

HIGH-VOLTAGE AIR-BLAST CIRCUIT BREAKERS.

By E. L. L'ESTRANGE, M.Eng., A.M.I.E.E.

THE development of air-blast circuit breakers for high-voltage service, although of quite recent origin in this country, has already reached the stage where this equipment is well established as a competitor of the more familiar bulk-oil and low-oil-content types.

adverse effects on system stability. An additional feature is the dielectric safety of air-blast circuit breakers. This applies particularly when all the insulation components exposed to air, whether they are intermittently stressed in the interrupters or permanently stressed to earth, are entirely ceramic in construction. The risk of moisture absorption is then eliminated, an important point in connection with high-voltage outdoor circuit breakers.

The infrequent need for maintenance of the

ment results in low structural height above ground level. A further advantage of air-blast circuit breakers is their adaptability to either single-phase or three-phase high-speed reclosure. This requirement is now becoming increasingly prominent.

In a recent paper before the Institution of Electrical Engineers,* the principles considered desirable for high-voltage air-blast circuit breakers were outlined; and a design in which they were employed, rated at 3,500 MVA for 132-kV service, was described. The range has now been extended and carried into production for 165 kV and 220 kV, and equipments for these voltages have been installed on the Portuguese and Finnish networks. Similar equipments for 220 kV are in production for other networks. These circuit breakers incorporate a number of features intended to ensure high speed and reliable operation under the most adverse system operating conditions.

As regards structural arrangement, four interrupting units are employed per phase, each interrupter containing a fixed and moving nozzle contact assembly of the double-flow type, the blast air being discharged axially through both nozzles. In the closed position the nozzles, which are silver-alloy faced to minimise contact surface deterioration, are held in contact by spring action. During an opening operation, the build-up of air pressure in the interrupter housing actuates a piston which retracts the moving nozzle against the spring to give a "break" of the order of $\frac{1}{8}$ in. The interrupters are mounted on post-insulator support columns carried on the air-receiver framework, two interrupters and two support columns at each end, as seen in Figs. 1 and 2. A porcelain-enclosed non-linear ceramic resistor is connected in parallel with and placed horizontally above each interrupter. The dual air receivers in each phase are of drawn steel shell construction. Receivers formed in this manner are subject to considerable relaxation in insurance control, and also provide an additional safeguard for equipments operating at extremely low ambient temperatures.

The blast tubes, through which air is supplied from the receivers and valve gear to the interrupters, are located one between each pair of support columns. They are made from porcelain for the dielectric reason given above and are relieved of all structural stresses, except hoop stress due to air pressure, by resilient spring mounting. Vibration, shock, windage, and earth tremor loads, and also tensile loading due to air pressure, are sustained separately by the post-insulator supports.

The sequence switch, or isolator, which opens in sequence with the interrupting breaks and is in series with them, consists of a moving arm of tubular Duralumin which engages with spring-loaded fixed contacts on the interrupter assemblies. A single-unit porcelain, midway between the pairs of interrupters, carries the Duralumin arm and is rotated about its vertical axis by an air motor. This arrangement of horizontal double break gives an isolator of robust construction, capable of operating under icing conditions of extreme severity.

Since the two interrupters in each pair are supplied in parallel from one blast tube and since the two blast tubes give a parallel air-supply path from the controlling blast valves, identical pneumatic conditions, as regards rate and direction of air flow, pressure, and timing, are afforded for all the four breaks. Moreover, the air supply to any one break is unaffected by heat energy released from the arcs in the associated breaks. This identical aerodynamical condition is backed up by balanced voltage distribution between the breaks, this distribution being provided by the resistors shunted across them. These resistors pass sufficient current during both the restriking transient and the 50-cycle recovery voltage periods to swamp any distorting capacitive or leakage resistance currents. This ensures an even distribution of duty between the four interrupters. In consequence of the parallel-connected air supplies and the uniform voltage distribution, all the interrupters have the same breaking capacity, and they each have the same

* See paper by C. H. Flurscheim and E. L. L'Estrange, "Factors Influencing the Design of High-Voltage Air-Blast Circuit Breakers," *Jl. I.E.E.*, vol. 96, Part II, page 557 (1949).

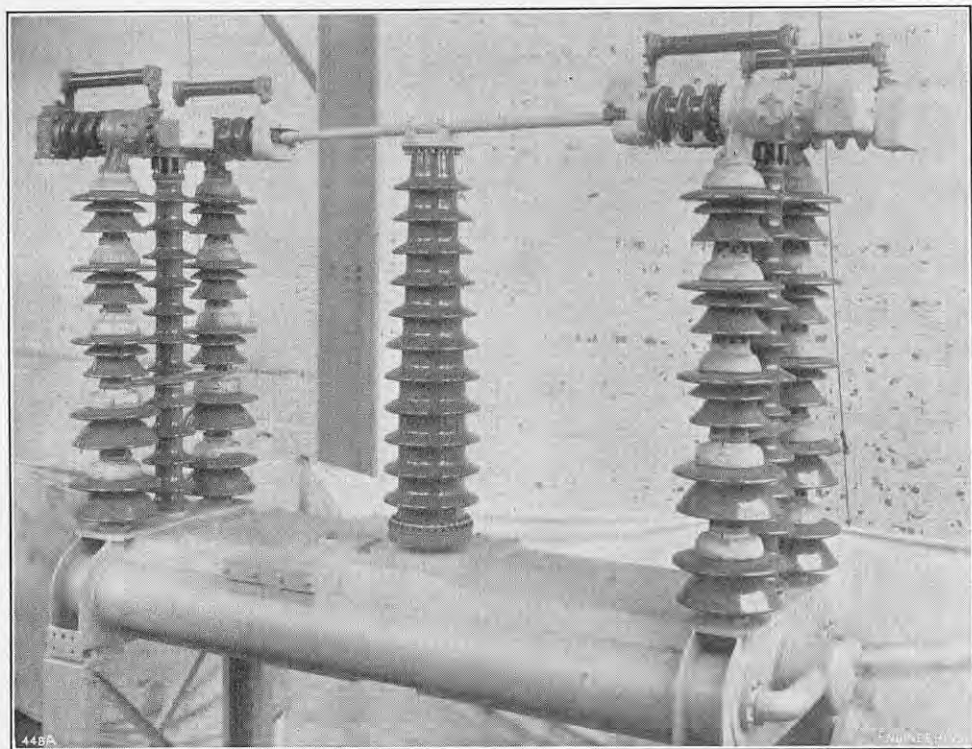


FIG. 1. INTERRUPTING UNITS OF HIGH-VOLTAGE CIRCUIT BREAKER.

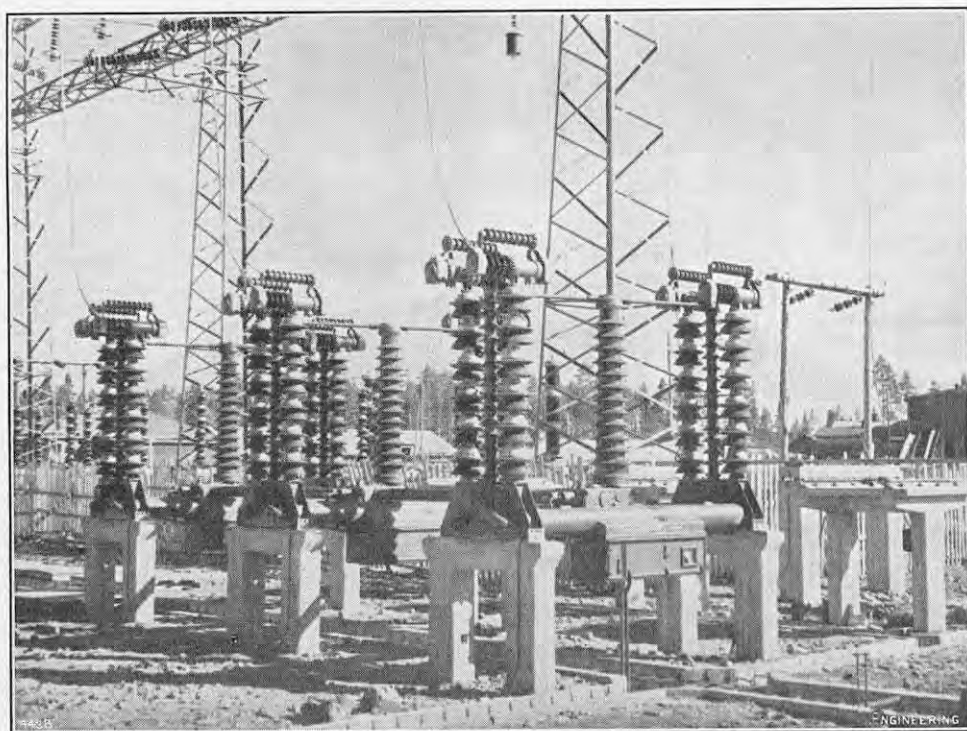


FIG. 2. SUPPORTING COLUMNS AND AIR-RECEIVER FRAMEWORK.

Circuit control by air-blast circuit breakers presents several features of note, which are brought into greater relief in proportion to increase in service voltage. From a short-circuit aspect, the use of compressed air as a forced-blast deionising medium, in conjunction with a multi-break design in which the arc length per phase is subdivided into a number of short arcs in series, provides a positive and reliable means of interruption. It affords the high-speed performance demanded for large interconnected networks, where delay in fault clearance may have

interrupting parts is also worthy of reference. Because of the rapid cooling of the arc and its transference away from metallic contacting faces, one set of nozzle contacts will deal with many full-rating short circuits without renewal. When maintenance is eventually required, it can be carried out with speed and simplicity due, in large measure, to the absence of insulating oil. The ease of renewal is greatest with designs in which the individual interrupters for each phase are separately mounted because, in addition to accessibility, such an arrange-

breaking duty imposed upon them. The breaking capacity of the complete circuit breaker is therefore known to be directly proportional to the number of interrupters in series.

