |           |                 |           |                 |
| 28184               | 280                     | 0.028     | —         | 0.28      | —              | 2.80      | —               | 28.575    | $1\frac{1}{8}$  |
| 31623               | 315                     | 0.032     | —         | 0.32      | —              | 3.175     | $\frac{1}{8}$   | 31.75     | $1\frac{1}{4}$  |
| 35481               | 355                     | 0.035     | —         | 0.35      | —              | 3.572     | $\frac{3}{16}$  | 34.925    | $1\frac{3}{8}$  |
| 39811               | 400                     | 0.040     | —         | 0.3969    | $\frac{1}{4}$  | 3.969     | $\frac{5}{32}$  | 39.688    | $1\frac{9}{16}$ |
| 44668               | 450                     | 0.045     | —         | 0.45      | —              | 4.50      | —               | 44.45     | $1\frac{3}{4}$  |
|                     |                         |           |           |           |                | 4.763     | $\frac{3}{16}$  |           |                 |
| 50119               | 500                     | 0.050     | —         | 0.50      | —              | 5.00      | —               | 50.80     | 2               |
| 56234               | 560                     | 0.055     | —         | 0.55      | —              | 5.5566    | $\frac{7}{32}$  | 55.56     | $2\frac{3}{16}$ |
|                     |                         |           |           |           |                | 6.00      | —               |           |                 |
| 63096               | 630                     | 0.060     | —         | 0.60      | —              | 6.35      | $\frac{1}{4}$   | 63.50     | $2\frac{1}{2}$  |
| 70795               | 710                     | 0.070     | —         | 0.70      | —              | 7.144     | $\frac{9}{32}$  | 69.85     | $2\frac{3}{4}$  |
| 79433               | 800                     | 0.080     | —         | 0.794     | $\frac{3}{32}$ | 7.938     | $\frac{1}{16}$  | 79.375    | $3\frac{1}{8}$  |
|                     |                         |           |           |           |                | 8.731     | $\frac{11}{32}$ |           |                 |
| 89125               | 900                     | 0.090     | —         | 0.90      | —              | 9.525     | $\frac{3}{8}$   | 88.90     | $3\frac{1}{2}$  |
| 100000              | 1000                    | 0.100     | —         | 1.00      | —              | 10.00     | —               | 101.60    | 4               |

available, with the result that for each new hole a new gauge is bought or made and that one gauge fulfils its life's task by measuring one particular hole on one particular component.

The combination of a standard tolerance system with a list of standard preferred nominal diameters would completely eliminate this wasteful procedure. Much consideration has been given in the past to preferred number series, and the series published in the "Report on the Selection of Ranges of Types and Sizes (Preferred Numbers)," by J. E. Sears, introduced these in the form of a British Standard (B.S. 1638-1950). All the suggested series are geometric, using 5, 10, 20 or 40 steps, as required. These series are inherently decimal and their application is ideal wherever the metric system or the decimal-inch system is in use. Where, however, the fractional-inch system is systematically applied a fractional series is to be used. This also is an approximate geometric series, with the 10 and 20 series as the basis of the system and 5, 40 and 80 series derived from these by various means. No attempt at correlating the differences between the decimal and fractional series appears to have been made, thus restricting the user of the Imperial fractional system to the fractional series, the user of the metric or decimal-inch systems to the decimal series, and therefore, apparently, only enlarging the gulf between them.

In firms dealing mainly with sizes below 1 in., it is often found that, due to their structure, fractional-inch as well as metric units are used side by side. Where there are good reasons for not changing all future design to decimal-inch or metric units, the introduction of two preferred number series, as described above, would only add to the confusion. Although accepting the principle of preferred numbers based on a geometric series, a slightly different approach to the construction and application of a combined series is proposed. The above-

mentioned report (B.S. 1638), as its name implies, deals with preferred numbers and not sizes. To obtain a preferred number series, the range from 1 to 10 is divided into equal logarithmic steps. The natural numbers corresponding to these logarithms form the required series. By dividing the logarithmic range by 5, 10 or  $n$ , a 5 series, 10 series or  $n$  series, respectively, will be obtained. Once a number has been derived it will remain a preferred number of that series, whatever its decimal size. Thus, 0.28, 2.8, 28, 280, etc., all correspond to one preferred number, and when multiplied by a unit become preferred sizes. It has been found more practical, when dealing with the fractional-inch and metric systems, to attribute dimensional limits to the preferred number series, rather than attempt

to find one and the same solution for dimensions from 0 to 1 in., 1 in. to 10 in., 10 in. to 100 in., etc. As the size of the dimension increases, the same geometric series will no longer satisfy requirements. Such factors as thickness of material begin to regulate the dimensional step between two consecutive preferred sizes. For example, the same figures will not be applicable in the range from 90 in. to 100 in., as in the range from 0.9 in. to 1.0 in., where the latter might, as in the 20 series, be in itself a satisfactory step. The consideration of the combined standardisation of tube diameter and tube-wall thickness will clarify this point. The practical preferred series in larger dimensional ranges resembles an arithmetic series more than a geometric series as a great number of sizes will be required to cater for all practical requirements. In the range from 0 to 1 in., however, such steps may be taken as to accommodate the effect of material thickness, and hence this range—perhaps this range alone—lends itself to strict dimensional control based on one of the geometric preferred number series. Therefore, only the range from 0 to 1 in. is considered here.

The following is an example of the practical derivation of a preferred size series from 0 to 1 in. for the use of a firm where both metric and Imperial units are in use. It has generally been found that, wherever the combined use of these units in one firm or group of firms arises, the metric units cover the range up to approximately 5 mm., and Imperial units in the form of fractions rule the field from this dimension to 1 in. Some fractional-inch sizes below the size of 5 mm. may also be deep rooted in design practice, as well as in material and tool sizes. In Table I, herewith, column 1 gives the theoretical 20 Series. In column 2, the rounded 20 series, as given by the International Standards Association, is listed. This forms the basis of the derived millimetre sizes listed in sections *a* of the following

TABLE II.—Standard Nominal Diameters for S. Smith and Sons (England), Limited.

| Inch.  | Fractions.      | Millimetres. |
|--------|-----------------|--------------|
| 0.0028 | —               | 0.07         |
| 0.0031 | —               | 0.08         |
| 0.0035 | —               | 0.09         |
| 0.0039 | —               | 0.10         |
| 0.0043 | —               | 0.11         |
| 0.0047 | —               | 0.12         |
| 0.0055 | —               | 0.14         |
| 0.0063 | —               | 0.16         |
| 0.0071 | —               | 0.18         |
| 0.0079 | —               | 0.20         |
| 0.0087 | —               | 0.22         |
| 0.0098 | —               | 0.25         |
| 0.0110 | —               | 0.28         |
| 0.0126 | —               | 0.32         |
| 0.0138 | —               | 0.35         |
| 0.0156 | $\frac{1}{64}$  | 0.3969       |
| 0.0177 | —               | 0.45         |
| 0.0197 | —               | 0.50         |
| 0.0217 | —               | 0.55         |
| 0.0236 | —               | 0.60         |
| 0.0276 | —               | 0.70         |
| 0.0313 | $\frac{1}{32}$  | 0.794        |
| 0.0354 | —               | 0.90         |
| 0.0394 | —               | 1.00         |
| 0.0469 | $\frac{3}{64}$  | 1.191        |
| 0.0492 | —               | 1.25         |
| 0.0551 | —               | 1.40         |
| 0.0625 | $\frac{1}{16}$  | 1.588        |
| 0.0709 | —               | 1.80         |
| 0.0787 | —               | 2.00         |
| 0.0938 | $\frac{3}{32}$  | 2.38         |
| 0.0984 | —               | 2.50         |
| 0.1102 | —               | 2.80         |
| 0.1250 | $\frac{1}{8}$   | 3.175        |
| 0.1406 | $\frac{3}{16}$  | 3.572        |
| 0.1563 | $\frac{5}{32}$  | 3.969        |
| 0.1772 | —               | 4.50         |
| 0.1875 | $\frac{3}{16}$  | 4.763        |
| 0.1969 | —               | 5.00         |
| 0.2188 | $\frac{7}{32}$  | 5.5566       |
| 0.2362 | —               | 6.00         |
| 0.2500 | $\frac{1}{4}$   | 6.35         |
| 0.2813 | $\frac{9}{32}$  | 7.144        |
| 0.3125 | $\frac{1}{16}$  | 7.938        |
| 0.3438 | $\frac{11}{32}$ | 8.731        |
| 0.3750 | $\frac{1}{8}$   | 9.525        |
| 0.3937 | —               | 10.00        |
| 0.4375 | $\frac{7}{16}$  | 11.113       |
| 0.5000 | $\frac{1}{2}$   | 12.70        |
| 0.5625 | $\frac{9}{16}$  | 14.288       |
| 0.6250 | $\frac{5}{8}$   | 15.875       |
| 0.6875 | $\frac{11}{16}$ | 17.463       |
| 0.7500 | $\frac{3}{4}$   | 19.05        |
| 0.8125 | $\frac{13}{16}$ | 20.638       |
| 0.8750 | $\frac{7}{8}$   | 22.225       |
| 1.0000 | —               | 25.40        |

for practical use. It gives a full nominal diameter series in the range 0.0028 in. to 1 in., as it is presented to the designer for practical use. Decimal-inch units and corresponding fractions and millimetre sizes are given. This table is intended for use in conjunction with a standard tolerance system. Where normal production methods are considered, the limits may be rounded to the nearest 0.0002 in. or 0.005 mm., since general production methods will not attain closer tolerances on normal batch runs. Moreover, dimensioning on production drawings will thus be sufficient to the nearest 0.0002 in. or 0.005 mm. The seemingly cumbersome figures shown in the tables will therefore not appear on the tolerated drawing at all, but will be rounded to 0.0002 in. or 0.005 mm. by means of the imposed

tolerance, the size and distribution of which will depend on the standard tolerance system adopted. Considering, for example, a general hole tolerance of 0.015 mm. in the range from 1 to 2 mm., the actual upper and lower limits corresponding to the preferred diameter of 1.191 mm. (0.0469 in.,  $\frac{3}{64}$  in.) will be 1.205 and 1.190 mm., or 0.0475 in. and 0.0469 in. When combining the proposed standard nominal diameters with a standard tolerance system covering adequately the range from 0 to 1 in., the product of the number of standard types of fit in such a system with the 55 standard nominal diameters suggested will give the total number of gauges required to operate the system.

Where the standard tolerance system is based on either a hole basis or a shaft basis, the actual upper and lower limit of hole and shaft may be calculated and explicitly listed, either in decimal inches or millimetres, for the use of all designers. Thus a diameter, whether designed in fractional inches or millimetres, will be measured, to the accuracy required by normal production, by one and the same gauge.

In addition to the obvious economic advantages of the introduction of such a rational system, the list of standard nominal diameters will be a help to designers, co-ordinating their activities throughout one firm or group of firms and supplying information enabling them to design more economically. Thus, by efficient standardisation, in the field of limiting sizes, design and production staffs can achieve a reduction in variety of materials, tools, and especially inspection gauges, with a resultant decrease in production costs. For the greatest benefits, however, the application of such a system would require overall co-operation and agreement between all firms concerned in order to bring sub-assemblies, bearings, special bushes, etc., into the standard. Such agreement on the use of a series of standard nominal diameters, in conjunction with a standard tolerance system in this restricted range, should bring immediate beneficial results to all concerned. Certainly, in the works of Messrs. S. Smith and Sons (England), Limited, for whom the author developed the system, it has been applied with success.

### CONTRACTS.

THE BURNTISLAND SHIPBUILDING CO., LTD., Burntisland, Fife, have secured a contract to build a cargo motorship of 11,550 tons deadweight capacity for the Power Steamship Co., Ltd., London. The vessel will have a length, between perpendiculars, of 450 ft., a breadth of 64 ft., a depth moulded of 40 ft. 5 in., a load draught of 27 ft., and a speed of 15 knots. The propelling machinery will consist of Hawthorn-Doxford type Diesel engines of 6,600 b.h.p., constructed by R. & W. HAWTHORN, LESLIE & CO., LTD., Newcastle-upon-Tyne. Another contract obtained by the Burntisland Co. is for a cargo motorship of 10,500 tons deadweight capacity for the Dover Hill Steamship Co., Ltd., London. She will have a length, between perpendiculars, of 435 ft., a breadth of 60 ft., a depth moulded of 39 ft. 6 in., a load draught of 26 ft. 7 in., and a speed of 13½ knots. The propelling machinery will comprise 4,400 b.h.p. Kincaid-B. & W. Diesel engines constructed by JOHN G. KINCAID & CO., LTD., Greenock.

During the past month, the British Electricity Authority have placed contracts for equipment for power stations, transforming stations, and transmission lines amounting, in the aggregate, to 13,516,471l. The principal contracts include: six 320,000 lb. per hour boilers for Brighton "B" power station, with BABCOCK AND WILCOX, LTD.; four 180,000 lb. per hour boilers for East Yelland Power Station and three 540,000 lb. per hour boilers for Tilbury Power Station, with JOHN THOMPSON WATER TUBE BOILERS, LTD.; and circulating water valves for Tilbury station with J. BLAKEBOROUGH & SONS, LTD.; generator and station transformers for Goldington power station, with the HACKBRIDGE AND HEWITT CO., LTD.; structural steelwork for Ince power station, with HORSELEY BRIDGE AND THOS. PIGGOTT, LTD.; superstructure for the main and ancillary buildings for Bold power station, St. Helens, with JOHN LAING & SON, LTD.; condensing and feed-heating plant for Thornhill power station, with VICKERS-ARMSTRONGS LTD.; three 550,000 lb. per hour boilers for the Stella South and three similar boilers for the Stella North power stations, near Newcastle-upon-Tyne, with CLARKE, CHAPMAN & CO., LTD.; superstructure to the main buildings of Chadderton power station, with J. JARVIS & SONS, LTD.; and three 305,000 lb. per hour boilers for Humcoat power station, with SIMON-CARVES, LTD.

### MALLEABLE CAST-IRON MANHOLE COVER.

THE accompanying illustrations (Figs. 1 and 2) show the frame of a heavy-duty manhole cover, which has been developed by Messrs. Hale and Hale (Tipton), Limited, Dudley Port, Tipton, Staffordshire. With the cover, which is made of malleable cast iron, it weighs about half as much as a normal grey cast-iron manhole cover of comparable size and strength, and, using the lifting key provided, it can be opened easily by one man. In a factory test, it has withstood a load of 25 tons without permanent set.

The frame is of grey cast iron, but the cover itself is of blackheart malleable cast iron to British Standard 310-1947, grade 3. The cover, which comprises two identical plates, is attached to the frame by long link hinges which allow it to lie flat on the roadway

Fig. 1. SECTION A-A

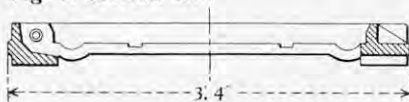
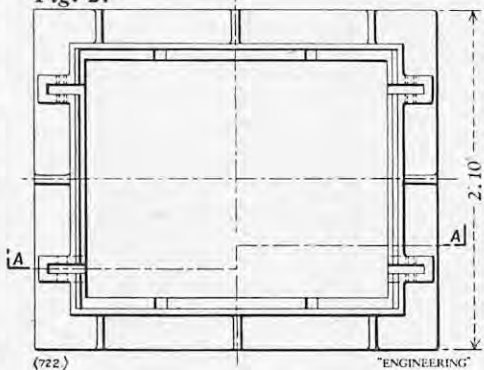


Fig. 2.



when it is open, giving a clear opening of 30 in. by 24 in. The hinges are self-cleaning, to eliminate any possibility of jamming due to dirt in the hinge slots. At the anchorages, the tail of each hinge-link has a downward extension which is almost in contact with the bottom of the slot. As the cover is opened, the hinge-link swings through an arc across the bottom of the slot and scrapes out any dirt which may have accumulated. The links are carried on mild-steel pins with brass bushes. Each cover plate is provided with four seating pads on the underside, which are adjusted during assembly at the manufacturers' works to ensure that the cover plates lie flush. A locking mechanism can be fitted to the covers, if desired.

A light-weight cover of similar construction, intended for installation in pavements, is also available, with either hinged cover plates or ordinary lift-out plates. It also provides an opening of 30 in. by 24 in.

INSTITUTION OF METALLURGISTS.—The next examinations for the licentiate and associate degrees of the Institution of Metallurgists, 4, Grosvenor-gardens, London, S.W.1, will be held at various centres from August 25 to September 2. Overseas candidates must submit their applications for permission to enter the examinations before April 1, and candidates living in this country before May 1. Examinations for the fellowship will also be held in August. Papers set at previous examinations are obtainable, at 1s. per set, from the registrar-secretary of the Institution at the above address.