Another important function in the prevention of high over-voltage, which might otherwise result when circuit breakers are called upon to switch small inductive currents, is performed by the shunt resistors. During such operation, with relatively little ionisation of the arc gap across the interrupting nozzle contacts, the blast air can restore the electric strength of the gap at a very rapid rate. This may result in current "chopping," or suppression of the current to zero in advance of the normal sinusoidal zero. The inductive energy available during this chopping process in a circuit of high reactance (as, for example, when switching an open-circuited transformer) is then converted into heat energy in the resistors instead of into electrostatic energy in the system capacitance. Both calculation* and test demonstrate that, with the value of resistance employed, a safe over-voltage limit can be maintained even under unfavourable circuit connection conditions. It may be noted that the occurrence of current chopping is not confined to forced-blast circuit breakers, but is also experienced with oil circuit breakers of the self-blast type.

The resistors also serve a useful purpose in connection with over voltage during the switching of transmission-line charging currents. In this duty, when interruption is effected at a current zero, the line is left charged at peak 50-cycle voltage, but, because the voltage at the supply end of the circuit breaker continues to alternate at generated frequency, it follows that, during the half-cycle subsequent to interruption, the voltage across each pole of the circuit breaker progressively increases to twice phase-voltage peak. This presupposes that shunt resistors are not employed and that no discharge of the line by leakage or corona occurs in this time. Accordingly, the arc gap of the circuit breaker has to withstand this severe voltage condition without breakdown. If it fails and if a restriking occurs when the discharge current flowing through the gap is interrupted, the line may be left charged at a voltage up to three times phase-voltage peak. Further restriking could result, on interruption of the discharge current, in the line being left charged at successively higher voltages.

While forced-blast interruption in conjunction with short-stroke multi-break contacts is a combination well suited to building up sufficient gap strength in half a cycle to withstand twice phase voltage, the overall effectiveness of such a combination is nevertheless enhanced when shunt resistors are used. Immediately the charging current is interrupted, the line can discharge through the resistors, and, as the voltage across the circuit breaker during the subsequent half-cycle is in consequence reduced, the possibility of a restriking occurring is similarly reduced. Also, since the line over-voltage resulting from the interruption of a restriking is dependent in value on the voltage across the circuit breaker at the instant of restriking, the resistors have the additional effect of reducing the magnitude of over-voltage if a restriking does occur.

Whether small inductive currents or capacitive currents are being switched, the efficiency of shunt-resistors is dependent on the amount of current which can be passed through them under abnormal voltage conditions. The non-linear resistors used with the designs described are therefore particularly suitable for these applications, since by virtue of the resistor characteristic the current varies as approximately the fourth power of the voltage. The resistance is, however, high enough in value to avoid difficulties in resistor-current interruption when the sequence switch opens.

To ensure reliability of operation air-blast circuit breakers require a high standard of mechanical performance. The valve gear employed is, therefore, of metal-to-metal type, obviating the "stiction" and creepage deterioration that can occur with rubber-faced valve seats. All moving parts subject to rapid acceleration and deceleration are made from high-tensile rustless steel, and are designed

to avoid local concentration of stresses. Each valve is tested for mechanical operation before being fitted on the circuit breaker. At the same time, air leakage is measured with the valve in various angular positions on its seating; by virtue of such individual attention, the overall pressure drop on completed breakers averages less than $1\frac{1}{2}$ lb. per square inch per hour. To facilitate routine maintenance in service, the valves are designed as removable units, any of which can be subjected to electrical, mechanical, or air-leakage tests on a test panel which can be supplied for the purpose.

A summary is given in Table I of some of the short-circuit tests for a rating of 3,500 MVA (symmetrical breaking current 9.19 kA) to which the 220-kV circuit breaker has been subjected. The tests were made single-phase, and, in conformity with B.S. 116, were carried out on the basis of demonstrating that the complete pole would interrupt with a recovery voltage of 1.5 times the phase voltage—in this case 190 kV.

TABLE I.—SHORT-CIRCUIT TEST RESULTS ON ONE-POLE OF 220-kV FOUR-BREAK AIR-BLAST CIRCUIT BREAKER.

Rated Symmetrical Breaking Current: 9.19 kA (Equivalent to 3,500 MVA Three-Phase.)

Test No.	Operating Duty and Time Interval (Min.).	Applied Voltage kV (R.M.S.).	Making Current, kA (Peak).	Breaking Current, kA (R.M.S.).		Per Cent Direct-Current Component.	Arc Duration, Secs. $\times 10^{-3}$.	Total Break Time, Secs. $\times 10^{-2}$.	Recovery Voltage, kV. (R.M.S.).	Equivalent Line Recovery Voltage for Complete Three-Phase Breaker.	
				Sym.	Asym.					kV (R.M.S.).	Per cent. of Service Voltage.
Tests on Four Interrupters in Series.											
1	B ₃	205		0.944	0.944	1.4	1.2	5.5	190	219	100
2		205		0.928	0.928	0	1.5	5.8	186	214	97
3		205		0.928	0.928	0	1.1	5.4	186	214	97
4	B ₃	220		1.36	1.36	6.9	2.4	6.7	203	234	106
5		220		1.37	1.37	1.7	1.3	5.6	203	234	106
6		220		1.36	1.37	10.3	1.3	5.6	206	237	108
7	MB ₃	214	2.44	1.19	1.19	5.9	2.0	6.3	174	200	91
8		217	2.24	1.21	1.21	3.8	2.5	6.8	178	205	93
Tests on Two Interrupters in Series.											
9	B ₃	122		0.724	0.724	3.1	1.4	5.7	116	267	121
10		122		0.749	0.749	0	1.4	5.7	118	272	124
11		122		0.736	0.736	4.6	2.0	6.3	118	272	124
12	B ₃	128		2.62	2.62	1.8	2.6	6.9	115	264	120
13		133		2.62	2.62	1.8	1.9	6.2	117	269	122
14		130		2.62	2.62	1.8	1.8	6.3	117	269	122
15	B ₃	111		5.56	5.56	1.7	1.6	6.1	104	239	109
16		113		5.51	5.51	6.9	1.1	5.5	104	239	109
17		113		5.51	5.51	6.9	2.2	6.7	99.3	228	104
18	MB ₃	113	11.8	4.81	4.81	5.9	1.4	6.0	89.2	205	93
19		113	11.8	4.92	4.92	3.8	1.4	6.0	89.2	205	93
Tests on One Interrupter.											
20	B ₃	62.7		0.582	0.582	3.6	1.3	5.7	60.6	279	127
21		62.7		0.582	0.582	3.6	1.2	5.5	60.6	279	127
22		62.7		0.570	0.576	5.5	1.2	5.6	59.6	274	125
23	B ₃	65.7		2.41	2.43	10.8	1.6	6.2	60.6	279	127
24		65.7		2.41	2.41	4.6	1.8	6.2	60.6	279	127
25		65.7		2.47	2.47	1.5	1.7	6.2	61.5	283	129
26	B ₃	64.7		4.39	4.39	1.4	1.7	6.2	57.7	265	120
27		63.7		4.39	4.39	1.4	1.6	6.2	57.7	265	120
28		63.7		4.25	4.32	10.4	1.1	5.5	53.8	248	113
29	B ₃	63.7		6.71	6.71	1.6	1.7	6.3	52.8	243	110
30		62.7		6.71	6.71	1.6	1.4	5.9	54.8	252	115
31		63.7		6.83	6.83	0	1.4	5.9	53.8	248	113
32	B ₃	56.9		9.24	9.24	1.4	2.3	6.8	51.3	236	107
33		56.1		9.10	9.10	2.9	1.4	6.0	50.5	232	105
34		56.9		8.95	9.17	15.9	1.3	5.6	49.7	229	104
35	B ₃	58.1		10.7	12.9	46.3	1.1	6.1	53.6	247	112
36		58.1		10.7	12.9	46.3	2.3	6.8	52.9	243	110
37		58.1		10.4	11.1	26.2	1.2	6.0	53.6	247	112
38	MB ₃	56.4	20.8	9.14	9.14	5.3	1.4	6.1	44.8	206	94
39		57.8	26.3	9.31	9.31	1.8	1.3	6.0	46.2	212	96

* See paper 103, by C. H. Flurscheim, K. J. Saulez and R. W. Sillars, Conference Internationale des Grands Reseaux Electriques, June, 1950.

AIR-BLAST CIRCUIT BREAKER.

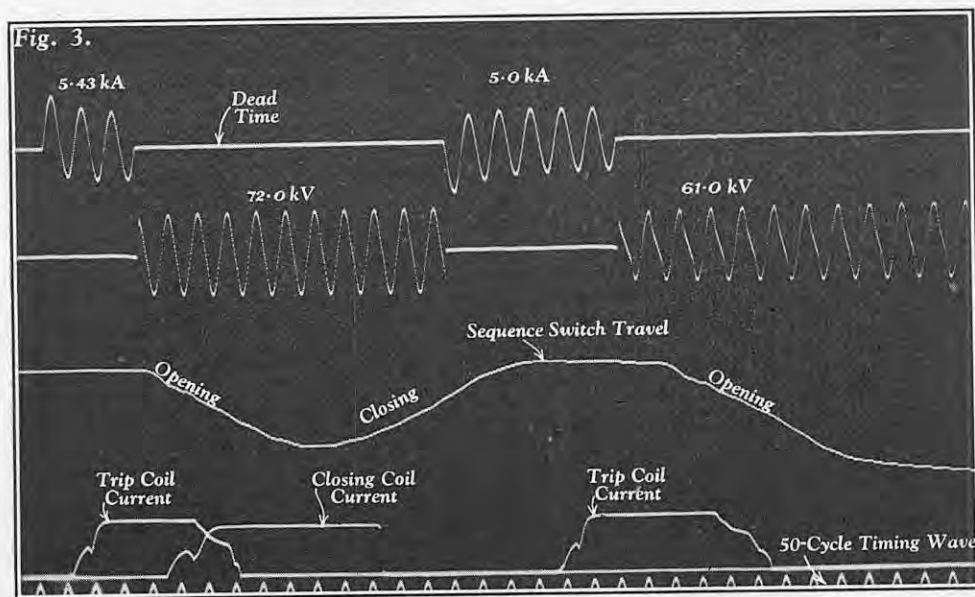


FIG. 3. OSCILLOGRAMS OF 165-KV CIRCUIT BREAKER.

breakers described were tested with restriking rates far above those prevailing on systems of the general class in which they will be installed, and for this reason large factors of safety exist in service.

The 165-kV and the 220-kV circuit breakers can both be arranged for high-speed reclosure with a time interval between interruption and re-energising the circuit (dead time) of the order of 10 cycles as a minimum. This dead time can be increased if desired. The minimum corresponds to the time needed for an air flashover path to become sufficiently deionised to withstand restoration of the system voltage.*

For reclosing duty, the circuit breakers open in the normal way, as on an independent opening operation, i.e., the nozzle contacts and sequence switch open in turn. The sequence switch reverses, however, before becoming fully open and recloses to re-make the circuit. In this way there is no complication of additional operating mechanism, and air consumption is not increased. Furthermore, since the sequence switch opens far enough to interrupt the resistance grading current, prolonged electrical loading of the resistors, which might otherwise occur on a persistent fault, is avoided. Fig. 3 is an oscillogram of the 165-kV circuit breaker operating on single-phase reclosure during test. The circuit was re-made after a dead period of 10.5 cycles, but as the fault was permanently earthed the circuit breaker interrupted a second time immediately after reclosure.

The "impulse-withstand" test level of the 220-kV design is 1,050 kV, but modern practice is tending towards somewhat lower levels when circuit breakers are associated with a solidly-earthed neutral; 1,050 kV is, in fact, sufficiently high for 275-kV service on such systems. With the trend towards a lower impulse level, it becomes even more important to ensure that circuit-breaker operation does not produce high over-voltage. This requirement, as previously stated, is met by providing the interrupters with resistor shunts.

The breaking capacity of air-blast circuit breakers is largely dependent on the pressure and rate of flow of air supplied to the interrupting nozzle contacts. By using larger valve gear and air receivers, the 220-kV circuit breaker can be rated at 5,000 MVA. Similar designs are available for 7,500 MVA at 275/300 kV.

The information given in this article is based on investigations carried out at the Trafford Park works of the Metropolitan-Vickers Electrical Company, Limited, and the illustrations refer to equipment manufactured by them.

* See Paper 135, by A. C. Boisseau, B. W. Wyman and W. F. Skeats, "Insulator Flashover Deionisation Times as a Factor in Applying High-Speed Reclosing Circuit Breakers," Conference Internationale des Grands Resaux Electriques, 1950.

LITERATURE.

Annual Report of the Director of the Department of Terrestrial Magnetism for the Year 1949-1950.

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

THOUGH the period covered by the present report is not marked by any spectacular new discoveries, steady progress is recorded in the wide range of investigations sponsored by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, under the direction of Merle A. Tuve. In experimental geophysics further work on the magnetic susceptibility of ancient sedimentary rocks has revealed extensive fluctuations that may be due to extreme folding processes, but do not appear to be ascribable to a reversal of the earth's magnetic field or to a drifting of the continents. Stray magnetic fields from power or lighting circuits have been shown to cause changes in the direction of magnetisation of rock samples stored for several months in the laboratory, and, to obtain consistent measurements on such magnetically weak specimens, it has been found essential to compensate the earth's field. In collaboration with the staff of the Seismological Laboratory of the California Institute of Technology, a discrepancy between the velocity of earth waves from surface explosions and those from near earthquakes was cleared up by assuming a structure of the earth's crust comprising a surface layer 6 to 11 km. in depth, in which the wave velocity increases from 5.7 to 6.2 km. per second; underlying this is material in which the mean wave velocity is 6.8 km. per second. Further work by a different method is being undertaken to ascertain the degree of complication of the internal topographic relief of the earth's crust.

A promising contribution to upper-atmosphere research is being provided by the simultaneous operation of three high-speed ionospheric recorders at stations located at the vertices of a triangle with sides of approximately 100 miles. It is hoped to be able to measure the apparent velocity and size of sporadic E-clouds, to measure lateral as well as vertical distribution of E-region and F-region ionisation, and to register sunrise effects in the F-region. Observations made from aeroplanes flying at great heights directly above thunderheads indicate that thunderstorms provide the mechanism giving rise to the negative electrical charge of the earth with respect to the surrounding atmosphere. The large ionisation chamber, with its 4-in. lead shield, has been operating continuously, and a very large increase in cosmic-ray intensity was noted during the solar flare of November 19, 1949. Theoretical and statistical work has been carried out on the performance of this large ionisation

chamber and on the solar-flare effects on cosmic rays. A rocket experiment, embodying a magnetometer unit to indicate the height of electric current layers in the atmosphere responsible for the solar daily magnetic variation, showed that these currents probably flow near the 100-km. level.

In the Department's laboratory, investigations of proton-proton and neutron-deuteron scattering have been continued. The main effort in biophysics was devoted to studies of the relations of inorganic ions to cellular activity and to work on the biological effects of radiation. To facilitate investigations into the role of trace elements, a number of techniques have been evolved, permitting studies to be made at levels of less than one-tenth part per thousand million of the ion or element under examination. The biophysics group has also been responsible for the operation of the 60-in. cyclotron and for the preparation of purified tracer substances which have been made available to other research groups. Progress was made in the reduction and publication of geomagnetic data, and the editing of the *Journal of Geophysical Research* was continued. Details are also included of projects nearing completion or under consideration, which promise to maintain the level of interest of these annual reports.

Les Nombres et les Espaces.

By PROFESSOR GUSTAVE VERRIEST. Collection Armand Colin No. 269. Librairie Armand Colin, 103 Boulevard Saint-Michel, Paris (5e). [Price 200 francs.]

MOST of the mathematics required for practical application by the student of engineering dates back a century or more, and with what has been happening in mathematics since then he is usually quite unfamiliar. Professor Verriest in this little book aims to remedy this state of affairs by providing an introduction to topics in modern mathematics selected to indicate the lines along which the subject is continuing to develop. Little in the way of mathematical equipment is assumed on the part of the reader, though the subtlety of many of the arguments and the paradoxical nature of some of the conclusions demand his close attention. Within the space available, technical details have had to be omitted, and but few mathematical formulae are given. Attention is concentrated mainly on the basic postulates, and the simplest examples are chosen to illustrate deductions from them.

The opening chapter deals with the generalisation of arithmetic by tracing the extension of the idea of number and the concept of ensembles or classes. The properties of natural, rational and irrational, algebraic, transcendental, transfinite, cardinal and ordinal numbers are explained, and the guiding principle of one-to-one correspondence is employed to define denumerably and non-denumerably infinite classes. Attention is directed to the significance of this work in supplying a self-consistent foundation for the continuum of real numbers in analysis, while a discussion of certain consequences of the theory of classes aptly demonstrates how little intuition is to be trusted in excursions into the infinite. The major advances made in geometry during the Nineteenth Century are outlined in the second chapter. Concentration on the non-metric aspects of geometry, began with Poncelet, who laid the foundations of projective geometry during his captivity in Russia in 1813-14. Examples of the unifying power of the principles of continuity and duality are provided, as well as of the usefulness of the anharmonic ratio. Part of the interest attaching to projective geometry resides in the fact that its results are applicable not only to Euclidean but also to non-Euclidean geometries. How Lobatchewsky created the first of these non-Euclidean geometries by challenging the parallel axiom of Euclid is described, together with the subsequent development of other self-consistent geometries by Riemann and others, the significance of which in modern astronomical theory is pointed out.

Chapter III is devoted to the theory of groups, which now dominates so much of mathematics, and deals incidentally with the celebrated problems of the quadrature of the circle, the duplication of the cube and the trisection of an angle; it ends with a sketch of the tragic life of Evariste Galois. The following chapter is on modern algebra which, as the author points out, differs more radically

REINFORCED-CONCRETE PILES UNDER TENSION.



FIG. 1.



FIG. 2.

from classical algebra than does classical algebra from arithmetic. Modern algebra is highly abstract, employing symbols without attaching any meaning to them, but merely prescribing certain rules according to which they must be manipulated and which serve to determine their mathematical properties. Nevertheless, it is shown that even such purely mental concepts are not devoid of application to natural phenomena.

The concluding chapter traces the history of the main stages in the development of geometry from the Greeks, through the analytical geometry of Descartes, the infinitesimal geometry of Gauss, the projective geometry of Poncelet, and the various, non-Euclidean geometries previously discussed, the Erlangen programme of Klein and the formalism of Hilbert, to the recent algebra of geometry. Professor Verriest's enthusiasm for his subject is very apparent, and his skill as a teacher is everywhere evident. Moreover, those who are stimulated by him to penetrate more deeply into modern mathematics will be additionally grateful to him for having left them with no false notions to correct.

ANNUAL DINNER OF THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—The next annual dinner of the British Electrical and Allied Manufacturers' Association will take place at Grosvenor House, Park-lane, London, W.1, on Thursday, January 24, 1952, and not on Thursday, November 15, 1951, as previously announced.

HIGH-TENSILE STEEL FOR CANAL BOATS.—Three 50-ton motor canal boats of the Liverpool type, which are being built by the Fairmile Construction Company, Limited, Cobham, Surrey, for the North Western Division of the Docks and Inland Waterways Executive, are being constructed of high-tensile steel with welded joints, thereby increasing the cargo capacity of each by 4 or 5 tons. The steel is to British Standard Specification 968; it has a yield point of 22 tons per square inch, and a tensile strength, in plate form, of 37 to 43 tons per square inch, and in section form of 35 to 41 tons per square inch. Scantlings that are lighter and shell plates $\frac{1}{16}$ in. thinner than in normal riveted mild-steel designs are being used. This reduction in weight will offset the increased cost of the high-tensile steel per unit weight, so that the total cost will be unaffected. Welding in place of riveting will save between a half and one ton in weight. At the request of the British Iron and Steel Federation, one of the three vessels is to be plated in Cor-Ten—a low-alloy high-tensile structural steel containing 0.25 to 0.5 per cent. copper and more resistant to atmospheric corrosion than mild steel.

REINFORCED-CONCRETE PILES UNDER TENSION.

By J. A. WAKEFIELD, A.M.I.E.E.