ASLIB AERONAUTICAL GROUP CONFERENCE.—A week-end conference of the Aslib Aeronautical Group is to be held at the College of Aeronautics, Cranfield, from Saturday, April 5, to Monday, April 7. The conference will open with a meeting of the three working parties at 3 p.m. After dinner, which is at 6.30 p.m., a lecture will be given by Mr. P. L. Taylor, M.A., on "Electrical Engineering and Aircraft." The annual general meeting of the Group will be held on Sunday at 10.15 a.m.; before it takes place, those attending the conference will have an opportunity to inspect the College library. The annual general meeting will be followed by a talk on the work of the Technical Information Bureau of the Ministry of Supply, to be given by Mr. A. H. Holloway. In the afternoon a meeting will be held to consider the reports of the working parties and to plan new projects. On Monday morning there will be a tour round the College premises, and demonstrations of research equipment will be given. The inclusive fee for the conference is 50s. Application forms, which should be returned by March 14, may be obtained from the Secretary, Mr. C. W. Cleverdon, Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire.

### TECHNOLOGY AND HISTORY.\*

By PROFESSOR CHARLES SINGER, D.Sc.

LEONARD TRELAWNEY HOBHOUSE, in whose memory this lecture was founded, was particularly sympathetic to the idea that, just as mankind needed to be considered as a whole, so should the history of mankind; and he held, too, that the historic whole must include all major human activities. This view, largely through his influence, is now a mere commonplace but, early in the Nineteenth Century, the unity of human history was much less of a commonplace. Then, "history" usually carried the meaning "political history," and the very word "political" implies separation of mankind into groups; despite this limitation to the term "history," efforts to integrate the records of the various manifestations of the human spirit go back farther than, perhaps, many would think. The first major attempt that I have traced was by the Belgian, L. Laurent. From 1855 onward, he was issuing a long series of *Etudes sur l'Histoire de l'Humanité*. It was premature because many of the activities discussed had not yet been summarised by specialists. The first successfully integrated history was confined by the limited scale of a single country. It was J. R. Green's *History of the English People*, which appeared late in the seventies.

The United Nations Economic, Scientific and Cultural Organisation (Unesco) is now embarked on the preparation of an integrated *Scientific and Cultural History of Mankind*. The preliminary stages, it is estimated, will occupy several years. We can expect the finished product about 1956 or 1958. Conceived by Laurent about 1855, the time of gestation of this idea will thus be rather more than a century. During that period, the histories of economics, of science and of art have passed from the stage of receiving occasional attention from a few amateurs, to recognition as university disciplines with their own departments. These subjects are now sufficiently digested for the results to be freely used by historians who are not specialists. Well-arranged and documented histories of these subjects will be available to the editors of the Unesco history and their contributors. They will have more difficulty with the allied department of the history of technology on which, in a sense, science and art and, perhaps, economics all depend. No extensive attempt to summarise this theme has yet appeared. A little consideration will make clear the reason for this delay with technology.

In our own time, technology has become almost synonymous with applied science. As scientific knowledge is made accessible, it is rapidly given technical application. Inventions follow hot upon discoveries. Moreover, much scientific effort has been made with its application in clear view. This was certainly not always so, and notably not in classical antiquity. Plato and Aristotle repudiated any close relation between theoretical knowledge and the activities directed to the satisfaction of human needs. Two centuries later, Archimedes thought well to apologise for the usefulness of his inventions. The hand of Aristotle and Plato has lain heavy on posterity. For a millenium and a half, the philosopher despised mere manual dexterity. On the other hand, technical skill often reached an extremely high standard with hardly any theoretical background. After the fall of the Roman Empire, this remained true for a thousand years and more.

Why do techniques improve or deteriorate? That is a hard question to answer. So far as sheer dexterity is concerned, there is no reason to believe that it has increased during the past several thousand years. Its climax had probably been passed by the first millennium B.C., or perhaps even earlier. We must not mistake powers enhanced by improved instrumental aids for increase in skill. Art and experience are one thing, skill another. Robert Hooke, at once one of the most dextrous and one of the most inventive of modern scientific men, wrote in 1665: "It is the prerogative of Mankind, above other Creatures, that we can not only behold the works of Nature but have also the power of considering, comparing, altering and assisting them to various uses. And as this is the privilege of human nature so it is capable of being so far advanced by Art and Experience as to make some Men excel others almost as much as these do the Beasts, by the addition of artificial Instruments and Methods."

It was not until the Seventeenth Century, with Francis Bacon, that an influential writer stressed any intimate relation of the sciences and the crafts. If the founders of the Royal Society were not deceiving themselves—and perhaps they were—this Baconian suggestion of the alliance of theory and practice was the basis of their efforts. But, in spite of all this, the technical arts were even then still little affected by theoretical science. Most of the Eighteenth Century was not a greatly better case. It is well to remember

\* Hobhouse Memorial Lecture, delivered at the London School of Economics on Tuesday, October 23, 1951. Abridged.

that, until at least the beginning of the Nineteenth Century, the main source of power, the world over, was the actual physical contraction of the muscles of men or of animals.

There was a clear change toward the end of the Eighteenth and at the beginning of the Nineteenth Century. A series of men in England and France—Lavoisier and Watt, Fourcroy, Black and Leblanc, Chaptal, Davy, Faraday, and others of their type—by precept or by example, convinced a substantial body of Western manufacturers and statesmen that the way of advance for industry was the scientific route. This rapidly proved true, and especially for the use of power derived from changes in the state of matter. Only from that time, that is, for about a century and a half, has technology been generally treated as applied science.

Scientific industry is now so evidently the main source of real wealth that we have entered on a new stage in the relations of pure and applied science. Industry, that is, applied science, will be increasingly the supporter of pure science—of fundamental research, as it is sometimes called. The question is no longer to what extent industry will use science, but how and to what extent industry will promote science.

In this connection, I hope to be forgiven for being autobiographical. Dr. E. J. Holmyard and I have been entrusted by Imperial Chemical Industries, Limited, and the Clarendon Press with the task of designing and editing a large-scale *History of Technology*. This work, though it deals with technology, will be purely scientific in the sense that it will deal only with the factual and theoretic bases of technological history. It will be related to present activities only in the sense that all history must be related to the life of to-day. Doubtless, all that we have and are rooted in history, but, for reasons of a purely practical literary nature, the work must end with the Nineteenth Century. On the other hand, our contributors will seek to trace the various processes that have been involved in the arts of life from their very beginnings.

It is not news that, by small steps, stumbling and slow, Man has gradually risen to be the most fundamentally social of all creatures; that he has come to form vast aggregates of his like; that he is now the commonest of all mammals; and that he has tamed Nature with his arts. What is, perhaps, still too little appreciated is the magnitude, the inventiveness, the intellectual respectability, and the vast expenditure of experimental energy that were involved in the taking of those first steps. A chipped flint, in its proper setting, tells of more inventiveness, resource, skill, and patient trial, a longer and more exciting technological tale, than the most complex of modern machines. These crude weapons are truly among the things that have made Man.

Of all the tools that he makes, the most characteristic, the most constructive, and also doubtless the most destructive, are words. I must not pursue the development of language as part of the history of technology, but I want to make the point that, even in learning to speak, a child of four has developed a superbly intricate control of minute muscles of mouth, tongue, lips, and larynx. Such power, if it could be developed for other muscles, and notably for the hand and arm, would yield results of the most dazzling dexterity. Such acquired skill as speech separates Man immeasurably from the highest of the brutes. Man is a maker, a maker of words and a maker of tools, and both his words and his tools are of the kinds that beget their like.

The new knowledge of prehistory, that is, knowledge of man's past on the earth before he developed the technique of recording his acts, has so evolved that it must change our thoughts about ourselves, it must change our attitude toward the so-called "humane" studies, it must change our outlook on history. It must, in fact, change our whole philosophy. The change that this new knowledge has worked or is working is as revolutionary, perhaps philosophically more revolutionary, than the change in the time-scale that came with the rise of geology. Man has been making tools and words for 500,000 years—possibly more. For 95 per cent. of this time he dwelt in minute communities of hunters or fishers, developing a skill with flint and stone and bone and wood that may well excite our wonder. Nevertheless, there is no reason to suppose that manual control has been improving throughout this time. Manual skill reached a very high point in late palaeolithic times, and perhaps passed its peak in Egypt some 5,000 years ago.

The inventiveness and technological skill of Stone Age man is inadequately appreciated. At first, Palaeolithic man knew nothing of a flint knife, or even that an edge would cut. He was quite ignorant that plants grew from seeds, or that animals could be bred. To discover these things that we think simple and obvious took half a million years. Yet the best achievements of late Palaeolithic technology, as exhibited in flint and obsidian and quartzite tools culminate in an intelligently guided dexterity that has seldom been excelled. They are worthy of the respectful attention of technologists. Palaeolithic men dwelt

in groups of a dozen or so. His traditions were of the narrowest, for the population of a whole country was to be numbered in hundreds where it is now in millions. Yet some of these men achieved a skill in shaping flints which no archaeologist has yet rivalled. Our knowledge of the works of these ancient technicians provides a background to the more dramatic Palaeolithic cave art which everybody knows. Technologically, that is, judged as the products of human ingenuity and acquired skill, the tools must be ranked higher than those astonishing cave paintings.

Remembering such things, consider how to set out an ordered history of technology. As we seek to visualise the course of development of the arts of life, political history fades away. For one thing, it is on such a small time-scale—5,000 years at most, as against 500,000 at least. For another, the study of prehistory corrects some of the fallacies that have been instilled into us by an education based on the Renaissance estimate of Greece and Rome. In actual fact, the arts of life of the Graeco-Roman world, the technology that was passed on to the North West of Europe, was far from being the climax of ancient technology. The techniques of the Greek or Roman craftsmen were much below the standard of their Egyptian, their Assyrian, or even their Etruscan predecessors.

One of the difficulties in Unesco's task of constructing a coherent social and cultural history will certainly be that the time-curve of the rise and fall of the different forms of human activity do not easily fit each other. Specifically, the rise and fall of techniques form curves which do not obviously fit the curves which we conceive to be those of art or those of science, until we get to quite modern times. In constructing their integrated History, the Unesco authors will therefore have to penetrate behind the artistic, technical, and scientific achievements. The first problem of this, as of every field for historical investigation, is to divide it into manageable areas of discourse. The conventional time divisions of the political scene help little with technology. For one thing, not all mankind is at the same or even at a comparable technological level at any one date; there are, even to-day, many peoples still in the Stone Age. Again, from the Tenth Christian Century, culturally the least esteemed and most barbarous of Western history, we have technical triumphs that were not excelled for hundreds of years. Yet again, Etruscan art is rated low, as being either imitative or degenerate, yet Etruscan craftsmen of 700 B.C. used for ornamentation of gold objects a simple technique, applied with such minute skill and dexterity, that no one now living can do what they have done.

Thus, for the history of technology, ordinary dating, time-sequences, cannot yield a very useful framework. A more practical way is to treat the history of technology in relation to cultures. In any culture, some elements diffuse much more rapidly than others. Among the more rapid diffusers are technical processes. This cuts us off, in fact, from any but the broadest attempt at synchronising technology with the movements of political power until quite modern times. I would say a few words as to the scheme that we propose to adopt.

The long period of primal savagery of, perhaps, 500,000 years, was followed by one of primal barbarism of, perhaps, 10,000 years. "Savagery" and "barbarism," used in this sense, are cultural terms. Technologically, they correspond roughly to the Old and to the New Stone Ages. In the Old Stone Age, food was merely gathered. In the New Stone Age, food was more or less completely produced. Food-gathering and food-producing stages, the hunting stage and the agricultural stage, must therefore be our primary divisions, the former lasting some 500,000 years, the latter 10,000 years or more. Food-producing implies cultivation of some crops and domestication of some animals. Such early agriculture led to some sort of rough building in wood and turf in place of life in the open, or in rock shelters, or in the mouths of caves. Among other new techniques were grinding and polishing stone implements; the discovery of the qualities of baked clay and the invention of pottery, and then of the potter's wheel; cooking and preserving food; and the first developments of weaving, basket-making, and netting, and so on. All these early techniques have to be treated as the primitive forms of processes still in general use. We owe them all to the Neolithic barbarisms.

By such techniques the small agricultural communities achieved an economic and social surplus that made specialisation natural and possible, and gradually made it common. These technical advances were associated with the great social change that has been named the "Urban Revolution." In the great river valleys, this led in turn to the City-State and finally to the Early Empires. The Urban Revolution is the first great dividing event of the food-producing stage. It was narrowly anticipated by the discovery of native metals, gold and copper, and was coincident with the invention of writing.

In the period which follows—with the development

in the working of metals, with the discovery of the arts of smelting ores and of alloying metals, with the many refined applications of the different metals—techniques begin to assume that specialised aspect, demanding skills that are formally trained. Many of the methods of the miner, the smith, the gold-worker, the mason, the builder, the brickmaker, the ploughman, the wheelwright and the jeweller become recognisable as those still in use. The technology of the Ancient Empires will close the second phase of our historical survey.

Till this point, our narrative will treat mostly of the Near East, with glances farther afield and notably to the Far East; but, with the decline of the Ancient Empires, a true history of technology should turn to the Far East for its centres of interest. There is, as yet, neither the knowledge, nor as yet are there the scholars, to write an adequate history of Far Eastern technology between 500 B.C. and 1000 A.D. In its place we must weakly substitute an account of the technology of the civilisations of the Mediterranean and the Near East and of their mediaeval successors. When knowledge is more adequate, European technology, in a truer history of the subject for this period, will appear as a peripheral incident during this Asiatic millennium and a half. The close of the European Middle Ages corresponds fairly closely to the end of the great Asiatic period. The West now becomes supreme, and the operative factor in this change is more significant for the history of technology than any since the Urban Revolution. It was the Rise of Experimental Science. The four events—the rise of the Neolithic culture about 10000 B.C., the Urban Revolution about 3500 B.C., the decline of the Ancient Empires in the first millennium B.C. (c. 500 B.C.) and the Rise of Experimental Science, about 1600 A.D.—divide the history of the material condition of Man into five fairly clearly marked technological periods.

About 400 years ago, say, 1550, science—that is, experimental science—becomes distinguishable in the Western world. It took another century for science to become self-conscious. We shall not be far out in saying that, from about 1650, self-conscious science began to determine the main direction of technology. From then, scientific technology has, very slowly but to an ever-increasing degree, determined the general course of social and political history. This is only one aspect of the obvious fact that, for about 300 years, the supremacy of Western Europe in world affairs has been determined by the increasing application of science to the arts of peace and of war.

The debatable frontier before this period, say, 1450 to 1650, gives us the fourth great dividing line in the history of technology. All before is ancient, all after is modern; and in the modern period the history of technology approximates increasingly to the history of science. When the subject has been adequately explored, the history of modern technology will probably be found related to the great political movements of this modern period, that is to say, to the rise of the nation-State; to the passage of power from nation to nation, and, within the nation, from class to class; to the enlargement of the world by exploration; to the enlargement of knowledge by the use of instruments which provide, in effect, new senses; to the enlargement of thought by disclosing new views as to our own nature and that of the universe in which we dwell. In these three centuries, technology has become something more than the humble serving-maid of civilisations. She now directs and commands them.

Science and technology have now become largely identical. The instrumental extension of the senses, which Hooke stressed 300 years ago, has now assumed such proportions that every man of science has become a technician. Every man of science is now specially trained to use his own set of instruments and to work in his own chosen media. From the other side, techniques have become dependent, both for their practice and their development, on science. So much is this the case that the old empiric technological tradition is often a mere obstacle to scientific development.

There is, unfortunately, no comprehensive survey of the history of technology, nor will it be within the power of any one man to write it until, in the course of years, the subject has been marshalled by a large team of authors. That this will be possible is, of course, due to the work of many investigators. Of this number, three should surely be singled out, because their contributions are so extensive, so fundamental, so trustworthy, that without them the work forecasted could not even be undertaken. There is just one point in time—one only—the technology of which has been specially illuminated. Denis Diderot, in his great *Encyclopædia of the Sciences, Arts, and Crafts*, has given a majestic survey of the technology of the mid-Eighteenth Century. It is unique, and for that period we have information more detailed and complete than for any other. Diderot's work is not history, but it is very much the material out of which history can be built. It is very fortunate for historians of technology that Diderot provides this survey of

technology just before the Industrial Revolution got under way.