A CONSIDERABLE saving can be made on the cost of piled transmission-tower foundations if account is taken of the fact that certain types of pile are extremely difficult to extract from the ground. This article describes a simple test which was devised by Pressure Piling (Parent), Limited, for W. T. Henley's Telegraph Works Company, Limited, who were the main contractors for the transmission towers concerned, to obtain a definite value for this resistance to extraction. The towers were for the British Electricity Authority (Southern Division), with whom the author is associated. The normal foundation for a steel transmission tower consists of four concrete pyramids, one for each leg, the compression pyramids being just below ground level and the uplift some 10 ft. or 12 ft. below. The depth and size of the uplift footings is governed by the uplift forces, which, in turn, depend on the particular function the tower is carrying out.

To excavate to such depths under wet site conditions, it would be possible to construct a cofferdam, but it is considered more economical to construct a mass concrete block nearer to the surface, to compensate for the loss in weight of earth above the more usual pyramid. To prevent this block foundation from settling, it then becomes necessary to support it on piles. Because of the inaccessibility of most of these positions, the cast-in-situ "bored" type has been used.

As can be seen from the accompanying illustrations, Figs. 1 and 2, herewith, the plant required for this type of pile is fairly light and mobile, and can be moved into any required position by four or five men. The versatility of the rig enables piling to be carried out in practically any condition, such as on embankment slopes, uneven ground, or, as was the case on a recent line, on very marshy waterlogged ground. It was realised that the type of pile used would resist, to some extent, a force exerted in an upward direction, as it would in a downward direction. As a result, it was calculated that the mass-concrete blocks could be reduced in size by an amount corresponding to the resistance to extraction of the piles.

All that remained was to devise a simple and economic method of testing the piles in tension. It

had to be an economic method, or the cost would have cancelled the saving in the size of concrete block. It may be of some interest, therefore, to describe both the method of forming the pile and the method of testing it, together with some of the results obtained.

The boring was carried out by means of small boring tools, similar to well-boring equipment. The sides of the bore were lined by a steel tube, in small sections approximately 5 ft. long, each tube having a male and female thread cut into it; thus, any continuous length of steel lining could be used by screwing the sections together. Power for moving the tubes and operating the boring tools was provided by the small compact winch, driven by compressed air, which was fixed to the back leg of the boring rig. The boring continued until a safe load-bearing strata had been reached, and an accurate record of the various strata encountered was also obtained.

The strata found on a recent contract consisted of fill, peat, ballast and clay. Where the ballast was considered thick enough (trial borings having been made before the contract was commenced), the piles were driven only into the ballast bed, but in other cases, where the ballast was not of sufficient thickness to distribute the load, the piles were taken down into the clay below. After completion of the boring, the in-situ concrete was placed inside the steel tubes. For piles finishing in ballast, the method of concreting the piles was as follows.

The required steel reinforcement was lowered into position and then an air-lock was screwed on to the top of the tubes. A flexible pipe was lowered through the air-lock down to the toe of the pile, and, by applying air pressure, the ground water present in the tubes was forced out through the pipe, thus giving a completely dry hole. Cement grout was then poured into the tubes through the air-lock, followed by a rich mixture of concrete; this ensured that, at all times, the air pressure inside the tubes remained constant, keeping the borehole completely dry. When there was a sufficient head of concrete in the tubes to withstand the ground-water pressure, the pipe was withdrawn, the air-lock removed, and the tubes slowly lifted from the ground. After removing a tube, more concrete was poured into the boring, a pressing cap fitted to the top of the tubes, the concrete compressed by the air, and the tubes again gently withdrawn. This process continued until the pile had been concreted to its correct level.

REINFORCED-CONCRETE PILES UNDER TENSION.

Fig. 3. ARRANGEMENT FOR TENSION TEST

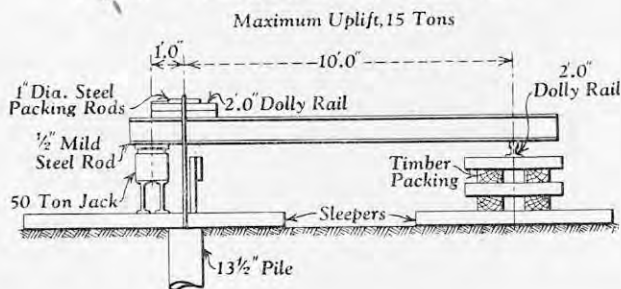
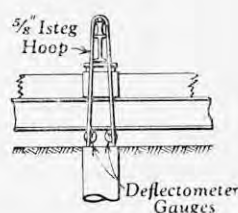
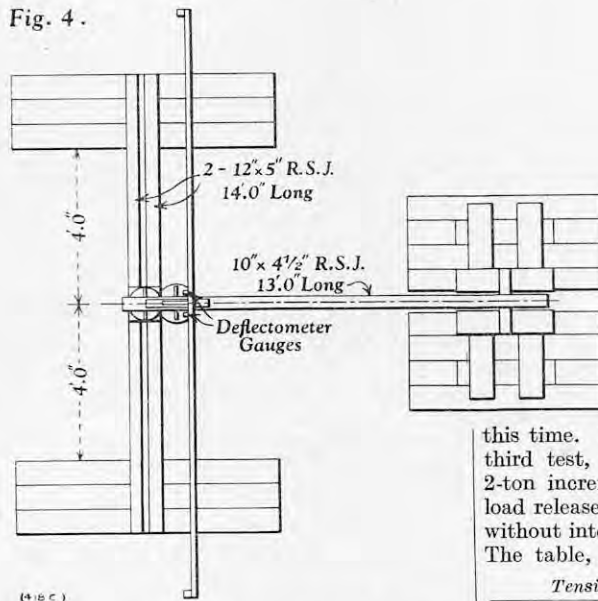


Fig. 5.



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Fig. 4.



For piles finishing in clay, as no ground-water was present, there was no need to use the air-lock. Before lowering the steel reinforcement, however, a batch of very dry concrete was introduced into the tubes and rammed into the clay at the toe of the pile by means of a heavy drop-weight. The reinforcement was lowered into position and the pile concreted as before.

By these means, either by use of cement grout which, under air pressure, was forced between the particles of sand and gravel, thereby "cementing" a large area, or by using dry concrete, rammed with the heavy weight, an enlarged base was formed at the bottom of every pile. Furthermore, the concrete was forced into any voids or cracks that might exist in the various strata. This method forms a very rough cast pile, having a high skin-friction value.

Figs. 3 to 6, herewith, show the method used to exert a force in an upward direction, and the method of measuring movement of the pile. Arrangements were made for the reinforcement in the pile to be brought round to form a loop. One end of a rolled-steel joist was passed through this loop and supported on grillage and packing at one end, and on a 50-ton hydraulic jack at the other. The jack rested on two beams at right angles to the joist. The ends of these beams rested on a timber grillage remote from the piles, so as to ensure that the pile was not affected by any external influence.

To measure the movement, two deflection gauges were fixed to a board across the top of the pile, which was supported at each end by stakes remote from any ground movement which might take place during the test. The deflection gauges were so placed that their plungers were in contact with prepared surfaces grouted to the pile top. The load was then applied by means of the jack. Fig. 7 shows the various strata and the levels at which they were found while boring for a 13 1/2-in. pile.

Four tests were applied. In the first of these, a maximum load of 16 tons on the jack was applied in 2-ton increments over a period of 10 minutes. This load was maintained for 2 1/2 hours and then released. In the second test, a load of 16 tons on the jack was again applied and maintained for 21 hours, readings being taken at intervals during

this time. Finally, the load was released. In the third test, the 16-ton load was again applied in 2-ton increments, the readings observed, and the load released. Lastly, the 16-ton load was applied without interruption and the final reading observed. The table, herewith, shows the movement of the

Tension Test on 13 1/2-in. Dia. Pressure Pile.

Date and Time.	Load on Jack (tons).	Load on Pile (tons).	Uplift, 0.001 in.	
			Left.	Right.
Feb. 2, 1951.				
12.20	0	0	0	0
	2	2.11	10	10
	4	4.22	20	20
	6	6.33	29	28
	8	8.44	35	34
	10	10.55	46	44
	12	12.66	56	53
	14	14.77	71	68
12.30	16	16.9	88	85
12.35	16	16.9	98	93
3.00	16	16.9	146	138
3.05	0	0	64	60
	4	4.22	78	75
	6	6.33	87	83
	8	8.44	99	94
	10	10.55	110	105
	12	12.66	125	119
	14	14.77	138	132
	16	16.90	154	148
Feb. 3, 1951.				
8.00	16	16.90	160	154
10.30	16	16.90	165	161
12.00	16	16.90	170	166
	0	0	70	71
	2	2.4	73	75
	4	4.22	79	80
	6	6.33	90	92
	8	8.44	104	105
	10	10.55	120	122
	12	12.66	136	138
	14	14.77	151	153
	16	16.9	169	172
12.30	0	0	70	71
	16	16.9	170	171
	0	0	70	71

pile under varying loads. The tests were made at Site No. 14, on Eling saltings, near Southampton.

Test 1 showed a movement of 0.138 in. after 2 1/2 hours, and a residual movement of 0.06 in. after the load was released. In Test 2, there was a movement of 0.166 in. after 21 hours, and a residual movement of 0.071 in. after the load was released. In Test 3, a movement of 0.172 in. at 16 tons was recorded, with a residual movement of 0.071 in. after the load was released; and, in Test 4, a movement of 0.171 in. at 16 tons, and a residual movement of 0.071 in. after the load was released.

From Tests 1 and 2, it will be observed that movement continued for a period after the maximum load was applied, but that the rate of movement de-

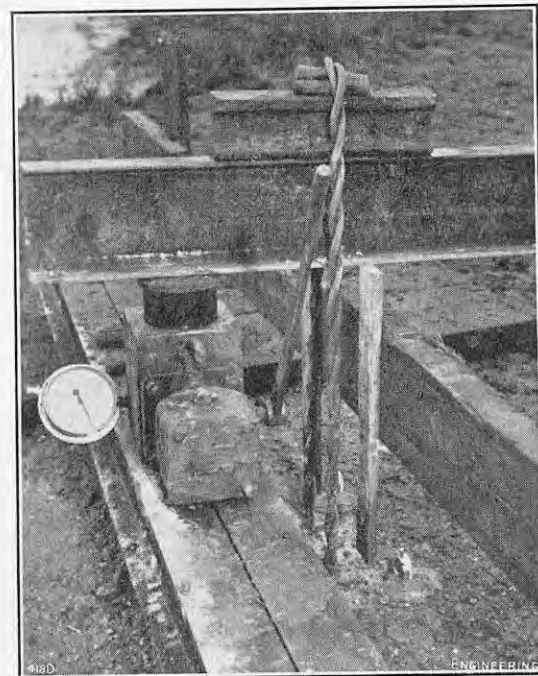
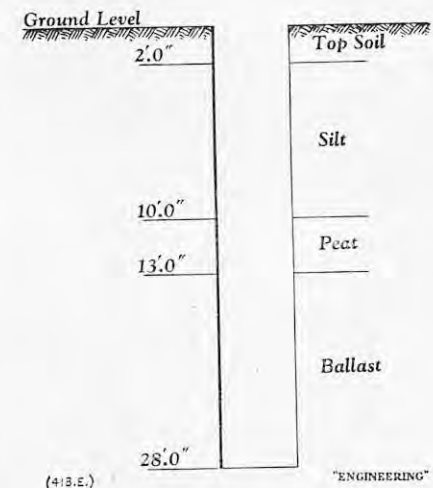


FIG. 6. ARRANGEMENT OF GEAR ABOVE PILE.

Fig. 7. SOIL STRATA TEST PILE POSITION

Length of Pile 24.0"
Dia. of Pile 13 1/2"



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creased, so as to be almost negligible after the first 12 hours. From Tests 2, 3 and 4, it will be seen that the residual movement remained constant at 0.071 in. From Tests 3 and 4, the maximum movement was 0.172 in. and 0.171 in., respectively, from which it would appear that the movement was becoming constant and did not exceed 0.101 in.

Since the tower designers recommend that movement on footings should be restricted to 1/8 in., as, otherwise, unequal stresses would be set up in the tower members, the results obtained on this test were considered satisfactory, and an uplift value of 15 tons was allowed on this pile.

It may be argued that the values obtained for uplift on one site would not correspond to the next; but, where the same strata were encountered, it was considered unnecessary to test each pile. Therefore, wherever a change in formation was observed, a test was carried out. It is interesting to note that the results of three tests, carried out where different formations were encountered, were very similar, and that, in each case, 15 tons was a safe figure to use.

On a recently-constructed 132-kV line near Southampton, 12 towers were situated on marshy ground and a total of 78 piles were beneath uplift footings. The total weight of concrete saved was 1,170 tons, representing a saving of 25 per cent. on the total cost of 12 piled foundations.

THE INSTITUTE OF METALS.

THE opening meeting of the fifth national congress of the Associazione Italiana di Metallurgia and of the 43rd annual autumn meeting of the Institute of Metals was held at the Palazzo Ducale (Doge's Palace), Venice, Italy, on the morning of Sunday, September 16. The chair was occupied by the Mayor of Venice, Professor Angelo Spanio, who, in the course of his speech, stated that collaboration in cultural and other walks of life promoted international well-being. Other speeches of welcome were delivered by Professor Antonio Segni, Minister of Public Education, who spoke on behalf of the Italian Government, Mr. G. Battista Dall'Armi, President of the Association of Industrialists of Venice, and by Cavaliere Aldo Dacco, President of the Associazione Italiana di Metallurgia, who were the Institute's hosts during the autumn meeting in Italy. Professor Albert Portevin voiced the greetings of the French members who were present at the meeting. Professor A. J. Murphy, the President, in returning thanks to all individuals and firms who had worked to make the meeting a success, stated that the Institute were meeting in Italy for the first time and the members were looking forward to seeing some of the metallurgical works and scientific establishments in Italy. After the conclusion of the speeches of welcome, the members walked to the Town Hall, the Ca' Farsetti, where a reception was held by the Mayor and Municipality of Venice. In the afternoon, a steamer trip was made round the Lagoon, the visitors landing on the Island of Torcello for a short tour. In the evening, a sound film entitled "Aluminium, the Metal of the Century" was shown. This had been made by the Duomo Film organisation with the scientific and technical collaboration of the Istituto Sperimentale dei Metalli Leggeri.

CHANGES ON COUNCIL.

A business meeting preceded the first technical session held at the Ca' Foscari, Venice, on the morning of Monday, September 17. Professor A. J. Murphy, the President, occupied the chair. The secretary announced that the following members would retire from the Council at the annual general meeting in March, 1952, as required by the Articles of Association. They were, as President, Professor Murphy; as past-president, Colonel Sir Paul Gueterbock, K.C.B., D.S.O., M.C., M.A.; as vice-presidents, Major C. J. P. Ball, D.S.O., M.C., and Dr. C. J. Smithells, M.C.; as honorary treasurer, Mr. W. A. C. Newman, O.B.E.; and as ordinary members of Council, Mr. D. F. Campbell, Mr. T. M. Herbert, Mr. H. W. G. Hignett and Mr. A. R. Powell. In addition, Mr. Alfred Baer and Mr. N. I. Bond-Williams, who had been appointed by the Council, during 1951, to fill casual vacancies, also retired and presented themselves for re-election. In accordance with the Articles, Professor Murphy would fill the vacancy on the Council as past-president, and the Council had nominated the following members to fill the other vacancies, namely, as President, Dr. C. J. Smithells; as vice-presidents, Mr. G. L. Bailey and Dr. S. F. Dorey, C.B.E., F.R.S.; as honorary treasurer, Mr. E. H. Jones; and as members of Council, Dr. N. P. Inglis, Dr. Ivor Jenkins, Dr. A. G. Ramsay, Dr. H. Sutton, Major P. Litherland Teed and Mr. W. J. Thomas. The Council had also elected Professor F. C. Thompson to serve as senior vice-president for the year 1952-53, and Professor Thompson would be the Council's nominee for the Presidency in 1953-54. The secretary finally reminded members of the all-day general discussion on "Metal Economics," to be held at the Park Lane Hotel, London, on Wednesday, October 17, when a number of short, invited papers would be presented. In the evening, an informal conversation would be held at 4, Grosvenor-gardens, and on the morning, visits would be paid to three works in the London area.

CORROSION-RESISTING COPPER-NICKEL-IRON ALLOYS.

The first paper considered was a communication from the British Non-Ferrous Metals Research Association, by Mr. G. L. Bailey, on "Copper-Nickel-

Iron Alloys Resistant to Sea-Water Corrosion." The author, in presenting it, stated that his paper described the development of copper alloys, containing from 5 to 10 per cent. of nickel and from 1 to 2 per cent. of iron, as materials easily worked by the coppersmith and resistant to moving sea water. Work carried out some years before the war had revealed the beneficial effect of small additions of iron and manganese on the resistance of 70:30 copper-nickel alloy to sea-water corrosion. As a result of this the corrosion resistance of copper-nickel alloys, low in nickel and with various iron contents, had been explored. The experimental work had comprised mainly tests of resistance to impingement attack in moving sea water containing air bubbles, and had included the observation of corrosion at shielded areas under conditions of rapid water movement. These tests had been supplemented by an examination of the resistance to attack under deposits in stagnant conditions. This exploratory work had shown that the addition of iron in amounts of the order of 1 to 2 per cent. greatly improved the resistance to corrosion of alloys of low-nickel content and pointed to the excellent performance of the alloys containing from 5 to 10 per cent. of nickel. The resistance to corrosion had been found to be affected by the heat treatment given. In view of the importance of providing alloys for use in pipes carrying sea-water in H.M. ships—alloys which would be more resistant to corrosion than was copper, normally used for the purpose—an examination had also been made of the mechanical and working properties of these alloys. This examination had shown the materials to be readily workable, both hot and cold, provided certain precautions were taken in heat treatment.

Dr. I. G. Slater, who opened the discussion, stated that in turning to the engineering aspects of the problem of corrosion in sea-water pipes, a dominant feature was that many of the troubles were caused by undue water turbulence. In addition, designs were such that there was much shaping and bending to form the piping. As the author had indicated, engineers had, in the 70:30 cupro-nickel having suitable iron and manganese contents and in aluminium brass, two materials notably resistant to impingement attack and other forms of marine corrosion. The ability to form and bend tubing in these alloys obviously presented problems, but the craft of coppersmithing was ever being extended, thanks to newer welding techniques and the further availability of machines for manipulating tubing and sheet. A further stimulus to turn away from the older materials used in ships' piping was the need to economise in non-ferrous metals generally. The allowance for corrosion deterioration and the low strength properties of copper had meant that the designer had had to employ substantial thicknesses for his piping. Possibly these scantlings might well be halved by using the better corrosion-resistant materials, which incidentally had much better strength properties than copper. The next speaker, Mr. J. O. Hitchcock, said that there was a great deal to be said for the method of manufacture adopted for the production of the tubes. Material produced by the extrusion process might give better results than tubing manufactured by other hot-working processes.

The next contribution to the discussion was from Professor C. S. Smith, who read a communication from Mr. J. R. Freeman, Junr., and Mr. A. W. Tracy, of the American Brass Company. These metallurgists wrote that much of their work agreed fully with data given in the paper. All their work had led to the development of an alloy, for condenser-tube service, having a nominal composition of 90 per cent. copper, 10 per cent. nickel, and 0.75 per cent. iron. Simulated service tests carried out in an experimental condenser at Kure Beach, North Carolina, with clean sea water flowing at 11.7 ft. per second, had shown cupro-nickel of this composition to be superior to Admiralty gunmetal, aluminium brass and 5 per cent. aluminium aluminium-bronze, and almost equivalent to a 70 per cent. copper, 30 per cent. nickel alloy containing 0.4 per cent. of iron. A large installation of the 10 per cent. alloy had now been in service for over four years and the tubes were showing excellent service. The cooling water was partially diluted with fresh water

and carried a moderate amount of pollution from domestic sewage and some industrial wastes.