The work of the two other great contributors to the subject is too little known to historical writers. It is therefore fitting to end by saying something about them. The first is the Frenchman, Charles Frémont. He was born in 1855, the year in which Laurent began his history of humanity. Frémont died in 1930. There must be few who have lived a life so uniform, with aims so much of one piece, so directed by one simple motive. As a youth, he began to study medicine, but was soon deflected by interest in chemical processes and by his innate skill and delight in mechanical devices. He developed an intense enthusiasm for techniques, and especially for their evolutionary history. He began by setting up a laboratory of his own for testing strengths of materials. Soon he became, and remained for life, a technical demonstrator at the School of Mines in Paris. He had no academic standing and his status was nominally subordinate. His special powers were early recognised and his duties lightened. He was given great scope, if little practical encouragement. Every minute that he could, he devoted to the double aim of historical research on technical methods and the practical testing of them in the laboratory. His industry was prodigious. He wrote no book, but he published his results in periodicals, in 82 memoirs, many of book size. They deal with the history and development of many instruments, substances, and processes, all combined with experimental work of a magisterial order. He lived in poverty, a recluse, sharing a couple of attics with his sister, who remained with him through life. He never married, never took a holiday, never left France, and very seldom left Paris. He refused many honours, including several very flattering invitations to visit England. He did accept, however, a number of medals and decorations, which he gave to his country to be melted down during the first World War. No history of technology could be written without frequent reference to his astonishing writings, of which, I believe, there exist only two complete sets, both in Paris libraries. They should be reprinted. I never met Frémont, though I made several attempts to do so. He was not at all an easy man to meet.

Of the second of these great scholars of the history of technology, I can speak with more knowledge. Dr. Henry Winram Dickinson is, unlike Frémont, a well-trained man of science and an experienced engineer. He was, for many years, an official at the Science Museum. He is a most fertile writer over an immense range of the history of technology. He has produced many important books on the subject and is recognised as the leading authority on the history of technology, especially in relation to the Industrial Revolution. He is a founder, the editor, and the most active member of the Newcomen Society for the Study of the History of Engineering and Technology, and has now edited 25 volumes of its *Transactions*, besides many accessory works. Dickinson and Frémont are undoubtedly the leading modern authorities on the history of the subject.

Scholarship on the scale of that of Frémont and Dickinson has in it something of the heroic. Such singleness of purpose, such learning, such skill, such penetration, inevitably affect the character of those who exhibit them. The contemplation of their lives induces a reflection on the effect on these fortunate and happy men of the single-minded pursuit of truth. The patterns of conduct and character moulded by devotion to science are, of course, different from those determined by devotion to religion. Though different, yet they are not wholly different. The mood in which such scientific men approach their tasks is surely derived from something very near to "that subtle lively, clear, and undefined thing that is more moving than any motion and goes through all things by reason of her pureness, yea, Wisdom, which is the artificer of all things."

**TRAINING OF MERCANTILE-MARINE ENGINEER OFFICERS.**—The new alternative scheme for training engineer officers for the merchant navy, details of which were given on page 211, of our last week's issue, has, in general, been welcomed by shipping companies and several already have announced their intention of taking part. The Anglo-Saxon Petroleum Company, Limited, for example, are putting the scheme into force at once, and to meet the demands of their continually-expanding fleet, aim to recruit and train annually 200 apprentice engineers. The company will consider applications from public schoolboys, even if over 18 years old, provided they have reached the required degree of proficiency. The apprenticeship course occupies 4½ years, part of which time is spent at sea, and on its completion, successful candidates will be appointed as junior engineers in the Shell fleet. Wages will be paid throughout the training period and certain allowances will be made towards board and lodging while ashore. The company, however, will continue, to recruit potential engineer officers from among those who have completed the required full-time shore apprenticeship,

## LABOUR NOTES.

**OSTRACISM** as a means of stimulating railwaymen to join their trade union is advocated in an article in last Friday's issue of the *Railway Review*, the official publication of the National Union of Railwaymen. Out of a staff of some 600,000 persons employed by British Railways, it is estimated that more than 560,000 belong to one or other of the four railway unions. The N.U.R. alone has a membership of nearly 400,000, and the remaining unionists belong either to the Associated Society of Locomotive Engineers and Firemen, the Transport Salaried Staffs' Association, or to the Confederation of Shipbuilding and Engineering Unions. The N.U.R. has sought for some time to achieve a hundred per cent. trade-union membership among railway employees.

After referring to non-unionists in strong terms of disapproval, the article suggests that such employees "must be given the option, in no mild manner, to come with us or be drilled out like any common deserter who is weakening his own class." It is suggested that this is a job "for everyone who at any time, in any place, or on any occasion, meets one of these miserable people." The article also comments: "So long as there is one non-unionist outside our ranks, no effort must be spared to make him join. If he still refuses, loyal members will be forced to treat him in the way he deserves. He must be ostracised. He must be made to feel what he is—an outcast."

Proposals designed to minimise hardships to those who may be displaced as a result of the forthcoming staff reductions in Government Departments, were announced on Monday last by the staff side of the National Whitley Council for the Civil Service. The staff side will seek an early meeting with Treasury officials for this purpose. Most of the suggestions which would be put forward, it was stated, would be concerned with administrative problems, but the unions represented on the staff side would propose that the recruiting of newcomers to the Service from open competitions should be limited in many Departments. Such action would enable the reductions desired by the Government to be obtained by normal wastage rather than by the dismissal of temporary staff. The staff side would not suggest, however, that this policy should apply to the administrative class or to those Departments urgently needing recruits.

In an interview on Monday, after a private meeting of the staff side in London, Mr. T. R. Jones, the secretary, said that another suggestion would be that Government employees, aged 55 and over, should be permitted by the Treasury to retire if they so wished, and that such persons should be granted a pension in proportion to their length of service. It may be recalled that, as recorded on page 184, *ante*, Mr. R. A. Butler, the Chancellor of the Exchequer, announced at the beginning of February that retirements from the Civil Service at early ages would be discouraged. In future, new rules would be operated, whereby retirements would not normally take place before the age of 60. Employees would not be compelled to remain after that age, however, but would be free to retire then or subsequently if they desired. Their continued employment beyond the age of 60 would depend upon the needs of the Department concerned, which would apply tests of efficiency as they neared that age, and at regular intervals afterwards.

Principles involved in the recognition of trade unions by the Postmaster-General form the subject of a report by the Post Office (departmental classes) recognition committee, of which Lord Terrington, C.B.E., was the chairman. The report was recently submitted to the Postmaster-General, Lord De La Warr, and has now been published as a White Paper by the Stationery Office (Cmd. 8470, price 9d. net). In general, the report recommends that claims by the smaller unions for recognition should be refused, and that the Department should embark upon a policy of encouraging existing unions to amalgamate. It is proposed that the formula for recognition established by Lord Listowel, when Postmaster-General, in 1946, should be abolished. This laid down the principles that recognition would be considered where a staff association could show that it had obtained a membership of at least 40 per cent. of the organised staff in the grade concerned, and that recognition would be withdrawn should the percentage decline to less than one-third.

It is recommended by the committee that no other formula, based on a percentage of members, should be substituted for that already existing, but that, in future, three main principles should be applied to all requests for recognition. These principles are, firstly, that it is undesirable to have more than one union or association representing the same grade or group of

grades; secondly, that the union seeking recognition should be required to prove to the satisfaction of the Postmaster-General that the existing recognised body had failed, and that it was unable to promote the welfare of the grade or grades concerned; and, lastly, that the new body must show that it was financially stable and organised in such a manner that it could serve the interests of its members more efficiently than the existing recognised organisation.

The committee recommends that, where more than one union at present represents the same grade or group of grades, efforts should be made to effect an amalgamation, and that, where there was an "absence of progress" towards amalgamation within a period of twelve months, the Postmaster-General should cause all cases of dual recognition to be re-examined. It is proposed that difference of sex should no longer be regarded as justifying dual recognition of associations catering for the same grade. In this connection, the report quotes the example of men and women telephonists, who are organised into separate associations. Among Post Office unions whose claims the committee does not advocate are the National Guild of Motor Engineers and the Engineering Officers (Telecommunications) Association.

Proposals that, in some instances, payments to miners in respect of their annual holiday should be free of income tax were put forward at a meeting of the Scottish area executive committee of the National Union of Mineworkers in Edinburgh on Monday last. The suggestion originated with the union's branch at Michael Colliery, Fife, which considered that, as the granting of a second week's holiday with pay had been made by the National Coal Board on the understanding that, in 1952, miners should work during the second week, a demand should be presented to the Government for payments in respect of the second week's holiday to be free of tax. The committee decided to make representations, in support of this proposition, to the Chancellor of the Exchequer and Members of Parliament representing mining constituencies.

There was an increase of 75,800 in the number of unemployed persons in Great Britain during the five weeks between December 10, 1951, and January 14, 1952. The total number of persons out of work on the latter date was 378,741, of whom 63,700 were only temporarily unemployed, but a further 117,600 had been disengaged for more than eight weeks. Statistics issued by the Ministry of Labour and National Service, on Monday last, show that the total of 378,741 comprised 206,100 men aged 18 and upwards, 143,556 women aged 18 and upwards, 10,279 youths under 18, and 18,806 girls under 18. These figures included all unemployed persons on the registers of employment exchanges, with the exception only of severely disabled persons, who were only capable of work under special conditions. The level of unemployment on January 14 represented 1.8 per cent. of the estimated total number of employees in Great Britain, compared with 1.4 per cent. on December 10, 1951, and 1.6 per cent. on January 15, 1951.

The total working population in Great Britain rose from 23,185,000 at the end of 1950 to 23,426,000 on December 31, 1951, an increase by 241,000. Of the total on December 31 last, 16,007,000 were men and boys, and 7,419,000 women and girls, compared with 15,881,000 men and boys, and 7,304,000 women and girls, at the close of 1950. These figures include all persons aged 15 and over who work for pay or gain, or who register themselves as available for such work. The total comprises the Armed Forces, men and women on release leave, registered unemployed, and employers and workpeople in civil employment, including private indoor domestic servants and gainfully-occupied persons over pensionable age. Part-time employees are counted as full units.

There were 852,000 persons in the Forces at the end of December last, of whom 829,000 were men and 23,000 women. The total number twelve months previously was 752,000, which comprised 730,000 men and 22,000 women. Persons in civil employment (industry, commerce, and services of all kinds) numbered 22,221,000 at the end of December, 1951, compared with 22,105,000 at the end of December, 1950. Of the total on December 31 last, 4,074,000 were engaged in the basic industries—agriculture, fishing, mining, quarrying, transport and communications, and in gas, electricity and water undertakings. This was an increase of 12,000 on the total for the previous year. Some 8,786,000 persons were engaged in the manufacturing industries at the end of last year, compared with 8,702,000 at the close of 1950. There were 627,000 persons in the Civil Service on December 31, 1951, compared with 613,000 on December 31, 1950. Persons in the employ of local authorities numbered 746,000 at the close of 1951, against 737,000 a year previously.

## FUELS FOR MARINE AUXILIARY OIL ENGINES.

Fig. 1. INFLUENCE OF FUEL DENSITY ON MAX. BRAKE THERMAL EFFICIENCY.

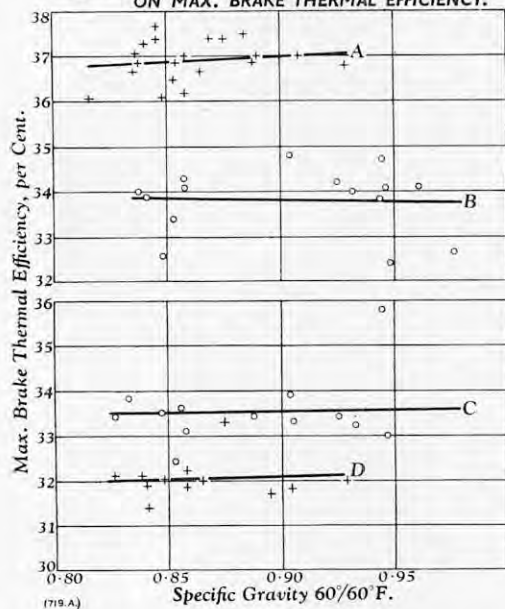


Fig. 2. INFLUENCE OF IGNITION QUALITY OF FUEL ON PERFORMANCE.

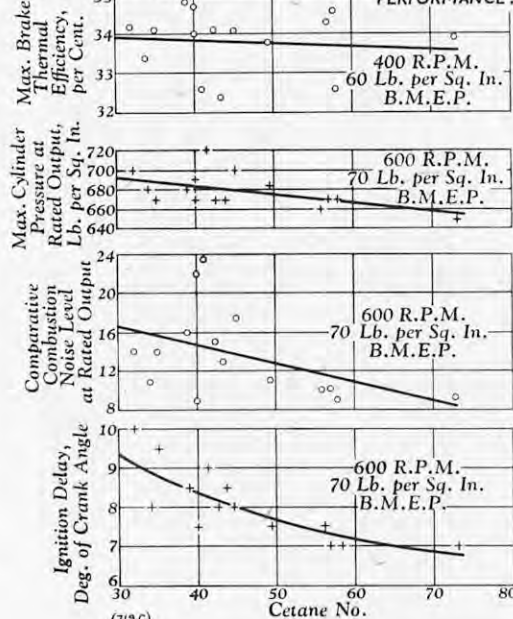


Fig. 3. IGNITION QUALITY AND VISCOSITY OF FUELS.

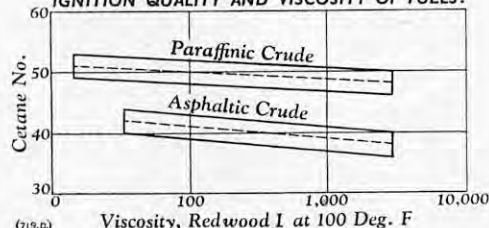
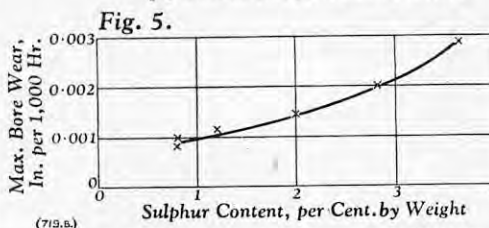
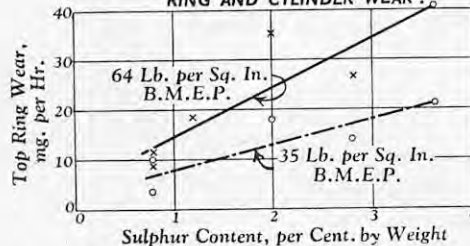


Fig. 4. INFLUENCE OF SULPHUR ON RING AND CYLINDER WEAR.



## FUELS FOR MARINE AUXILIARY OIL ENGINES.\*

By C. D. BREWER, M.I.Mech.E., F.Inst.Pet.

IN motor ships having auxiliary equipment of the compression-ignition type, solution of the fuelling problem presents three possibilities; firstly, to run all engines, main and auxiliary, on a single fuel judged to be best suited to the usually smaller auxiliary types; secondly, to bunker fuels separately where economics suggest the use of a cheaper fuel for the main engines that may be judged to be unsuited to the auxiliary engine; or thirdly, because of the obvious disadvantages of bunkering two separate fuels, to run all engines on a compromise fuel, which, being cheaper than that

may be the fundamental operating requirements of maximum overall economy or convenience. The fuel bill represents the largest single item in the operating budget of large marine engines, and is likely to be greater in aggregate than the price of the engines in less than three years' operation.