Dr. Maurice Cook asked whether Mr. Bailey could tell the meeting to what extent the new material would supplement the materials now in use for condenser tubes. Moreover, the author had not said why it was that specimens of the alloy which were cold-worked and intermediately annealed at about 700 deg. C. did not crack if they were heated to 600 deg. C. and severely hot-worked at that temperature. Neither had he said why it was that if the material were heat-treated at, and quickly cooled from, a high temperature, say, 900 deg. C., before work at 900 deg. C., it cracked during hot-working at 600 deg. C. Mr. Bailey had not given much information on welding, although it was implied that this was easy. He (Dr. Cook), however, had not found this to be as easily carried out as was suggested in the paper. The author had said that flame welding was carried out with an efficiency, as shown by the tensile test on a butt weld, of 82 per cent. He wondered how this efficiency had been measured and whether this figure meant that the tensile strength of the weld metal was 82 per cent. of that of the basic metal.

Mr. Bailey, in the course of his reply, said that the question of heat treatment had given a great deal of trouble. Tubes of commercial manufacture which were cold-worked and intermediately annealed at about 700 deg. C., during fabrication, did not crack if they were heated to 600 deg. C. and severely hot-worked at that temperature. Like rod and tube materials made from laboratory casts, however, these cracked during hot-working at 600 deg. C., if the material were heat-treated at, and quickly-cooled from, a high temperature, such as 900 deg. C., before working at 600 deg. C. The heat treatment broke up the structure and ensured that the iron was dissolved.

SOLIDIFICATION OF SAND CASTINGS.

The second paper considered, entitled "The Influence of Alloy Constitution on the Mode of Solidification of Sand Castings," was also a communication from the British Non-Ferrous Metals Research Association. It was by Mr. R. W. Ruddle and Mr. A. L. Mincher and was presented to the meeting, on behalf of the authors, by Dr. G. L. J. Bailey. The authors stated that an experimental study had been made of the mechanism of solidification of castings in a number of metals and alloys differing widely in respect of constitution, freezing temperature, freezing range, and thermal properties. The solidification of cylinder and slab castings in each material had been investigated by making temperature measurements in the castings. The pure metals examined, namely, aluminium, copper, magnesium and zinc, all solidified by "skin formation," the casting consisting, at any instant during the solidification period, of a shell of completely-solid metal enclosing a core of completely-liquid metal, and approximate equations for the rate of skin thickening had been deduced. The solid-solution alloys, namely, Al 10 per cent. Mg; Al-5 per cent. Zn, Cu-10 per cent. Sn; Cu-20 per cent. Zn, and Mg-10 per cent. Al, solidified in the "pasty" manner. This consisted of a mixture of liquid and solid with solidification proceeding concurrently throughout the entire mass, freezing at the centre of the casting lagging slightly behind that at the surface. Two of the eutectiferous alloys studied, namely, Cu-10 per cent. Al, and Zn-5 per cent. Al, solidified by skin formation, but the mechanism of solidification of the others, Al-30 per cent. Cu; Al-11 per cent. Si; and Al-13 per cent. Si, was obscure, apparently approaching the pasty type. The observed solidification times of the castings had been compared with those calculated from thermal data for the metal and mould, and, in most cases, reasonable agreement had been found.

The discussion was opened by Dr. R. J. Parker, who stated that in the present paper the authors had continued the subject already given some treatment in earlier contributions. In an earlier paper the authors had had to admit that "the mode of solidification of near-eutectic alloys is somewhat obscure" and they had disappointed their readers in the present paper by the conclusion that "the mode of solidification of eutectics

remained obscure." The difficulty they had had to contend with was the apparent progress of solidification without the presence of a thermal gradient. He (Dr. Parker) felt that the solidification of eutectics, which appeared to be always capable of a form of "modification" by variation of cooling rate, could be expected to vary in behaviour between that of a pure metal and that of an alloy having a freezing range, depending upon composition and also upon cooling rate. The suggestion of the movement of metal, either solid or liquid, had also been mentioned in the description of the work on the solid-solution alloys. The formation of interdendritic fissures in magnesium and in aluminium alloys was suggested by the authors as being a result of metal movement but, without an illustration, it was difficult to visualise what was happening. In any case, it seemed that there were alternative explanations; one of these was that the cracks were due to hot tears or bridging, with consequent lack of feeding, and another was that they were due to cold cracking.

Dr. A. J. Shaler stated that, in work of this kind, meticulous care must be given to thermometry, and, moreover, the procedure adopted must be described in great detail. The next speaker, Dr. I. G. Slater, asked the authors whether they could throw any light on the possibility of the occurrence of inverse segregation in their alloys and whether they knew what were the effects of dissolved gases in their melts on the results obtained. In the course of a brief preliminary reply, Dr. Bailey said that he did not think that any information could be given by the authors on inverse segregation effects.

OXIDATION OF COPPER.

The last two papers considered on the morning of Monday, September 17, were by Mr. R. F. Tylecote, and, once again, were communications from the British Non-Ferrous Metals Research Association. Both papers were on the oxidation of copper and the adherence of oxide scales. The first dealt with "The Adherence of Oxide Scales on Copper," and, in this, the author stated that the scales formed on pure or arsenical tough-pitch copper and on phosphorus-deoxidised copper were known to behave very differently during fabrication, the phosphorus-bearing coppers shedding their scales more readily than the phosphorus-free coppers during hot-working. These differences in scaling behaviour were explained in terms of the mechanical properties of the scales at elevated temperatures. The oxide scales on copper, consisting largely of cuprous oxide, were remarkably ductile at elevated temperatures. The scales on coppers containing phosphorus, on the other hand, had very limited ductility, never exceeding about 5 per cent. elongation over the whole temperature range, and they were therefore unable to accommodate the plastic strains imposed on them by hot-working operations. Moreover, the hot shortness of these scales was due to intergranular films of a molten phase, probably a cuprous phosphate.

In an appendix to this paper, Mr. R. Eborall gave the results of an estimate he had made of the temperatures reached by the oxide scales when a slab, preheated to 900 deg. C., was passed through the rolls during a hot-rolling operation. He showed that the scale rapidly cooled to a temperature at which the ductility of the scale on phosphorus-free copper was fairly strongly dependent on the temperature, and added that it might be inferred that moderate reductions in initial slab temperature would markedly favour the exfoliation of the scale.

Mr. Tylecote's second paper dealt with the "Oxidation of Copper at 350 deg.—900 deg. C. in Air." He stated that, as part of his study of the adherence of oxide scales on copper and on phosphorus-deoxidised copper, the oxidation rates of these materials had been measured in the temperature range 350 deg. to 900 deg. C., by a continuous-weighing method. At 615 deg. C., and higher, the coppers oxidised according to the parabolic law, and the rate constants were similar for the two types of copper. At lower temperatures, the initial stages of oxidation departed significantly from the parabolic mode and the oxidation probably followed a logarithmic law, the rates again being similar for the two types of copper. As the scale thickened, however, the oxidation conformed more nearly to

the parabolic law. The final conclusion was that at temperatures from 600 deg. to 900 deg. C., all the coppers investigated had approximately the same oxidation rate at any given temperature. In other words, the amounts of phosphorus and oxygen present in deoxidised and tough-pitch coppers had little or no effect on the oxidation rate. Below 600 deg. C., however, the presence of phosphorus reduced the oxidation rate.

The discussion was opened by Dr. F. D. Richardson, who stated that the author had shown the clear-cut difference between the scales on pure copper and on copper containing phosphorus and arsenic. Mr. Tylecote, however, had said little on the question of how these results fitted in with the general picture of the manner in which metals were oxidised and scales formed upon them. It was generally accepted that scale on the surface of a metal thickened by the movement of metallic atoms forward through to the surface of the scale. Experiments had shown that when the surface of a material had been disorganised by a scratch a tree-like growth of material was built up above the surface of the metal. The reason for such growths and the mechanism at work were not understood.

Sir Arthur Smout asked the author if he had made studies, similar to those described in his paper, on copper alloys containing 0.3 to 0.5 per cent. of arsenic. A subsequent speaker, Dr. L. B. Pfeil, F.R.S., made a special plea for the further study of the tree-like or, as they were sometimes termed, steeple-like excrescences on the outside of a wire or other test-piece. These occurred from time to time during investigations on scaling and they were worthy of detailed investigation. When such scaling phenomena occurred he appealed to those concerned to send details of them for inclusion in the *Journal* of the Institution, even if the matter only consisted of one or two paragraphs. The President, Professor A. J. Murphy, who spoke next, said that it certainly seemed that some of these reactions between a vapour phase and a solid one might be given a little more publicity.

Dr. Maurice Cook said that Dr. Richardson had stated that it was generally accepted that, in scale thickening, a migration of copper atoms occurred to the outside of the scale surface. This statement was no doubt generally correct but he (Dr. Cook) had had cases in which pockets filled with oxide had formed on the surface of a copper test-piece. The next speaker, Dr. J. C. Chaston, gave brief details of an experiment in which a platinum plate had been embedded in a quantity of silica and heated. The only change which had taken place had been that some of the rhodium from a platinum-rhodium thermocouple inserted in the base of the reaction vessel had "walked" into the platinum. Dr. C. J. Smithells, who spoke next, said that a point to note from the information given by the author was the extraordinary ductility of some of the oxide films examined. If it were possible to measure the physical properties of these scales it would be possible to learn a great deal on how to get rid of them where necessary.

In a brief reply, Mr. Tylecote said that he could not give any help regarding the tree-like surface structures. He had not had any cases of "steeples" or excrescences on his test-pieces. These had all had smooth surfaces. In answer to Sir Arthur Smout, he had done no work on copper-arsenic alloys other than that on arsenical tough-pitch copper mentioned in the paper. The pick-up of rhodium by the platinum was interesting and he felt that a type of electrolytic cell had been set up in which the silicon oxide behaved as some form of solution.

At this stage of the proceedings the President adjourned the meeting. In the afternoon the works visited included those of the *Alti Forni e Acciaierie d'Italia*, Stabilimento di Marghera; the *Industrie Nazionali Alluminio*; the *Società Alluminio Veneto* par Azioni; the *Società Industriale "San Marco"*; the *Società Italiana del Piombio e dello Zinco*; and the *Società Vetrocoke*. In the evening the 22nd Autumn Lecture on "Electro-Chemistry and the Science of Metals" was delivered in English by Professor Roberto Piontelli, following which a lecture, in French, on "Organisation des Recherches Métallurgiques en Grande Bretagne" was delivered by Dr. C. J. Smithells.

(To be continued.)

THE SUPERIMPOSITION OF PLANE WAVES OF FINITE AMPLITUDE.

By F. J. WALLACE, Ph.D., B.Sc.

THE problem of the superimposition of plane waves of finite amplitude is met with frequently in the analysis of various pulsating gas-flow phenomena, such as flow through reciprocating air compressors and internal-combustion engines. Increasing importance is being attached to the utilisation of wave effects in these types of machines and a considerable amount of work has been published on various aspects of this matter. However, the analysis of the problem of superimposition of wave trains travelling in opposite directions, such as occurs in the exhaust and inlet ducts of reciprocating machinery, presents considerable difficulties and a solution on purely analytical lines has not, so far, been established. Two methods which are widely used at present are that described by Bannister and Mucklow,* and the method of characteristics. The former method is based in part on a treatment in terms of the Lagrangian equations of motion established by Earnshaw† which, however, applies only to single waves. Apart from this important limitation, the method has the advantage of giving analytical solutions for the propagation of individual wave points. The method of characteristics, as discussed by Sauer,‡ de Haller§, and Kestin and Glass,|| is perfectly general, and permits the analysis of the propagation of single waves, superimposition and reflection, but involves the use of somewhat laborious and necessarily inaccurate graphical constructions. It is the object of the present analysis to show the close connection which exists between the two methods and, thereby, to extend the analytical treatment of Bannister and Mucklow to the problem of superimposition. The equations for the particle and propagation velocities of single waves as given by Bannister and Mucklow are a special case of the solution of the general potential equation for one dimensional transient flow. This equation forms the basis of the method of characteristics. It is of the quasi-linear hyperbolic type and has the peculiar mathematical property that solutions can only be found for limited regions. The lines separating such regions, across which the solutions are discontinuous, are termed characteristics.

Having established the fact that the equations of Bannister and Mucklow for the particle and propagation velocities of a wave point of absolute pressure P , namely,

$$u = 5a_0 \left[\left(\frac{P}{P_0} \right)^{\frac{1}{5}} - 1 \right] \quad (1)$$

$$c = a_0 \left[6 \left(\frac{P}{P_0} \right)^{\frac{1}{5}} - 5 \right] \quad (2)$$

where

- u = particle velocity,
- c = propagation velocity,
- a_0 = acoustic velocity in undisturbed air,
- P = absolute pressure of wave point,
- P_0 = absolute pressure of undisturbed air,

are a solution of the general potential equation, a purely algebraic step-by-step method for the solution of the problem of superimposition of waves is outlined. This method has the advantage over the graphical treatment, that any desired degree of accuracy may be attained.

The fundamental equations for one-dimensional unsteady flow are the equation of continuity and the momentum or Eulerian equation. These may respectively be written:

$$\frac{\partial \rho}{\partial t} + u \frac{\partial \rho}{\partial x} = -\rho \frac{\partial u}{\partial x} \quad (3)$$

* "Wave Action Following Sudden Release of Compressed Gas from a Cylinder." *Proc. I. Mech.E.*, vol. 159 (1948).

† *Phil. Trans. Roy. Soc.*, vol. 150, page 133 (1860).

‡ "The Method of Characteristics Applied to One-Dimensional Unsteady Gas Flow." *Ingenieur Archiv*, vol. 13, No. 2 (1942).

§ "Über eine graphische Methode in der Gasdynamik." *Tech. Rundschau*, Sulzer, No. 1 (1945).

|| "Application of the Method of Characteristics to the Transient Flow of Gases." *Proc. I. Mech.E.* vol. 161 (1949).

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} = - \frac{1}{\rho} \frac{\partial P}{\partial x} \quad (4)$$

where

ρ = density,
 t = time,
 x = distance from datum point.

A velocity potential ϕ may be introduced, such that

$$\frac{\partial \phi}{\partial x} = u \quad (5)$$

Moreover, for isentropic flow,

$$\left(\frac{\partial P}{\partial \rho} \right)_s = \text{const.} = a^2 \quad (6)$$

where

s = entropy,
 a = acoustic velocity at absolute pressure P ,

so that equations (3) and (4) may be rewritten:

$$\frac{\partial \rho}{\partial t} + \frac{\partial \phi}{\partial x} \frac{\partial \rho}{\partial x} = - \rho \frac{\partial^2 \phi}{\partial x^2} \quad (7)$$

$$\frac{\partial^2 \phi}{\partial x \partial t} + \frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x^2} = - \frac{a^2}{\rho} \frac{\partial \rho}{\partial x} \quad (8)$$

Equation (8) may be integrated with respect to x and becomes:

$$\frac{\partial \phi}{\partial t} + \frac{1}{2} \left(\frac{\partial \phi}{\partial x} \right)^2 = - \int_{\rho_0}^{\rho} \frac{a^2}{\rho} \frac{\partial \rho}{\partial x} dx = f(\rho) \quad (9)$$

The lower limit under the integration sign, ρ_0 the density of undisturbed air, is introduced as an arbitrary datum.

Since, for isentropic flow,

$$a = a_0 \left(\frac{P}{P_0} \right)^{\frac{\gamma-1}{2\gamma}} = a_0 \left(\frac{\rho}{\rho_0} \right)^{\frac{\gamma-1}{2}}$$

$$f(\rho) = - \frac{1}{\gamma-1} [a^2 - a_0^2] = - \frac{5}{2} [a^2 - a_0^2]$$

where the ratio of the specific heats, γ , for air is taken as 1.4.

Hence, equation (9) becomes:

$$\frac{\partial \phi}{\partial t} + \frac{1}{2} \left(\frac{\partial \phi}{\partial x} \right)^2 = - \frac{5}{2} [a^2 - a_0^2] \quad (10)$$

If $\frac{\partial \rho}{\partial x}$ and $\frac{\partial \phi}{\partial t}$ are evaluated respectively from equations (8) and (9) and substituted in equation (7), the general potential equation results:

$$\frac{\partial^2 \phi}{\partial t^2} + 2 \frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x \partial t} + \frac{\partial^2 \phi}{\partial x^2} \left[\left(\frac{\partial \phi}{\partial x} \right)^2 - a^2 \right] = 0 \quad (11)$$

The solutions of this equation are discontinuous across characteristics, the equations of which must themselves satisfy equation (11).

Although equation (11) is of the quasi-linear type, with x and t as the independent variables and ϕ as the dependent variable, the coefficients of $\frac{\partial^2 \phi}{\partial x \partial t}$ and $\frac{\partial^2 \phi}{\partial x^2}$ themselves being derivatives of ϕ , it is possible to linearise the equation completely by the use of the Legendre transformation.

Thus, if

$$\psi = x \frac{\partial \phi}{\partial x} + t \frac{\partial \phi}{\partial t} - \phi,$$

$$\frac{\partial^2 \phi}{\partial x^2} : \frac{\partial^2 \phi}{\partial x \partial t} : \frac{\partial^2 \phi}{\partial t^2} = \frac{\partial^2 \psi}{\partial q^2} : \frac{\partial^2 \psi}{\partial q \partial u} : \frac{\partial^2 \psi}{\partial u^2} = - \frac{\partial^2 \psi}{\partial u \partial q}$$

and equation (11) becomes

$$\frac{\partial^2 \psi}{\partial q^2} [a^2 - u^2] + 2u \frac{\partial^2 \psi}{\partial u \partial q} - \frac{\partial^2 \psi}{\partial u^2} = 0 \quad (12)$$

where $u = \frac{\partial \phi}{\partial x}$ and $q = \frac{\partial \phi}{\partial t}$.

The solutions of this completely linear equation (12), i.e., the characteristics in the u - q plane, may be treated according to the principle of superposition, i.e., different solutions for a particular time and place may be added algebraically. Thus,

$$u = u_1 + u_2 + \dots \quad (13)$$

This equation may be compared with the similar expression of Bannister and Mucklow, equation (10), *loc. cit.*

The solutions of the original quasi-linear equation (11), i.e., the characteristics in the x - t plane, do not obey the principle of superposition. Since the characteristics in the x - t and u - q planes represent the same physical process, it is clear that to each x - t characteristic there is a corresponding u - q characteristic. It can now be shown that equations (1) and (2) are two such characteristics.

Since isentropic flow only, is considered,

$$a = a_0 \left(\frac{P}{P_0} \right)^{\frac{1}{2}}$$

so that equations (1) and (2) become, respectively,

$$u = (5a - 5a_0) = \frac{\partial \phi}{\partial x} \quad (14)$$

from equation (5), and

$$c = (6a - 5a_0) = \frac{dx}{dt} \quad (15)$$

From equation (10),

$$\frac{\partial \phi}{\partial t} = - \frac{5}{2} a^2 - \frac{1}{2} \left(\frac{\partial \phi}{\partial x} \right)^2 + \frac{5}{2} a_0^2,$$

so that

$$\frac{\partial^2 \phi}{\partial t^2} = - 5a \frac{\partial a}{\partial t} - \left(\frac{\partial \phi}{\partial x} \right) \left(\frac{\partial^2 \phi}{\partial x \partial t} \right) \quad (16)$$

On substituting for $\frac{\partial^2 \phi}{\partial t^2}$, equation (11) becomes

$$\frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x \partial t} - 5a \frac{\partial a}{\partial t} + \frac{\partial^2 \phi}{\partial x^2} \left[\left(\frac{\partial \phi}{\partial x} \right)^2 - a^2 \right] = 0 \quad (17)$$

and since, from equation (10),

$$\begin{aligned} \frac{\partial^2 \phi}{\partial x \partial t} &= \frac{\partial}{\partial x} \left[- \frac{5}{2} a^2 - \frac{1}{2} \left(\frac{\partial \phi}{\partial x} \right)^2 + \frac{5}{2} a_0^2 \right] \\ &= - 5a \frac{\partial a}{\partial x} - \frac{\partial^2 \phi}{\partial x^2} \frac{\partial \phi}{\partial x} \end{aligned} \quad (18)$$

Fig. 1.