Lack of information as to the behaviour of engines operating on fuels of higher viscosity than those usually employed has put some restraint on their use. Data are presented here to guide the shipowner and engineer to a better appreciation of the relative merits of varying types of fuel. These data will—in addition to those referring to gas oils and marine Diesel fuels, i.e., the B.S.S. 209-1947 categories—extend to grades intended primarily for under-boiler use. Although the use of

TABLE I.—CLASSIFICATION OF FUELS.

| Designation                                                   | British Standards Specification 209-1947. |                                                                                   | Heavy Fuels or (Under-) Boiler Fuels.                                                                                                                                                                                              |
|---------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                               | Class "A."                                | Class "B."                                                                        |                                                                                                                                                                                                                                    |
| Make-up .. .. .                                               | Wholly distillate.                        | Mainly or wholly distillate; may contain straight run (but not cracked residual). | Mainly (in rare cases wholly) residual; usually blended with some distillate to reduce viscosity.                                                                                                                                  |
| Cetane number .. .. .                                         | 45 minimum                                | 23 minimum                                                                        | Rated almost entirely on viscosity, which may be as great as 6,500 seconds Red. I at 100 deg. F. Limits for water, sediment, flash-point and calorific value may be specified, as for instance in B.S.S. 742-1947, Tables 2 and 3: |
| Viscosity at 100 deg. F. cs .. .. .                           | 2.0-7.5                                   | 24 maximum                                                                        | 150 minimum                                                                                                                                                                                                                        |
| Viscosity at 100 deg. F. cs Redwood I .. .. .                 | 31-45                                     | 100 ..                                                                            | 18,500 or 18,000 minimum                                                                                                                                                                                                           |
| Carbon residue Conradson, per cent. w .. .. .                 | 0.1 maximum                               | 2.0 ..                                                                            | Marine fuel oil.                                                                                                                                                                                                                   |
| Distillation, per cent. vol. recovered at 662 deg. F. .. .. . | 85 minimum                                | ..                                                                                | Boilers: sometimes in large main propulsion engines.                                                                                                                                                                               |
| Sulphur, per cent. w .. .. .                                  | 1.5 maximum                               | 2.0 maximum                                                                       |                                                                                                                                                                                                                                    |
| Water, per cent. w .. .. .                                    | 0.1 ..                                    | 0.25 ..                                                                           |                                                                                                                                                                                                                                    |
| Ash, per cent. w .. .. .                                      | 0.01 ..                                   | 0.03 ..                                                                           |                                                                                                                                                                                                                                    |
| Sediment, per cent. w .. .. .                                 | 0.01 ..                                   | 0.1 ..                                                                            |                                                                                                                                                                                                                                    |
| Flash point (closed), deg. F. .. .. .                         | 150 minimum                               | 150 minimum                                                                       |                                                                                                                                                                                                                                    |
| Calorific value, gross, B.Th.U. per lb. .. .. .               | 19,000 ..                                 | 18,500 ..                                                                         |                                                                                                                                                                                                                                    |
| Equivalent marine grade .. .. .                               | Gas oil                                   | Marine Diesel fuel                                                                |                                                                                                                                                                                                                                    |
| Normally used in .. .. .                                      | Marine auxiliary and some main engines.   | Larger marine and some auxiliary engines.                                         |                                                                                                                                                                                                                                    |

used in the first arrangement, will effect a worthwhile economy for the main engine operation. It is this third alternative with which this paper is mainly concerned.

Fuel cost in the auxiliary units is not necessarily of prime importance, particularly when considered in relation to the fuel consumption of the main engines. Where the main-engine fuel is a gas oil, no operating problems on account of the fuel should arise. However, where the main-engine fuel is of a marine Diesel grade, the possibilities of using it in the auxiliaries also is of immediate interest, in that it obviates the necessity of having two fuel-handling and storage systems. This paper discusses the problems which may be expected to arise when using, in auxiliary engines, main-engine fuel of a quality of which neither the manufacturer nor the engineer has had experience for this purpose.

The desire of operators to ensure the highest possible degree of reliability, with minimum routine attention, has sometimes led to requests for fuels of unnecessarily high quality for successful operation. Opposed to this

fuels not specifically marketed for compression-ignition engines is not actively encouraged, there can be an economic advantage in their use in the largest engines, in certain circumstances.

It is first necessary to strike a clear dividing line between two completely different groups of fuels; these are, first, such grades as are generally marketed specifically for Diesel use, and second, fuels which, though primarily supplied for use under boilers or in furnaces, are also chosen as engine fuels because their cost is generally much lower. For convenience, fuels in the first category may be said to be covered by British Standard Specification 209-1947, which is subdivided into Class "A" and Class "B," embracing, in both cases, limits for tests such as ash, Conradson carbon and sulphur. In marine circles, gas oils would approximate to Class "A" stipulation, although not necessarily so in respect of ignition quality. Those within Class "B" are more familiarly known as marine Diesel fuels. Immediately a fuel fails to meet the wider limits of this specification (i.e., the Class "B" stipulation) it is strictly no longer regarded as a Diesel fuel or marketed as such. It becomes an under-boiler grade or component, and is subject only to such guarantees as affect its suitability for use in steam-raising or furnace

work. Such fuels are variously known as "fuel oils"; "boiler (or under-boiler) fuels" or "heavy fuels." For simplicity, the designation "heavy fuels" is used throughout this paper. All fuels within Class "A" limits would also meet the Class "B" stipulation. Thus the specification does not attempt to describe two completely different grades, but lays down outer limits for Class "B" grades with closer ones for Class "A" fuels, so that users may have a choice according to their type of equipment and service. Table I, herewith, shows clearly the foregoing classification and explains what guarantees can be expected from supplies in the "heavy fuel" category.

Fuel costs are influenced by the economics of production, supply and demand, and the degree of tolerance by way of specification permitted. Gas oil, being subject to more rigorous specification controls, is usually more expensive than marine Diesel fuel. Heavy fuels are usually cheaper than either, since the principal control is viscosity, though sediment and water are also subject to limitations. Specifications which are unnecessarily restrictive—that is, having tolerances the extremes of which could not significantly influence engine behaviour—can only result in reduced quantity and availability and, therefore, an increase in price. In the high-speed and, therefore, more fuel-sensitive end of the engine range, some form of quality control within relatively narrow limits is necessary; but, in the procession down the range towards larger engines and slower speeds, data will be presented which show that individual fuel characteristics become of less importance. In general, for a good design, an engine is much less sensitive in its fuel requirements than is usually realised. B.S.S. 209-1947 gives only very general guidance as to which of the classes specified should be employed in a particular engine; it states, "the decision as to which of these fuels should be employed depends on the design, size and operating conditions of the engine and must be the responsibility of the user based on experience and on the engine manufacturer's advice." Where fuels are destined for steam-raising or other similar duties, control of viscosity for handling purposes is virtually all that is required.

The fuels normally burnt in the larger marine propulsion engines come under the Class "B" heading, and at least one fuel within this specification is therefore usually available in any port with bunkering installation. Any compression-ignition engine will operate on a high-grade gas oil, but whether a particular engine needs such a fuel to carry out its job at a level satisfactory to the owner or engineer, after taking into account the convenience and economy of using it, is the point to be decided. It is important, however, in considering the use of an alternative grade, to bear in mind that all fuels are not marketed in all ports, and that the choice of alternatives is limited to those available at a particular port or bunkering station.

In considering the selection of different fuels for engines, the first point that must be determined is which of the characteristics of the fuel, usually

\* Paper read at a meeting of the Institute of Marine Engineers, in London, on February 12, 1952. Abridged.

measured and quoted in a specification, really influences the behaviour of the engine. Where these fuel characteristics can be shown to influence engine behaviour, it is also necessary to know within what limits their influence is significant. The exact answer, however, can be found only by testing the particular fuel on the particular engine under the particular condition of running, and bearing in mind such factors as standard maintenance periods, the cost of "shut-down" time, or the availability of stand-by engines.

It has been shown, in the research laboratories at Thornton and elsewhere, that the compression-ignition engine will run with virtually the same brake thermal efficiency on all fuels that it can digest; this excludes, for instance, a fuel which is so viscous at the operating temperature at the injector that it cannot be properly atomised; this can be overcome, within limits, by preheating the fuel. It would also exclude a fuel of such low ignition quality that it misfires. What this limit is, in terms of cetane number, is not known, except that it is outside the lower limit of the Class "B" specification. In the experiments from which the data here presented are derived, the lowest value for any fuel tested was 24. Thus, a fuel of excessively high viscosity, or one of low ignition quality, by causing poor combustion, can detract from the brake thermal efficiency of the engine. The insensitivity of an engine, in respect of the brake thermal efficiency, to differences in fuel characteristics is well illustrated in Fig. 1, on page 249, which shows that there is little relationship between the density of the fuel and the maximum brake thermal efficiency of four different engines. These engines cover a wide range of size, from 80 mm. to 240 mm. bore, both two-stroke and four-stroke, and all show the same tendencies. These data are derived from tests on fuels which were selected with reference to their viscosity, which, as will be shown, implies insensitivity to this factor. The scatter of the results, while small when considered in relation to the scale used, may be attributable to such factors as extremes of viscosity and ignition quality.

The influence of ignition quality on general engine behaviour has been found to be much less than would be expected and, even in high-speed engines of the automotive type, fuels having cetane numbers of greater than 45 behave well in most types of engine in such directly observed respects as rated power output, consumption, and exhaust smoke. Fig. 2, on page 249, shows the influence of this ignition quality of the fuel on the performance of a single-cylinder engine, typical in size of those used for marine auxiliary purposes. The engine factors which show direct relationship with ignition quality and are themselves directly related, are ignition delay, combustion noise and maximum cylinder pressure. While the rise on maximum cylinder pressure, in the case illustrated, may not be considered to be objectionable, the graph does not give a very true impression of the increase in noise level, which was, in fact, considerable for fuels having a cetane number of 40 or less. The single-cylinder engine is usually characterised by its apparent combustion roughness, and the increase in noise experienced with the fuels of low ignition quality would be much less noticeable in a multi-cylinder engine. The effect of ignition quality on noise becomes of greater significance as the size of engine is reduced, but even on the smaller engines, though the increase in combustion noise is progressive with a reduction in cetane number, the rate of increase is not sufficient to give appreciable differences in noise between two fuels having different cetane numbers until at least one of them is below about 45.

With some designs, a reduction in cetane number does give some improvement in the maximum power that can be obtained with a clear exhaust. There are several explanations of this. Ignition delay is directly related to cetane number and the increase in delay with reduction in cetane number may enable the fuel to become better mixed with the combustion air before ignition starts. Once ignited, low-cetane fuels burn quicker than those of high cetane number, resulting, within limits, in greater thermal efficiency of the cycle.

The effect of ignition quality on starting is dependent somewhat on the characteristics of the engine, but again it is evident that, for values of cetane number above 45, differences between normally available fuels are not really significant. This is the case particularly where the engine and fuel system are heated before starting. From the foregoing it will be seen that ignition quality of fuels normally available is of little concern to the marine engineer or operator. Nevertheless, it is interesting to record the results of experiments in the laboratory to determine directly the ignition quality (i.e., cetane number) of Diesel fuels and heavy fuels up to the limits of viscosity normally available at bunkering stations.

One of the simpler standard methods of determining the cetane number of a fuel is by that usually referred to as the I.P. throttling method. Briefly, by this method the depression in the inlet manifold required to cause misfiring of the engine, running on the fuel

## FUELS FOR MARINE AUXILIARY OIL ENGINES.



FIG. 6. INJECTOR TIP DEPOSITS AFTER SIX HOURS ON HEAVY FUEL.



FIG. 7. DEPOSITS ON VALVE FACE.

to be tested, when the air inlet is throttled—usually by means of a gate valve or similar device in the air suction pipe—is compared with that required to cause misfire when running on each of two reference fuels, made up of blends of known cetane number. The ignition quality, in cetane numbers, of the fuel under test can be derived directly by interpolation by plotting the three results. A modification of this method, which is even more simple, is to match the test fuel with a blend of reference fuels to give the same manifold depression for misfire.

Because of the small size of the single-cylinder Diesel engines normally used for these tests, it is not possible to obtain directly, with any accuracy, the ignition quality of Diesel fuels or heavy fuels with a viscosity of greater than 50 seconds Redwood I at 100 deg. F. They have to be diluted with gas oils, of known cetane number, to reduce their viscosity to that which can be handled by the injection equipment. However, in the laboratory tests referred to, a medium-sized single-cylinder engine, having a bore of 240 mm., was used, which imposed no such limitations, and it was possible to test, without dilution, fuels covering the entire range of viscosities normally marketed. Preheating of the fuel was sometimes necessary to reduce the viscosity at the high-pressure pump to a maximum of 150 seconds Redwood I.

The results of these experiments showed that the cetane number of Diesel fuels and heavy fuels could be at least as high as that of some gas oils, and that the ignition quality of a fuel is determined essentially by the type of crude from which it is derived. Viscosity was shown to have little influence on ignition quality. The results of these tests are illustrated in Fig. 3, on page 249, which shows the relationship between ignition quality and viscosity of fuels of two different types, covering a range of viscosities from 34 seconds to 6,300 seconds Redwood I at 100 deg. F. The influence of the type of crude on the ignition quality of its derived fuels, and its indifference in this respect to viscosity, is clearly demonstrated. While there was some spread on the results obtained, the great majority of the determinations fell well within the normal limits of accuracy of the method of about  $\pm 2$  cetane numbers. It has frequently been observed that running main engines on some heavy fuels has resulted in smoother operation than on some Diesel fuels, and these experiments go some way to providing an explanation.

It would appear, from the foregoing discussion on the two fuel characteristics of viscosity and ignition quality, that these have little influence on the choice of fuels. However, it is in respect of those characteristics influencing fouling that trouble is most likely to be experienced. The ability of an engine to run on a particular grade of fuel is largely governed by its compression temperature and the mean temperature of the operating cycle. These temperatures must be high enough to effect complete volatilisation of the heavy components of the fuel if excessive combustion-chamber fouling and port blocking is to be avoided. The mean temperature of the operating cycle in any

engine is determined by the load on the engine and will therefore increase with increase in load. Thus it is often seen that engines which, while operating quite satisfactorily on certain fuels on high loads, may be in serious trouble at low loads because the mean temperature within the combustion space is too low to effect complete vaporisation of all the components in the fuel. On the other hand, engines in the smallest size group may not have sufficient "heat" to consume these fuels and would be very quickly in trouble, even when running at full load.

Laboratory investigations to establish the influence of individual fuel characteristics on wear on a number of small engines of various types have shown that ring and liner wear can increase with the sulphur content of the fuel, and that this increase is approximately linear for otherwise similar fuels. Not only has ring wear been shown to be more or less proportional to the sulphur content of the fuel in these cases, but also to engine load with a given fuel. The influence of sulphur is illustrated in Figs. 4 and 5, on page 249. The same may be true for cylinder bore wear, but this has not been so clearly demonstrated. However, these tests were designed to show the influence on wear of each of several individual characteristics of otherwise identical fuels, and the effect of other variables such as dust or ash were eliminated as far as possible. That the sulphur content of the fuel is not necessarily the principal characteristic influencing wear has been amply demonstrated by tests on large engines operated on several fuels of different type, as, for instance, where the rate of ring wear experienced in an engine operated on a certain marine Diesel fuel was as much as five times that of a distillate fuel of the same sulphur content. It is apparent, therefore, that, with some fuels, other properties than the sulphur content can be of greater significance in their influence on wear.

A source of trouble associated with the use of some Diesel fuels and heavy fuels is that of nozzle fouling—building up of deposits on the tip of the atomiser. While it can be shown that the extent of these deposits bears a direct relationship with certain fuel characteristics, such as Conradson carbon and sulphur, particularly where both are high, they are also influenced by operating conditions. Predominant among these are nozzle temperature and the mechanical condition of the injection equipment. The importance of these deposits is related to the maximum size they attain and thereby their interference with fuel/air distribution in the combustion chamber. They are, no doubt, influenced by combustion-chamber design and perhaps load, but it is nevertheless astonishing to discover the size that they can and do attain. Fig. 6, herewith, illustrates a typical formation. It is well known that the formation of these deposits is cyclic, with a periodicity of only a few hours in some cases. While the interference they cause to the operating efficiency of each cylinder in a multi-cylinder engine is therefore also cyclic, it is unlikely that any two cylinders would be in phase, so that the output of the whole engine could be appreciably affected.

## FUELS FOR MARINE AUXILIARY OIL ENGINES.



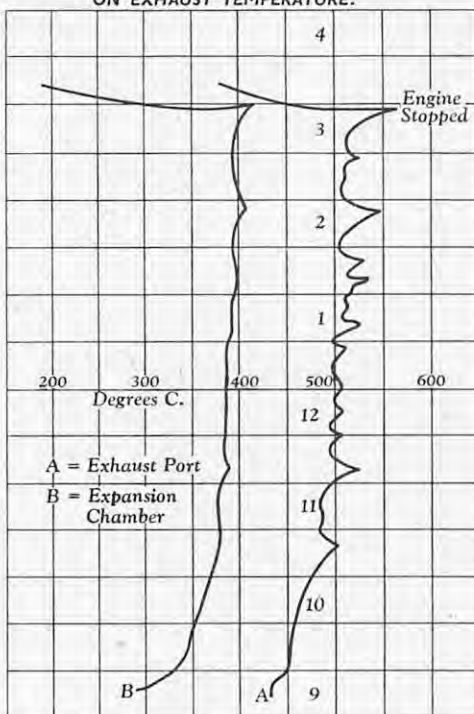
FIG. 8. GUTTERS IN EXHAUST-VALVE FACE.

In laboratory tests on a single-cylinder engine, it was interesting to examine the recorded trace of the temperature of the exhaust when operating under conditions favourable to the formation of nozzle deposits. Fig. 9, herewith, shows a section of such a record chart, in which the short and somewhat irregular period of interference to combustion efficiency by nozzle-tip deposits, resulting in increased exhaust temperature, is well illustrated. Proof of the relationship of the humps on the trace with the presence of nozzle deposits were obtained by examining the nozzle tip through the inlet port when the engine was shut down, at a point coinciding with the peak of a hump. The photograph of the nozzle deposits reproduced in Fig. 6 was obtained when the engine was stopped at the point on the trace in Fig. 9, by means of a periscope inserted through the inlet port after the removal of the inlet valve and cage. The size of the hump sometimes (though not necessarily) bears a direct relation to the size of the deposits, and may be taken as a convenient yardstick when studying the factors influencing the formation of these deposits.

Proper cooling of the injector is a matter of paramount importance if excessive fouling is to be avoided. The actual optimum operating temperature of the injector can only be obtained by experiment, since it has been shown that, whereas overheating of the nozzle is the more usual experience with fouling in medium-sized engines, there is some service evidence to suggest that overcooling in the case of large propulsion engines can give rise to equally serious trouble. In large marine engines with otherwise satisfactory injection characteristics, the occurrence of injector tip deposits is virtually unknown where satisfactory cooling systems exist, but the disappointing results obtained by some operators when attempting to use heavy fuels in auxiliary engines of medium size may well be attributable directly to the incorrect operating temperatures of the injector. Additional cooling of the injector nozzle assembly will probably be necessary for satisfactory service when medium-sized engines are changed over to operate on Diesel fuel rather than gas oils.

Unfortunately, this additional cooling is not always easily obtained, since laboratory tests have shown that the nozzle-tip temperatures are not greatly influenced in most cases by a reduction in the jacket cooling-water temperatures. On two engines differing greatly in size, it was found that, for every 18 deg. F. reduction in jacket temperature, the nozzle-tip temperature was reduced by only 3½ deg. F. approximately. These tests also indicated that the safe working temperature of the nozzle, measured in the fuel space, immediately above the injector seat, was about 257 deg. F. It is apparent, however, that this optimum temperature could vary between different types of engines. Any attempt to reduce the jacket cooling-water outlet temperature so as to give a worthwhile reduction in injector temperatures would result in an impossibly low temperature for the satisfactory operation of the engine as a whole.

Fig. 9. INFLUENCE OF NOZZLE TIP DEPOSITS ON EXHAUST TEMPERATURE.



(719E)

Apart from the direct and more obvious symptoms of a fouled injector on engine performance, it is not generally appreciated that faulty combustion arising from this condition can result in serious operating difficulties even before the symptoms of nozzle deposits become apparent by the condition of the exhaust, which, in any case, might pass unnoticed in installations where the exhaust system is shared by several engines. These operating difficulties are numerous and may include excessive combustion-chamber deposits, ring sticking and port blocking, and greatly increased contamination of the lubricating oil. The rate of cylinder-bore and piston-ring wear can also be greatly influenced by the condition of combustion, and rates of up to ten times that normally experienced have been reported by some observers to be entirely due to the unsatisfactory operation of the injection equipment. The importance of proper maintenance of injection equipment to ensure optimum combustion efficiency and reduction of nozzle deposits cannot be over emphasised. No dribble can be tolerated, and a sharp cut-off is essential.

A point of importance when considering the use in the smaller auxiliary units of main-engine fuel, where this is of an under-boiler quality, is the wide variations that can occur in fuel analysis, particularly in respect of viscosity, between different bunkering stations. This is a problem that does not usually face the operator of on-shore installations where, even if he is using other than a fuel meeting "A" or "B" requirements he may be reasonably sure of his supplies having a reasonably uniform viscosity. At sea, however, the picture is different. In modern practice, the main-engine fuelling arrangements may be such that full advantage can be taken of using any available fuel with perhaps an upper limit on viscosity of, say, 1,000 secs., or even 3,500 secs. Redwood I at 100 deg. F. Now the main engine, because of its size, is relatively insensitive to viscosity change and other changes which may go with it, though it is usually necessary to adjust heating of the fuel for proper handling and centrifuging or offset changes in viscosity by fitting different sprayers. The smaller auxiliary engine will be much more conservative in its appetite and certainly more critical in its adjustments to accommodate these changes. This sensitivity may not necessarily show up immediately in performance, but reliability and maintenance are bound to suffer, particularly if fuels are used of appreciably different viscosity from those usually employed.

On the change of fuel quality between bunkering installations and the possible influence of this on engine behaviour, Mr. J. Lamb, of the Anglo-Saxon Petroleum Company, reports on exhaust-valve failures in main engines following a substantial increase in exhaust temperature that had been observed when a changeover was made from a heavy fuel to a marine Diesel fuel for manoeuvring into port after a long period of operation on the former fuel.

An observation supporting this phenomenon has

been made in the laboratory on a smaller engine, of a size typical of those used for auxiliary purposes. In this instance, trials were being made to establish the fuel factors influencing the formation of injection-tip deposits and, because of the limitations of the fuel-handling equipment, it was necessary to flush through with a lighter fuel before shutting down, after operating on heavy fuels. The flushing operation was carried out while the engine was running and it was observed that, where the changeover coincided with the presence of injector-tip deposit build-up, a very rapid and considerable rise in exhaust temperature resulted which would be reflected in the exhaust-valve temperature, particularly the seat. While exhaust-valve failure of the type reported above had not been observed in this smaller engine, probably because of the better steel normally used for the exhaust valves of these engines, the possibility of trouble due to guttering of the deposits still remained.

Examination of a main-engine exhaust valve which had failed by guttering had shown that a carbonaceous deposit containing sodium sulphate had formed on the exhaust-valve seat while the engine was operating on the heavier fuel. This deposit would have its origin in the sulphur in the fuel, together with smaller quantities of sodium arising from sea water or from the ash of the heavy fuel itself. When the lighter fuel was substituted, the resultant higher temperatures would cause the deposit to burn; the conditions would tend to be reducing at the metal surface and iron sulphide would form. When sodium salts and iron oxide are present also, the melting point of the mixture would be in the region of 1,292 deg. F. or less, and it would be possible for the fluid oxide/sulphide mixture to attack the graphite of the cast-iron exhaust-valve head and to oxidise it. Since the presence of sulphide strings would embrittle the iron, failure would occur through combined scaling and disruption. Fig. 7, opposite, shows typical deposits on the valve face of an engine which had operated for more than 1,300 hours on a heavy fuel. In the valve illustrated, the carbonaceous deposits on the sealing face of the valve amounted to some 20 per cent. of the total. Fig. 8 shows a typical failure resulting from operating on a marine Diesel fuel after a period on heavy fuel, where an increase in exhaust temperature was recorded on changing over to the lighter grade.

(To be continued.)

## COURSES IN GAS-TURBINE TECHNOLOGY.

FREQUENT reference has been made in ENGINEERING to instructional courses at the School of Gas Turbine Technology, Farnborough, Hampshire. These courses, which are given at regular intervals, cover a wide range of subjects and attract numerous students from home and overseas. Normally, a course lasts three weeks, and in this period an effort is made to cover the whole of the syllabus selected as comprehensively as possible. There are many sides, however, to the design of a gas-turbine installation, and there may be some, particularly those who are specialists on the design staffs of industrial undertakings, who neither require nor, indeed, can spare the time, to acquaint themselves with the whole subject. Nevertheless, many of them would welcome an opportunity to study part of it in detail. To meet the requirements of such persons, and others who may be interested, the School has arranged three courses, of one week's duration, at which one particular major component of a gas-turbine installation will be discussed in detail.

The first of these new courses, which are to be held consecutively in the summer and will be open to British or Commonwealth students, will deal with the theory and design of compressors, and will extend from June 30 to July 4. The second, lasting from July 7 to July 11, will cover combustion and the design of heat exchangers. The third, from July 14 to July 18, is on the theory and design of turbines. For the benefit of foreign students, international courses, similar to those provided by the School in the past, will be held from March 17 to April 4, and from September 8 to September 26. These courses cover both industrial applications of the gas turbine and its use for aircraft propulsion. Other courses open to British and Commonwealth students this year are two on the design and applications of industrial gas-turbines, with commencing dates April 15 and October 27, and two on aero-engine design, starting on May 12 and November 24, respectively. All these courses run for three weeks, instruction days being from Monday to Friday. Previous knowledge of fundamentals, at university-degree standard, is assumed. Three courses of practical instruction in the stripping, assembly and installation of aero-engines, which are open to students of any nationality, will also be given. Each of these lasts a fortnight and the commencing dates are February 25, June 9 and October 6. Further particulars may be obtained from the Principal, School of Gas Turbine Technology, Farnborough, Hampshire.

## NOISE IN PRIVATE CARS.\*

By J. R. BRISTOW, B.Sc., Ph.D., A.M.I.Mech.E.

(Concluded from page 202.)

THREE saloon cars of popular make, in the 1-1½ litre range, about which there was general agreement as to their respective noisiness, were used for comparative tests. All three cars, designated A, B, and C, were saloons some six to twelve months old, and normal production models. All tests were run after the vehicles had warmed up for an hour or so, with normal tyre pressure, and all windows closed. When carrying out the measurements, the microphone was placed in the positions occupied by the heads of either the front or rear passengers, and, unless stated otherwise, the vehicles were driven over the same stretch of road at the Motor Industry Research Association's proving ground. Octave-band analyses were made over a speed range of about 30 to 50 m.p.h., thus giving a comparison of the noise-spectra in the three cars at a variety of speeds, and, at the same time, an indication of the change in character of the noise in each car as affected by speed. This latter relationship perhaps shows most markedly the differences between the three vehicles, and is given graphically by plotting the variations of noise-level in each octave-band against speed as shown in Fig. 3, opposite; such curves are referred to as speed-analyses. It should be noted that in these figures there are no true ordinates but only a grid at 5-decibel intervals, the curves for the various octave-bands being spaced in the most convenient manner. The actual levels are indicated, however, in decibels at the ends of the curves and the level for any intermediate speed is readily obtained by inspection.

The objectively-determined noise-spectra for the three cars are shown in Figs. 1 and 2, on this page, and these indicate that car A not only has a lower overall noise-level than either of the other two, but also a lower spectrum level at all frequencies, speeds, and microphone positions. Hence, it is deduced that car A is much the quietest of the three. Furthermore, the spectra for car A have less-pronounced "peaks" than those for the other two cars which, it is held, indicates that annoyance is less. Subjectively, car A was undoubtedly much the quietest of the three. It is, perhaps, not immediately apparent from these noise-spectra which is the quieter of cars B and C, but, remembering that high-intensity low frequencies have a considerable masking effect on lower-intensity noise in the mid-frequency and high-frequency range, it will be noted that, although from approximately 200 cycles per second upwards the noise-level may be about the same or even greater in car B than in car C, below 200 cycles per second the intensity of the noise is very noticeably greater in car C. Hence, it is deduced that car B is the quieter, that car B will appear "hard" or "tinny" and car C "boomy" or "rumbly," compared with each other, and, of course, with car A. This proves again to be in complete agreement with subjective estimates.

It is of interest to note that the overall noise-levels at the front are not significantly different between cars A and B at low speeds, or between cars B and C at the higher speeds, but the noise-spectra are noticeably and significantly different, and also that the characteristic noise-spectra of the three vehicles are, more or less, maintained at all speeds. Although the noise-spectra show similar characteristics both at the front and the back for any one car, the low-frequency noise is always higher at the back than in the front, whereas at the higher frequencies there is little, if any, difference between front and back.

The outstanding difference shown by the speed-analyses in Fig. 3 is that the curves for car A are noticeably the smoothest, and those for car C the most irregular. The curves for the rear microphone position are, in general, more irregular than for the front position; this is more apparent for car A, because the curves for the front position are particularly smooth. It is held that the irregularities of these curves are, more or less irrespective of absolute loudness, an indication of the relative noisiness of vehicles, so far as annoyance is concerned; the more irregular the curves the noisier does the vehicle appear and also the more disturbing the noise. Irregular increase of noise-level with speed in itself is annoying, but probably of equal importance is the annoyance caused by the character of the noise changing with speed. If the curves are "parallel" to each other, in the sense that the irregularities in noise-level mirror one another at all frequencies, as shown, for example, by car B in the upper frequency bands, then only noise-level, and not character, is affected. If the curves diverge noticeably from each other in shape as shown by those for car C, then the character of the noise changes with

## NOISE IN PRIVATE CARS.

Fig. 1. NOISE-SPECTRA FOR CARS A, B AND C. MICROPHONE AT FRONT HEAD POSITION.

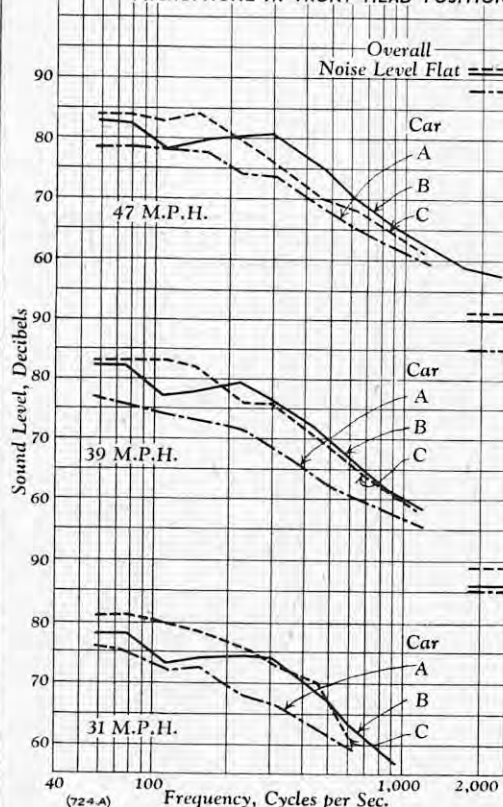
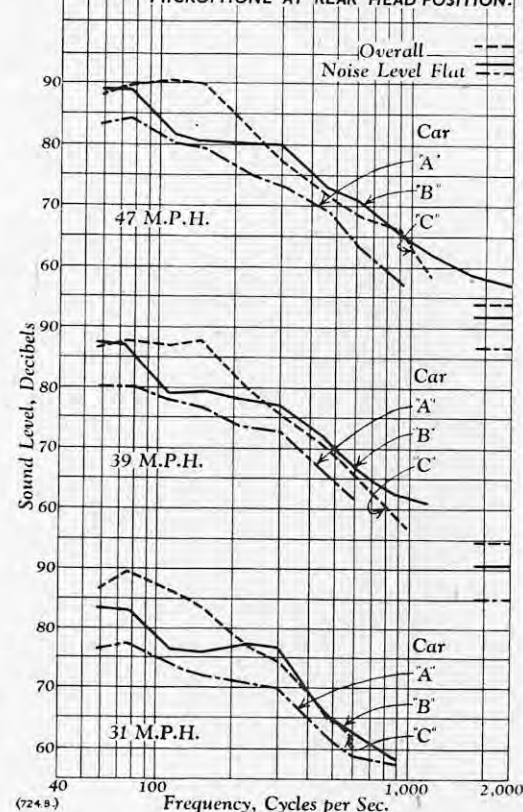


Fig. 2. NOISE-SPECTRA FOR CARS A, B AND C. MICROPHONE AT REAR HEAD POSITION.



speed; overall noise-level, however, may, or may not, change.

It will be noted that the difference in overall noise-levels between the three cars is not great. Yet subjectively, not only is car A very definitely quieter than the others, but car B is markedly quieter than car C. It cannot be doubted that the subjective difference between these cars is a function not only of absolute noise-level, but also of the character of the noise and the changes in intensity and character with speed, this latter being responsible as well as masking effects for the marked subjective difference between cars B and C. In brief, it may be said that all the differences shown by the octave-band analyses, taken over a range of speeds, are identical with general subjective estimates of the differences between these three vehicles.

The effect of road surfaces is shown in Fig. 4, opposite, in which the noise spectra for each car is shown when running on the proving ground and a road at Bureot, the latter having the smoother surface. The most interesting fact that emerges is that the greatest change is shown by car C and progressively less by cars B and A, respectively. This is shown by the measured overall noise-level in car C, but is shown only by the octave-band analyses for cars B and A. The noise-spectra show similar characteristics as between front and rear, and at the two speeds, as before, and also as between the two surfaces, except for certain peculiarities exhibited by car A on the smooth surface at Bureot. Subjectively, cars B and C were both quieter on the smoother road, especially in the front, although this is not reflected in the overall noise-levels for car B; this was most striking in car C, the vehicle seeming almost luxurious on the Bureot road by comparison with the proving ground. The behaviour of car A is peculiar; at 39 m.p.h. there is virtually no difference in noise-spectrum between the two roads. At 47 m.p.h., however, although at the front, in general, the spectrum level is lower on the smoother road, there is a very decided increase in intensity in and about the 100-150 cycles per second region. Subjectively, this behaviour appears as a "road-roar" at the front, due, perhaps, to the tyres on the medium-granite non-skid surface, and increased "boom" at the rear. It is difficult to explain this, but it may be due to a body resonance set up by the tyre and road noise of the front-end which is heard as tyre noise in front, but as body boom in the rear because the head position is more nearly at a pressure antinode and farther away from the source itself at the rear.

To illustrate further the effect of road surface, it is convenient to refer to some results obtained on a fourth car. The two lower curves in Fig. 5, opposite, show the results obtained at 30 m.p.h. on two very good smooth roads and the two upper curves the results on two "sett" roads in the North of England giving the considerable difference in noise-level of about 10 decibels in both the overall levels and the

analyses. The effect of speed on noisiness is shown in Fig. 6, opposite, where the noise-spectra for several speeds on the same road are given. It will be noticed that, as for the other three cars, the general shape of the noise-spectra is the same, but of increased level, at all speeds except the two lowest, and that although the overall noise-levels differ by only 6 or 7 decibels the spectra in the 150-300 cycles per second region show differences of about 20 decibels. The body of this car is identical with that of car B, but car B is some eighteen months older, and has a smaller engine and different suspension arrangement.

It must be admitted that an attempt to elucidate the so-called wind-noise problem on a particular model was not entirely successful, but the results obtained do illustrate the limitations of investigating a noise problem by only one approach (in this case only noise analysis) and also the danger of "naming" a noise problem from subjective estimates. Two cars were available for comparison: E, with acceptable wind-noise, and F, with excessive wind-noise. Figs. 7 and 8, opposite, give the noise-spectra of these two cars at 50 and 65 m.p.h. At the lowest frequencies there is little to choose between the two vehicles, E being perhaps slightly the noisier in this region, and in this connection it was noticed that the "thumps" produced by such road irregularities as Cats-eyes were more noticeable in car E. In the mid-frequency and high-frequency regions, however, the greater noisiness of car F is very marked, being about 15 decibels in the high-frequency region; yet it should be noted that the overall noise-levels, as measured, were not significantly different in the two cars. It is, of course, with the higher frequencies that wind-noise will be generally associated. Now this difference between the two cars might well be due to better noise-absorption characteristics of the quieter car, and the noisier car may, in fact, not generate more wind-noise than the quieter car. In an attempt to elucidate this, the two cars were placed in a known noise-field, and the resulting noise-levels measured inside the cars. The noise-levels in the noisier car, F, were, above 300 cycles per second, greater than in the quiet car E, by an amount increasing, more or less steadily, from 0 decibel at 300 cycles per second, to 10 decibels at 5,000 cycles per second. Hence, it would seem likely that the main difference between these two cars was due to the better absorption qualities of the quieter car.

It seems probable that road-excited body noise, that is, excluding engine, transmission, exhaust and wind noise, is due, basically, to excitation of the air mass inside the body at its many resonant modes, and that the energy to give the excitation is largely structure borne. In a car, reduction of the low-frequency noise is not possible by absorption, this being geometrically impossible in the space available; hence, reduction is only possible by decreasing the actual excitation. The initial source of energy can

\* Paper presented at a meeting of the Automobile Division of the Institution of Mechanical Engineers, held in London on Tuesday, February 12, 1952. Abridged.

## NOISE IN PRIVATE CARS.

Fig. 3. SPEED ANALYSES FOR CARS 'A', 'B' AND 'C'; MICROPHONE AT FRONT HEAD POSITION.

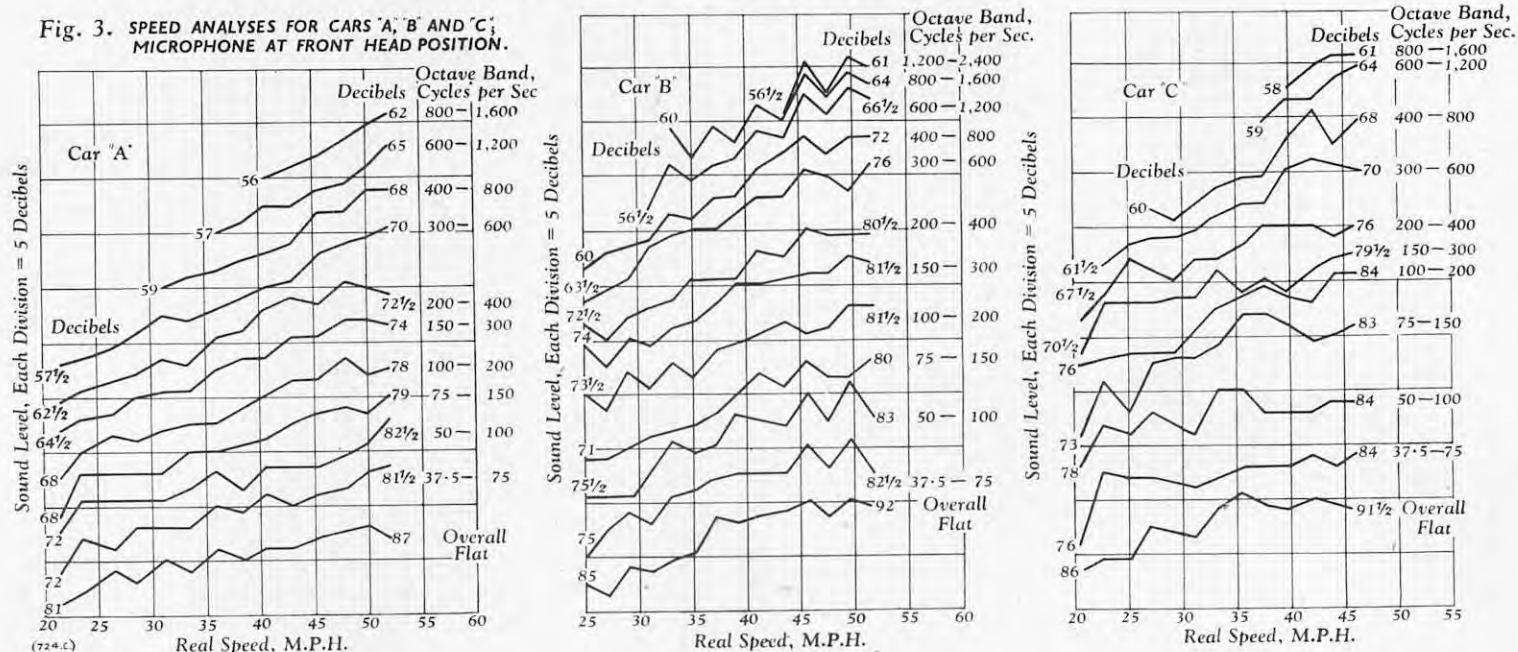


Fig. 4. ROAD SURFACE COMPARISONS, MICROPHONE AT FRONT HEAD POSITION.

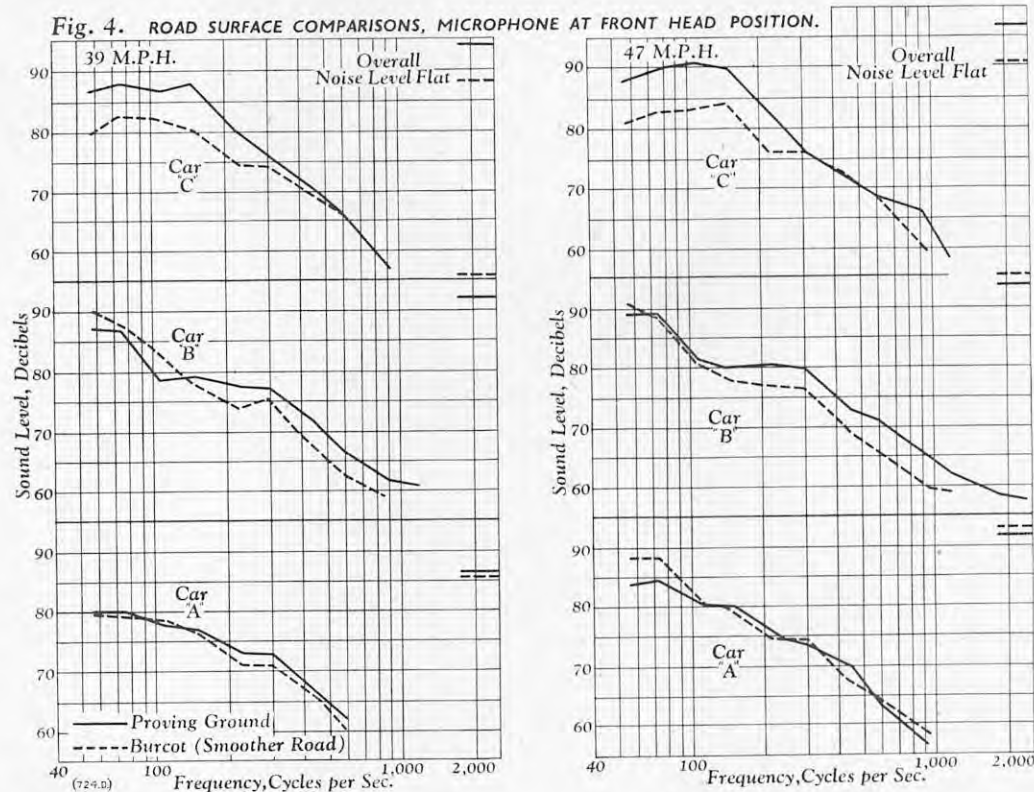


Fig. 7. NOISE-SPECTRA FOR CAR 'E' (FRONT) AT 50 AND 65 M.P.H.

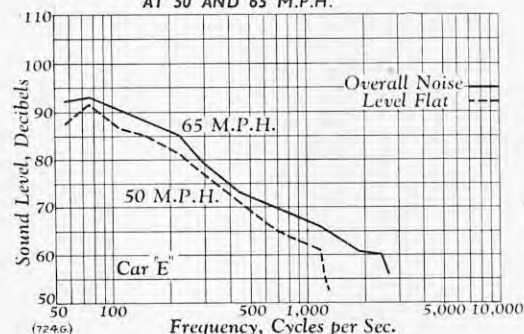


Fig. 8. NOISE-SPECTRA FOR CAR 'F' (FRONT) AT 50 AND 65 M.P.H.

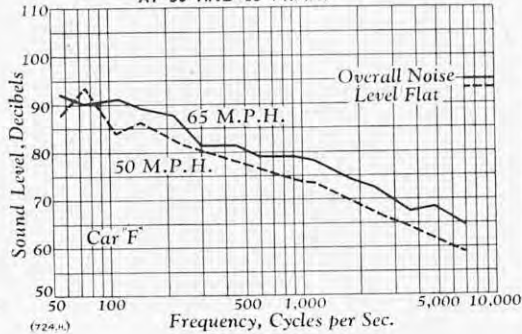


Fig. 5. NOISE-SPECTRA FOR CAR 'D' (FRONT) ON FOUR DIFFERENT ROAD SURFACES.

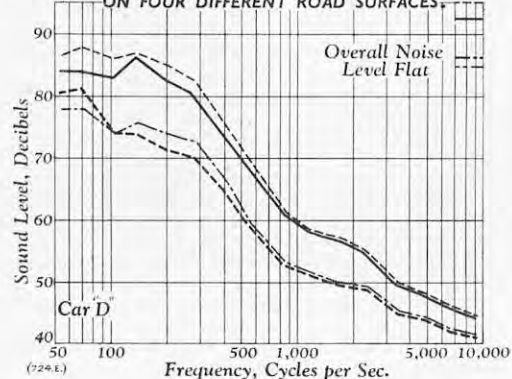
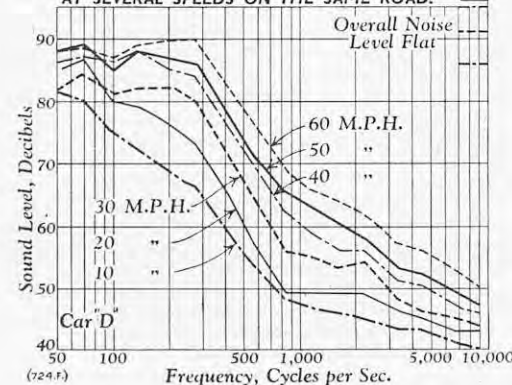


Fig. 6. NOISE-SPECTRA FOR CAR 'D' (FRONT) AT SEVERAL SPEEDS ON THE SAME ROAD.



only be the road irregularities exciting the whole system, in particular the unsprung-mass systems. The general layout of the suspension is largely determined by considerations of mechanical performance and strength; thus, reduction of the excitation energy to the air mass in the body can, possibly, only be attained by designing to produce the highest possible transmission losses throughout the structure from the wheels to the air mass in the body. Generally, transmission loss can be increased by discontinuities pro-

duced by the presence of some other material, such as rubber, by interfaces in frictional contact giving high damping, by using non-homogeneous materials, such as wood, and by combining high inertia with high damping in, for instance, the case of panels. The importance of ensuring that passengers' heads are not at pressure antinodes for the low-frequency standing waves must not be overlooked, particularly in the rear.

Of the first three cars used in this work, B and C are of unitary construction, whereas A is of separate

body-chassis construction with rubber washers on the body attachment bolts above and below the body mounting brackets. All three cars have independent front suspensions: A, coil spring, with outer ends of upper links and inner ends of lower links rubber-bushed; B, torsion-bar, with lower links pivoted in rubber at inner ends and rubber-bushed stay rods; whereas, no rubber at all is used in the front suspension of car C. If the views expressed above are correct, it is not surprising that car A is the quietest, and car C the noisiest and most sensitive to road conditions. High-frequency noise can, of course, be absorbed to some extent by the trim; so far as the interior trim of the first three cars is concerned, that in car C was the softest and that in car B the hardest, and this is reflected in the high-frequency components of the noise measured in these vehicles. Of cars E and F, E was the softer furnished, and sealing of windows and doors was much better on car E than on car F. Air-borne noise is kept out reasonably well by the body-work, especially at the higher frequencies. Generally, the greater the inertia of the body panels the more non-homogeneous their structure, and the greater the damping applied to them the more effective a barrier they are to air-borne noise.

# FLUIDS FOR HYDRAULIC POWER TRANSMISSION.\*

By A. E. BINGHAM, M.I.Mech.E.

(Concluded from page 215.)

THE amount of gas, including air, which can be absorbed by a fluid is most difficult to determine experimentally; generally, the amount of air absorbed in a mineral oil is small, and, as the taking in and giving out are slow processes, is unimportant. "Absorbed air" must not be confused with "mechanically entrained air"; in other words, bubbles. Except in high-viscosity oils, at room temperature and above, the mechanically entrained air is released within a few seconds in a low-velocity pool, e.g., a reservoir when the circuit is idling. On the other hand, removing the absorbed air by reducing the pressure may take hours or even days. The compressibility of a fluid is not affected by absorbed air, but is very much affected by mechanically entrained air. Light mineral oils can absorb air to roughly 8 per cent. of the oil volume; the weight of air, however, will depend on the pressure and temperature. To remove air, therefore, it is necessary to reduce the pressure and increase the temperature. In practice, this must be done with great care, otherwise the lighter fractions of the oil will be distilled off.

It is not possible to be very scientific when dealing with foaming; in extreme cases, it might be due to the release of absorbed air, but it would probably be due to mechanically entrained air, e.g., a jet impinging on a free liquid surface or air being drawn into the system at a poor joint at a point of low pressure. Returns to reservoirs should be "drowned," i.e., beneath the free liquid surface, and the suction to the pump should be well below the lowest surface level. Great attention must be paid to this point in aerobatic aircraft. Another cause of foaming could be by the formation of a metallic soap due to chemical action; for this reason, lead coating of vessels containing light mineral oil should be eliminated. Fluids with a low surface-tension are more prone to foam than those with a high surface-tension.

For the measurement of surface tension, reference should be made to the *Institute of Petroleum Handbook* 90/44, or a standard text-book on physics. Except for foaming and the prevention of leakage at joints, surface tension is unimportant in normal hydraulics calculations. Fluids having surface tensions of less than 30 dynes per centimetre are likely to be troublesome to seal.

It is known by experience that water will collect at the bottom of an oil tank which is vented to atmosphere if there are large changes in ambient temperature and humidity, but the process takes time and may extend over months. The reasons are not obvious and the effect varies considerably with the fluid. With a water-base fluid, a few per cent. of extra water would not upset the general behaviour of the fluid, and castor-base fluid D.T.D. 391 has a limiting water tolerance of 10 per cent. With a light mineral oil, e.g., D.T.D. 585, the water miscibility is small, and corrosion troubles have been known to start with as little as 0.3 per cent. water.

Draining the lower part of the reservoir and the lowest points of the system at each major inspection and checking the fluid for water content ensures that dangerous quantities do not accumulate. This should be borne in mind when designing the system. A very rough test may be made by plunging a piece of almost red-hot copper wire (about 20 S.W.G.) into a test tube of fluid. If there is a distinct crackling noise, water is present. Magnesium-base alloys should be avoided in the hydraulic system, as, even with mineral oils, corrosion becomes quite serious after a few months with as little as 0.5 per cent. water in the circuit. There is no standard method of testing for water miscibility of mineral oils.

The cloud point of a mineral oil is the temperature at which the waxes or other solid substances begin to crystallise out or come out of solution. This greatly increases the resistance to flow, especially in small-bore pipes and narrow passages when the system has been static for long periods at, or below, this temperature. However, the most serious aspect is the choking of filters, which, if on the suction side of the pump, leads to cavitation.

The pour point of any fluid is the lowest temperature at which the fluid will flow under prescribed conditions. In other words, the viscosity curve will suddenly rise. A convenient measure is given by determining the temperature at which the rate of flow in a 5-mm. bore glass tube becomes less than 1 cm. per second under a

pressure differential\* of 1 lb. per square inch. The pour points of fluids to which reference has been made are given in Table VII, col. 1.

The boiling point of a fluid decreases with pressure, but, for most aircraft fluids, the boiling point covers a wide range, as some of the more volatile fractions come off first and the nature of the fluid therefore changes. However, for the mineral oils, the lowest boiling point is well above 70 deg. C. (158 deg. F.) even at altitudes of 50,000 ft. in an open-vented system, but this is not

cause a crash which may lead to a fire. As might be expected, the water-base fluids head the non-inflammable list in all tests, but the remainder vary in order of merit with the test. The following list might be taken as a guide to non-inflammability: (1) water base; (2) halogenated hydrocarbons; (3) synthetic; (4) castor base; (5) hydrocarbon.

There is no satisfactory definition nor method of test for lubricity or oiliness, and the only way to obtain specific information is by testing the unit with the

TABLE VII.—CHARACTERISTICS OF VARIOUS HYDRAULIC FLUIDS.

| Fluid.                   | 1.<br>Pour Point,<br>1 lb. per sq. in.<br>Pressure Difference. | 2.<br>Boiling Point, or<br>Remarks (I.B.P. =<br>Initial Boiling<br>Point).                                                                         | 3.<br>Thermal Conductivity,<br>Calorie per cm. sec.<br>deg. C.                                                                                                            | 4.<br>Specific Heat, at<br>Room Temperature<br>Unless Otherwise<br>Stated.                                                           | 5.<br>Dielectric<br>Constant.                                                                                      |
|--------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Water ..                 |                                                                |                                                                                                                                                    | 14.7 × 10 <sup>-4</sup><br>at 10 deg. C. (50 deg. F.)<br>15.4 × 10 <sup>-4</sup><br>at 50 deg. C. (122 deg. F.)<br>16.0 × 10 <sup>-4</sup><br>at 80 deg. C. (176 deg. F.) |                                                                                                                                      |                                                                                                                    |
| Glycerine ..             |                                                                |                                                                                                                                                    | 6.8 × 10 <sup>-4</sup>                                                                                                                                                    |                                                                                                                                      | 39.1 at 15 deg. C.<br>(59 deg. F.)                                                                                 |
| Alcohol ..               |                                                                |                                                                                                                                                    | 4.3 × 10 <sup>-4</sup>                                                                                                                                                    |                                                                                                                                      |                                                                                                                    |
| Castor oil ..            |                                                                |                                                                                                                                                    | 4.32 × 10 <sup>-4</sup>                                                                                                                                                   |                                                                                                                                      | 4.6/4.8 at 20 deg. C.<br>(68 deg. F.)                                                                              |
| Paraffin ..              |                                                                |                                                                                                                                                    | 3.0 × 10 <sup>-4</sup>                                                                                                                                                    |                                                                                                                                      | 4.6/4.8 at 20 deg. C.<br>(68 deg. F.)                                                                              |
| D.T.D.44D ..             | -51 deg. C.<br>(-60 deg. F.)                                   | In. of mercury: 4;<br>14; 20; 30<br>I.B.P., deg. C. (deg.<br>F.): 217 (423);<br>262 (504); 277<br>(531); 300 (572)                                 | 3.18 × 10 <sup>-4</sup><br>at 15 deg. C. (59 deg. F.)                                                                                                                     | 0.444                                                                                                                                | 2.25 at 50 deg. C.<br>(122 deg. F.)<br>2.21 at 75 deg. C.<br>(167 deg. F.)<br>2.17 at 100 deg. C.<br>(212 deg. F.) |
| D.T.D.585 ..             | Below -65 deg. C.<br>(-85 deg. F.)                             | Cracks before boiling<br>at 1 atm. pressure.                                                                                                       | 3.24 × 10 <sup>-4</sup><br>at 15 deg. C. (59 deg. F.)                                                                                                                     | 0.456                                                                                                                                |                                                                                                                    |
| Skydrol ..               | -48 deg. C.<br>(-54 deg. F.)                                   | 300 deg. C. (572 deg.<br>F.) approximately<br>at 1 atm. pressure.                                                                                  | 5.30 × 10 <sup>-4</sup><br>at 15 deg. C. (59 deg. F.)                                                                                                                     |                                                                                                                                      |                                                                                                                    |
| EEL6 ..                  | -65 deg. C.<br>(-85 deg. F.)                                   | As water at all pres-<br>sures                                                                                                                     | 9.61 × 10 <sup>-4</sup><br>at 15 deg. C. (59 deg. F.)                                                                                                                     | 0.43<br>0.718 at 25 deg. C.<br>(77 deg. F.)<br>0.774 at 60 deg. C.<br>(140 deg. F.)<br>0.785 at 80 deg. C.<br>(176 deg. F.)<br>0.600 | 5.25 at 20 deg. C.<br>(68 deg. F.)                                                                                 |
| Lockheed No. 22          | -60 deg. C.<br>(-76 deg. F.)                                   | Evaporation of "Cel-<br>losolve" before<br>boiling at all pres-<br>sures. 135 deg. C.<br>(275 deg. F.) at<br>normal tempera-<br>ture and pressure. | 3.0 × 10 <sup>-4</sup><br>at 20 deg. C. (68 deg. F.)                                                                                                                      |                                                                                                                                      |                                                                                                                    |
| D.T.D.391 ..             | -38 deg. C.<br>(-36 deg. F.)                                   | Evaporation of "Cel-<br>losolve" before<br>boiling at all pres-<br>sures.                                                                          |                                                                                                                                                                           | 0.557                                                                                                                                |                                                                                                                    |
| D.T.D.641 ..             | Below -60 deg. C.<br>(-76 deg. F.)                             |                                                                                                                                                    | 6.42 × 10 <sup>-4</sup><br>at 15 deg. C. (59 deg. F.)                                                                                                                     | 0.52                                                                                                                                 |                                                                                                                    |
| Silicone<br>DC.200/20 .. | -50 deg. C.<br>(-58 deg. F.)                                   |                                                                                                                                                    |                                                                                                                                                                           | 0.391                                                                                                                                |                                                                                                                    |
| R.P.M. ..                | -70 deg. C.<br>(-84 deg. F.)                                   | Cracks to phosgene<br>at high tempera-<br>tures.                                                                                                   |                                                                                                                                                                           |                                                                                                                                      |                                                                                                                    |

\* "Cellosolve" was once the trade name for ethylene glycol mono-ethyl ether.

so for water-base fluids. High-flying aircraft generally have closed or pressurised systems, so the difficulty does not arise except in an emergency. The available data on boiling points are given in Table VII, col. 2.

The greater part of the transmission of heat in a fluid is by convection, which is greatly assisted by the turbulence due to the forced circulation. The difficulty in oil coolers is caused by the boundary layer, which adheres to the radiating surface; most of the hydraulic fluids are poor conductors of heat. The exceptions are the water-base fluids, which wet the surface well and have a good conductivity and a high specific heat. Systems running on water-base fluids run at a much lower temperature than those with mineral oils. When under the same conditions of work and ambient temperature, the difference is about 20 deg. to 30 deg. C. (36 deg. to 54 deg. F.) (Table VII, col. 3).

Much work has been done, mainly in the United States, and much has been written, concerning the fire hazard due to hydraulic fluids in aircraft; but no standard test has been evolved nor any standard order of merit determined. The order of merit does not depend directly on flash point, boiling point, or spontaneous ignition temperature (S.I.T.). Curiously enough, flash point and S.I.T. do not vary together; there is even a tendency for lower flash-point fluids to have a higher S.I.T., e.g., petrol has a higher S.I.T. than lubricating oil.

The methods of testing for fire hazard vary from firing incendiary bullets through cans of fluid with a sheet of steel in front to set off the bullets, to igniting the oil mist with an electric spark or oxy-acetylene flame. It is to be regretted that, so far, all the less inflammable fluids have an inferior all-round performance to D.T.D. 585, and lack of performance can

TABLE VIII.—Flushing Fluids Suitable for Various Hydraulic Fluids.

| Old Fluid.     | Flushing Fluid.                                                | New Fluid.     | Remarks.                                                                                                   |
|----------------|----------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------|
| Petroleum-base | Paraffin                                                       | Petroleum-base |                                                                                                            |
| Water-base ..  | Water.                                                         | Water-base     |                                                                                                            |
| Castor-base .. | Industrial methylated spirits                                  | Castor-base    |                                                                                                            |
| Petroleum-base | Paraffin                                                       | Water-base     |                                                                                                            |
| Petroleum-base | 1. Industrial cleaners<br>2. Pressure air                      | Skydrol        | New seals required; probable butyl-base.                                                                   |
| Castor-base .. | 1. Industrial methylated spirits<br>2. Pressure air            | Petroleum-base | New seals required.                                                                                        |
| Petroleum-base | 3. Paraffin<br>1. Paraffin<br>2. Industrial methylated spirits | Castor-base    | New seals required.                                                                                        |
| Petroleum-base | Paraffin                                                       | Halogenated    | The two fluids are miscible, but no very suitable rubber mix for the halogenated fluid has yet been found. |

fluid. In ordinary circumstances, the oiliness properties of various types of fluids could be put in the following order:—(1) halogenated hydrocarbons; (2) hydrocarbons; (3) water-base fluids; (4) castor-base fluids; (5) silicones. However, by suitably changing the circumstances, this order could easily be upset, and, for heavily loaded ball and roller bearings, the water-base fluids would drop to the bottom of the list. By very careful pairing of metals, silicones could be raised in the list, e.g., brass on steel, but cast iron on steel is exceedingly poor.

\* Paper presented at a meeting of the Institution of Mechanical Engineers, held in London on December 14, 1951. Abridged.

† In an aircraft a major inspection is made after 240 hours flying, but in commercial plants the period should be preferably every six months.

\* The pressure differential is often given as 12 in. head of water, which tends to raise the pour point, particularly with non-petroleum base fluids. The test then becomes more searching, but it is more difficult to obtain reproducibility.

## GUILLOTINE FOR SHEET METAL.

FR. DRABERT SÖHNE, MINDEN, GERMANY.

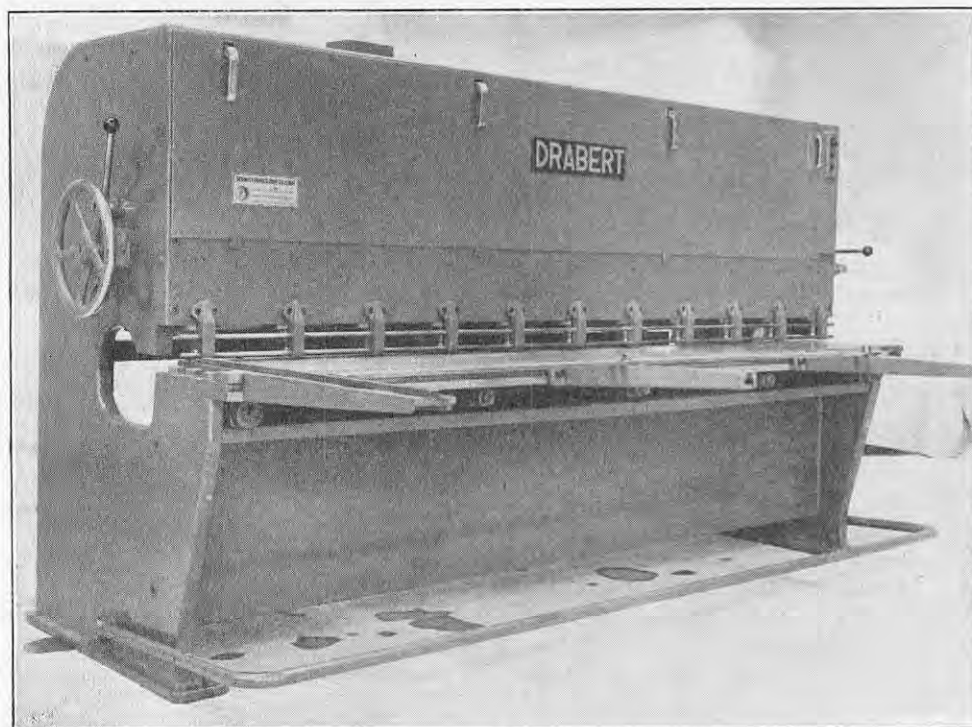


FIG. 1. 98-IN. MACHINE.

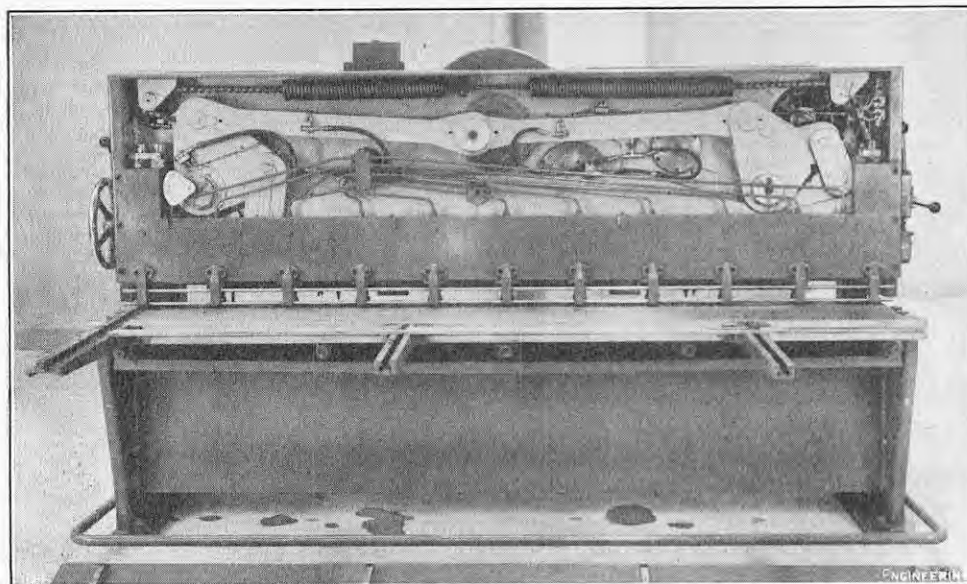


FIG. 2. RAM MECHANISM.

In the absence of an oiliness qualification or of the "polar body" content of the fluid, the best guide, for the engineer, is the viscosity, and also, for heavy contact pressures (e.g., ball and roller bearings) the increase of viscosity with pressure. It is also necessary that the fluid should "wet" the surface and have a reasonable film strength.

Another property that affects the lubricating qualities of the fluid is film strength, which concerns the power of the fluid to preserve a film which adheres to the solid surface and improves the boundary lubrication. This boundary lubrication is important in the region of the seal and is particularly noticeable in the force required to "break out" when a jack has been standing for a long time and the fluid lubrication has disappeared. Film strength additives, such as phosphates are, however, not accepted gladly officially, possibly because of long-term chemical effects which might lead to corrosion.

Generally speaking, the electrical properties of hydraulic fluids are unimportant except to the designers and makers of electrical condenser-type tank gauges. All fluids, except the water-base types, are reasonable insulators, so the tank gauge will only be affected by the dielectric value of the fluid.

At infrequent intervals, the period depending on the design of the system and the fluid used, it is necessary

to flush the system and care should be taken to use the correct fluid. As it is almost, if not quite, impossible to drain all fluid from a system without breaking the system down to the smallest details, the flushing fluid should be miscible with the original fluid, and should not be detrimental to the seals and packings. Strongly acting solvents, such as trichlorethylene and carbon tetrachloride, should not be used unless new seals are to be fitted.

If a system is being flushed in order to change the working fluid, it is probably necessary also to change the seals; again the makers should be consulted. If a system is being changed from a castor-base fluid to a petroleum-base fluid, it is essential to change the seals from natural-rubber base to synthetic rubber. As a broad guide, and in the absence of more specific information, the flushing fluids shown in Table VIII, opposite, are suggested. In all cases the system should be given a run through with the final fluid before filling up.

**INQUIRY INTO LOSS OF S.S. "PANDORA."**—The Minister of Transport has ordered a formal investigation into the loss, with all hands, of the S.S. Pandora, registered in Beaumaris, off the coast of Yorkshire on October 22, 1951. A further announcement will be made when the date and place of hearing have been fixed.

## GUILLOTINE FOR SHEET METAL.

THE Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, have recently been appointed sole agents for power-driven guillotines manufactured by Fr. Drabert Söhne, Minden Germany. The machines are available in two sizes: one, 78 in. between the end plates, is suitable for  $\frac{3}{8}$ -in. sheet, and the other, 98-in. between the end plates, for  $\frac{1}{2}$ -in. sheet. The larger machine is illustrated in Fig. 1, and Fig. 2 shows the same machine with the cover plate removed to reveal the ram mechanism. The machines are of fabricated construction, and the shear loads are transmitted through pins. The end plates are provided with deep throats which allow sheets of unlimited width to be cut and trimmed. The workpiece is mechanically clamped to the table in the smaller machine, whereas in the machine illustrated it is held by hydraulically-actuated pads at intervals along the sheet, so that whether the sheet is uniform in thickness or not, it is held firmly in place by an adjustable clamping pressure; a gauge is provided to indicate the pressure.

The machine is driven by an electric motor, through V-beltting and gearing to a centrally-mounted crank linked to a lever mechanism on each side of the ram; this is clearly shown in Fig. 2. The ram, which is counterbalanced by the two tension springs which can be seen at the top of the illustration, slides on guides at each end and on two bearings near the middle of the machine. All bearing surfaces are lubricated by a high-pressure automatic lubricating system. The machine is controlled by a multiple-plate clutch and brake, controlled by either a pedal or hand lever. It can be set for continuous operation or for single-stroking, and it is possible to stop the machine instantaneously. A safety mechanism is provided to prevent unintentional starting, or stopping when the machine is running continuously.

The upper and lower shear blades, of high-grade steel, are made up in sections to facilitate regrounding. The longitudinal shear angle between the fixed and moving blades can be adjusted by a handwheel to the optimum value for a particular thickness of sheet, a pointer and scale being provided to indicate to the operator the correct setting for any given thickness. It is thus possible to cut undistorted strips even when the material is very thin. Should the wrong shear angle be set, giving rise to too high a cutting pressure, the machine is protected from damage by the safety mechanism already referred to. Parallel angular-adjustment stops and table extensions are fitted at the front and back of the machine.

## TRADE PUBLICATIONS.

**Bench Assembly Trays.**—We have received a leaflet giving brief particulars of Kabi bench trays for assembly work, from the manufacturers, Precision Components (Barnet) Ltd., 13, Byng-road, Barnet, Hertfordshire.

**Meter and Instrument Manufacture.**—An illustrated pamphlet, received from the English Electric Co., Ltd., Queen's House, Kingsway, London, W.C.2, contains a brief description of the firm's meter and instrument factory at Stafford.

**Pneumatic Conveying.**—Davidson & Co., Ltd., Sirocco Engineering Works, Belfast, Northern Ireland, have issued an illustrated handbook describing Sirocco pneumatic-conveying installations, both permanent and portable, industrial vacuum cleaners, and boiler flue-dust extraction plant.

**Metalclad Switchgear.**—Metalclad switchgear of the horizontal draw-out type for service on circuits up to 11 kV is described and illustrated in a pamphlet received from the English Electric Co. Ltd., Queen's House, Kingsway, London, W.C.2.

**Mosaic Diagrams for Electric Control Rooms.**—Details of the mosaic diagrams which have been developed to meet the demand for flexible indications in electrical control rooms, are given in a pamphlet received from Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2.

**Jet Propulsion.**—A booklet entitled the *Book of the Jet* has been issued by Shell-Mex and B.P. Ltd., Aviation Department, Shell-Mex House, Strand, London, W.C.2. It explains, in simple popular terms, the principles of jet propulsion, and illustrates the practice of those principles in the de Havilland Ghost engine in a series of ingenious "transparencies."

**Bolted Flameproof Cable Couplers.**—A brochure received from British Insulated Callender's Cables Ltd., Norfolk-street, London, W.C.2, gives details of the bolted flameproof cable couplers, which they manufacture for use in mines. These are made in straight-through, terminal, two-way and four-way assemblies from interchangeable components, the material being a non-corroding ferrous alloy. A special feature is that all compound-filled joints can be made outside the mine.

### 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.

**Methods of Analysis for Raw Copper.**—A new specification, B.S. No. 1800, covers standard methods for the analysis of raw copper, intended for use as referee methods in cases of dispute. The methods are for the elements (except oxygen) for which definite limits are specified in B.S. Nos. 1035-40, dealing with raw copper, and B.S. Nos. 1172-74, concerning deoxidised and arsenical coppers. These elements are arsenic in arsenical coppers, bismuth, iron, lead, nickel, phosphorus, selenium and tellurium (with arsenic and antimony), silver, sulphur and tin. The methods have been found to give reliable and reproducible results. [Price 5s., postage included.]

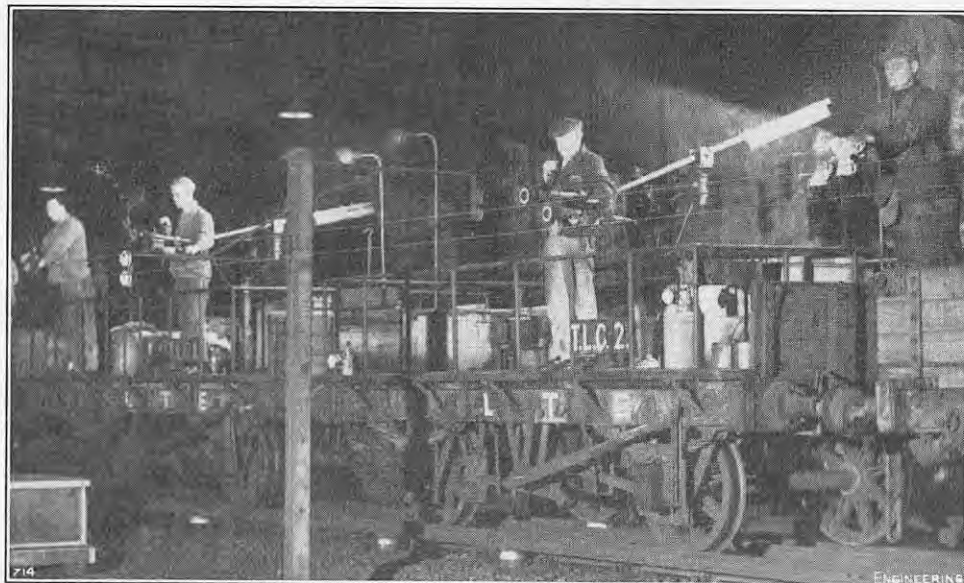
**Symbols, Terms and Definitions for Gas Quantities in Internal-Combustion Engines.**—A new publication relating to symbols, terms and definitions for gas quantities in reciprocating internal-combustion engines (excluding the carburettor type), B.S. No. 1798, has been prepared at the request of the British Internal Combustion-Engine Research Association because the exchange of information relating to the gas processes in compression ignition engines has been hindered by the lack of clear definition of such terms as "volumetric efficiency," "delivery ratio," "scavenging efficiency," and the like. According to circumstances, various meanings are commonly assigned to such expressions and it is considered undesirable to restrict their use by standardising single meanings. The difficulty can be overcome by the adoption of a standard method of defining the intended meaning. In the present publication, symbols, terms and definitions are given for simple quantities, and by means of the symbols, commonly-used expressions can be clearly defined. Moreover, many other relationships which may come under consideration can be simply expressed, whereas the allocation of names to them all is impracticable. The publication applies to two-stroke cycle and four-stroke cycle engines, atmospherically charged and pressure-charged, and also to free-piston engines. [Price 1s. 6d., postage included.]

**Domestic Electric Water-Heating Installations.**—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued, in final form, Code 324.202, covering domestic electric water-heating installations. Throughout the Code, great emphasis has been laid on the importance of heat conservation and recommendations are given on the design of some types of system, on desirable water temperatures and on volumes of stored hot water. Sections on inspection, testing and maintenance are included. Diagrams show typical layouts of water-heating systems and a method of fitting an immersion heater to a tank. [Price 3s., postage included.]

**Sizes and Layout of Commercial Forms.**—The numerous sizes and infinite variety in design of order forms, invoices, letter heads, delivery notes, and statements of account have frequently been a source of irritation to many persons handling them. A committee of the Institution, on which such bodies as the British Federation of Master Printers, the British Institute of Management, the Office Management Association and H.M. Stationery Office were represented, have now prepared a publication, B.S. No. 1808, outlining a standard range of sizes for each type of form, indicating principles which, it is hoped, will be of assistance to designers, and suggesting a standard position, on the forms, for each item of information. [Price 3s., postage included.]

**Flues for Domestic Appliances Burning Solid Fuel.**—Another Code issued in final form by the Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, Code C.P. 131.101, is concerned with flues for domestic appliances burning solid fuel. The Code deals with flues and chimneys depending for their operation upon natural draught, and includes recommendations regarding chimneys built of brick, stone masonry, cast-in-situ concrete, precast concrete units and hollow blocks. Metal and asbestos-cement flue pipes are also included. The scope of the Code is restricted to flues and chimneys serving appliances having a maximum heat input of 100,000 B.Th.U. per hour, where the temperature of the flue gases leaving the appliance does not exceed 850 deg. F. Information is given on the size and height of flues recommended for different appliances, on the design of the fireplace recess and throat, on bends and changes of section and on the height and position of chimneys above the roof in relation to fire hazards and wind effects. Nine pages of clear line diagrams of fireplaces, flues, chimneys and roofs are included. [Price 5s., postage included.]

### CLEANING RAILWAY TELEPHONE WIRES.



### CLEANING TELEPHONE WIRES ON THE LONDON UNDERGROUND.

THE bare telephone wires which are hung in the tunnels on the London Transport underground system provide a means whereby the train crews can cut off the traction current in emergency and communicate with the substation or traffic controller by hooking a telephone hand-set on to the wires. It is obviously of importance that these wires should be kept clean, and hitherto this work has been carried out by hand, mainly with emery cloth. A new method has now been devised, however, as shown in the accompanying illustration. Two wire brushes, 6 in. or 8 in. in diameter, are mounted on parallel shafts about 1 ft. apart and are driven by separate electric motors, which are counterbalanced to ease the work of the operator. The unit thus formed is free to pivot in a vertical frame about the end of a long rod, which is connected through a universal joint to an arm. This arm is mounted on a column in the centre of a suitably modified ballast wagon and can turn in a horizontal plane. So far, two wagons have been equipped and both wires can thus be dealt with simultaneously. The wagons are hauled by a battery locomotive, from which power for operating the brush motors is also obtained.

The train carries a crew of six: driver, supervisor, one man to remove the protective grease from the wires, two to operate the brushes, and one to re-grease the wires. At present, the use of the apparatus is limited, since the telephone wires on some lines are too low to be dealt with in this way. The results have, however, been so satisfactory that it is hoped to adapt a flat wagon, on the low floor of which the apparatus can be mounted and raised or lowered to suit the height of the wires that are to be cleaned. The advantages of the new method are that the man-hours per mile of wire cleaned are considerably reduced and the cleaning is more effective.

**LECTURES ON PRESTRESSED CONCRETE.**—Two public lectures on "Prestressed Concrete" will be delivered by Mr. O. J. Masterman, B.Eng., A.M.I.C.E., in the Faculty of Engineering, University of London, King's College, Strand, W.C.2, at 5.30 p.m., on Tuesdays, February 26 and March 4. Admission is free, without ticket.

**ASLIB SERVICES.**—In the current bulletin issued by Aslib, attention is drawn to their document-reproduction service, which undertakes to locate and copy any published document that is obtainable in this country or abroad. All difficulties connected with copyright will be cleared before the document is borrowed. Normally, a copy of the required document will be dispatched within a week of the request. Microfilms or photocopies can be supplied. Another project which is under consideration is the setting-up of a literature-searching service for members, should there be sufficient demand. It would probably provide for the preparation of a list of references on a given subject, and the supply of photocopies or microfilms, or original documents if available. The work would be carried out with the help of specialists in the subject concerned. A charge would be made to cover the cost of labour and materials. Members who are interested in such a service are requested to inform the Director of Aslib, 4, Palace-gate, London, W.8; if sufficient interest is not shown, the project will be abandoned.

### BOOKS RECEIVED.

- Geodesy.* By BRIGADIER G. BOMFORD. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 50s. net.]
- Selected Government Research Reports. Vol. 5. Serco-mechanisms.* H.M. Stationery Office, Kingsway, London W.C.2. [Price 63s. net.]
- Locomotives and their Working, with a Section on Gas Turbine, Diesel and Electric Locomotives.* By C. R. H. SIMPSON and F. BROWNE ROBERTS. In two volumes. Virtue and Company, Limited, 24, Holborn, London, E.C.1. [Price 70s.]
- The Displacement Method of Frame Analysis.* By G. P. MANNING. Concrete Publications, Limited, 14, Dartmouth-street, London, S.W.1. [Price 9s.]
- The Association of Supervising Electrical Engineers Year Book, 1951-52.* Fraser Pearce, Limited, Brighton, Sussex. [Limited edition issued to members.]
- The Glasgow University Engineering Society's Year Book for 1952.* No. 11. Edited by F. M. SIMPSON. The Editor, Glasgow University Engineering Society, James Watt Engineering Laboratories, Glasgow University. [Limited edition available to non-members, price 2s.]
- Onderzoekingen naar de Nauwkeurigheid van Tijdsnormen voor Menselijke Arbeid.* With abridged English translation, *A Treatise on the Accuracy of Time Standards for Human Work.* By DR. J. R. DE JONG. Published by the author at Krabbenbosweg 136, Hengelo (O), Holland. [Price 7.75 florins.]
- National Research Development Corporation. Report and Statement of Accounts for the Year 1st July, 1950, to 30th June, 1951.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9d. net.]
- Boiler Explosions Acts, 1882 and 1890. Report of Preliminary Inquiry (No. 3363). Explosion from a Wembley Steam Boiler at Beech Farm, Buttercrambe, Stamford Bridge, Yorkshire.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]
- Technology and History.* By PROFESSOR CHARLES SINGER. L. T. Hobhouse Memorial Trust Lecture No. 21, delivered on October 23, 1951, at the London School of Economics and Political Science. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 2s. net.]
- The Wire Industry Encyclopaedic Handbook to the Wire Drawing and Wire Fabrication Industry.* The Wire Industry, Limited, 33, Farnival-street, London, E.C.4. [Free to subscribers to *The Wire Industry*; price 21s. to non-subscribers.]
- Port of Aden Annual. 1951-52.* The Secretary, Aden Port Trust, Aden. [Price 2s.]
- Technical Data on Fuel.* Edited by H. M. SPIERS. Fifth revised and enlarged edition (second impression). The British National Committee World Power Conference, 201, Grand Buildings, Trafalgar-square, London, W.C.2. [Price 25s. net.]
- Memoirs of the Geological Survey. England and Wales. The Concealed Coalfield of Yorkshire and Nottinghamshire.* By W. EDWARDS. Third edition. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 22s. 6d. net.]
- United States National Bureau of Standards. Applied Mathematics Series No. 14. Tables of the Exponential Function e<sup>x</sup>.* Prepared by the National Bureau of Standards Computation Laboratory. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 3.25 dols.]