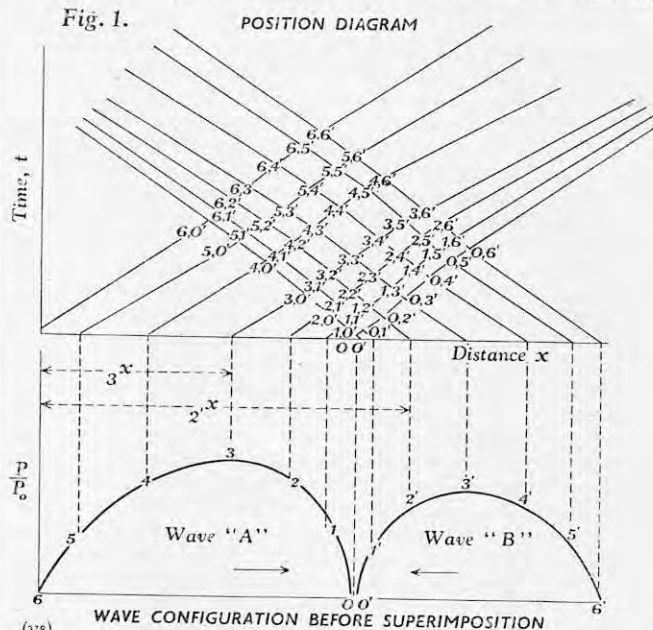
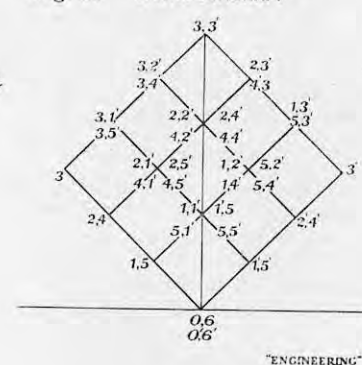


Fig. 2. STATE DIAGRAM



equation (17) may be rewritten

$$\frac{\partial \phi}{\partial x} \left[- 5a \frac{\partial a}{\partial x} - \frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x^2} \right] - 5a \frac{\partial a}{\partial t} + \frac{\partial^2 \phi}{\partial x^2} \left[\left(\frac{\partial \phi}{\partial x} \right)^2 - a^2 \right] = 0$$

or

$$5 \frac{\partial \phi}{\partial x} \frac{\partial a}{\partial x} + 5 \frac{\partial a}{\partial t} + a \frac{\partial^2 \phi}{\partial x^2} = 0 \quad (19)$$

But, from equation (14), $a = a_0 + \frac{1}{5} \frac{\partial \phi}{\partial x}$; hence,

$$\frac{\partial a}{\partial x} = \frac{1}{5} \frac{\partial^2 \phi}{\partial x^2},$$

and

$$\begin{aligned} \frac{\partial a}{\partial t} &= \frac{1}{5} \frac{\partial^2 \phi}{\partial x \partial t} \\ &= - a \frac{\partial a}{\partial x} - \frac{1}{5} \frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x^2}, \text{ by (18)} \\ &= - \frac{1}{5} a \frac{\partial^2 \phi}{\partial x^2} - \frac{1}{5} \frac{\partial \phi}{\partial x} \frac{\partial^2 \phi}{\partial x^2}. \end{aligned}$$

When these values of $\frac{\partial a}{\partial x}$ and $\frac{\partial a}{\partial t}$ are substituted in equation (19), the equation is satisfied identically, so that equation (14) and, hence, equation (1) may be regarded as a solution of the potential equation (11).

This solution constitutes a characteristic in the u - a plane and not in the u - q plane previously referred to in connection with the linearised potential equation (12). The connection between these two characteristics is, however, a very simple one, and may be obtained from equation (10). It is

$$\frac{\partial \phi}{\partial t} = q = - \frac{5}{2} a^2 - \frac{1}{2} u^2 + \frac{5}{2} a_0^2,$$

and since, by equation (14), $a = \frac{1}{5} u + a_0$

$$q = - \frac{3}{2} u^2 - u a_0 \quad (20)$$

which is the equation of a parabola. Sauer (*loc. cit.*) uses u - q , or parabolic, characteristics; most other workers use u - a , or straight-line, characteristics.

Equation (15) and hence equation (2) for the propagation velocity $\frac{dx}{dt}$, which may be regarded as the characteristic in the x - t plane, follow from the fact that the propagation velocity is the sum of the local acoustic and particle velocities:

$$\begin{aligned} c &= \frac{dx}{dt} = u + a \\ &= 6a - 5a_0, \text{ by equation (14)} \end{aligned}$$

Having proved that equations (1) and (2) are characteristic solutions in the u - a plane and in the x - t plane, respectively, the following method may be used for the analysis of the superimposition of two waves, A and B, moving in opposite directions. Referring to Fig. 1, on this page, let the wave A be given by 0, 1, 2, 3, 4, etc., and B by 0', 1', 2', 3', etc. Prefixes refer to the point of which the movement is being examined, and suffixes to the point upon which the former wave is superimposed at any given instant.

Equation (14) for wave A before superimposition on wave B, i.e., $u = 5a - 5a_0$, is represented by

the bottom line on the right-hand side of the state diagram, Fig. 2, while the corresponding equation for wave B before superimposition, i.e., $u = -5a + 5a_0$, is represented by the corresponding line on the opposite side of the a -axis, the two lines intersecting at the point $u = 0$, $a = a_0$. Taking any point such as 1, 2, 3, etc., on wave A, it is clear that its particle and acoustic velocities can change only as the result of superimposition on wave B; that is, if wave A continues to travel undisturbed, each wave point retains its particle and acoustic velocities indefinitely. If a wave point n on wave A is superimposed on a point n' on wave B, then, by equation (14), the particle velocity before superimposition is

$$nu = 5(na - a_0) \quad (21)$$

and the particle velocity after superimposition on n' is, by equation (13),

$$n u_{n'} = 5(na - a_0) - 5(n'a - a_0) = 5(na - n'a) \quad (22)$$

The acoustic velocity after superimposition obeys the relationship*

$$\left(\frac{n P_{n'}}{P_0} \right)^{\frac{1}{2}} = \left(\frac{n P}{P_0} \right)^{\frac{1}{2}} + \left(\frac{n' P}{P_0} \right)^{\frac{1}{2}} - 1 \quad (23)$$

or

$$n a_{n'} = na + n'a - a_0 \quad (24)$$

Subtracting equation (21) from equation (22), and substituting from equation (24), gives

$$n u_{n'} - nu = 5(na - n'a - na + a_0) = 5(na - n a_{n'})$$

or

$$\Delta n u = - 5 \Delta n a \quad (25)$$

Hence, changes in the acoustic and particle

* Bannister and Mucklow, *loc. cit.*

PRODUCTION OF GLASS TUBING.

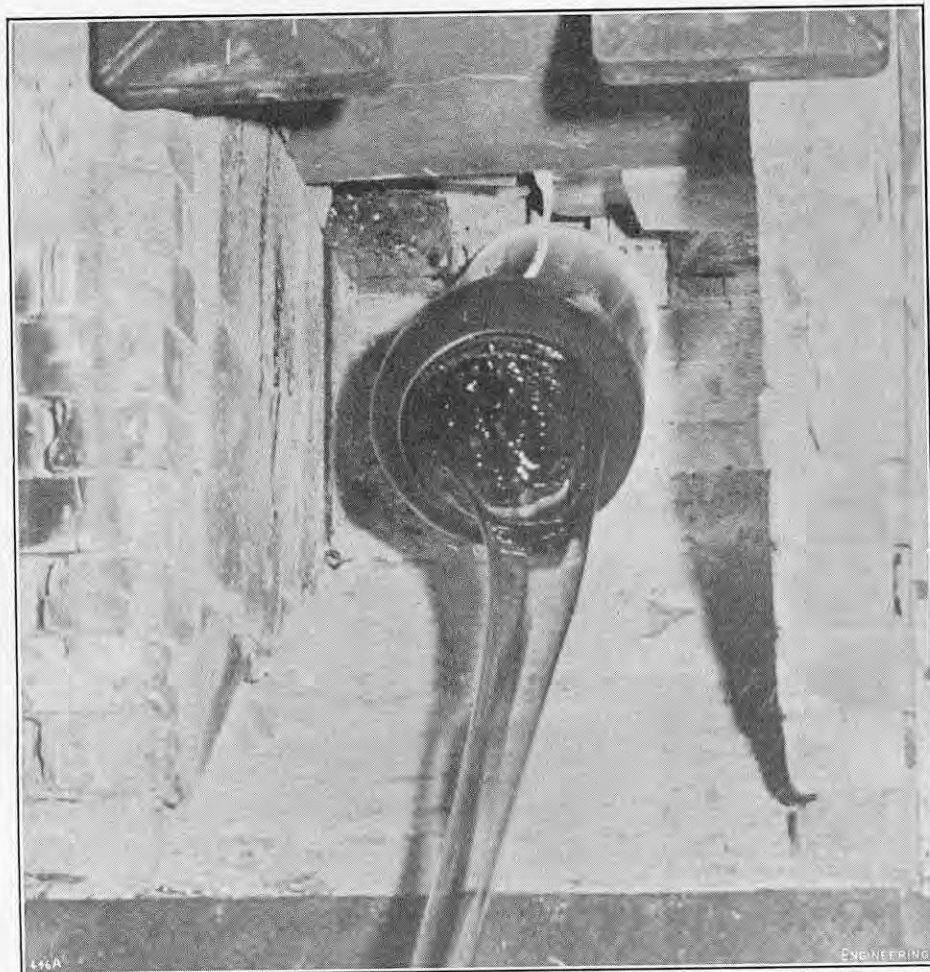


FIG. 1. GLASS TUBE LEAVING MANDREL IN THE DANNER PROCESS.

velocities of any point on the rightward moving wave A, take place in the state diagram along a line defined by equation (25), which may again be regarded as a characteristic. Similarly, changes in the acoustic and particle velocities of any point on wave B take place along characteristics of opposite, that is positive, slope. These characteristics are shown in the state diagram, Fig. 2, the values of u and a after superimposition being represented by the points of intersection of the appropriate characteristics. In the figure every point of intersection, with the exception of the peripheral points, applies to four possible cases.

The velocity of propagation of any wave point, n , after superimposition on a wave point, n' , is given by

$$\begin{aligned} n \left(\frac{dx}{dt} \right)_{n'} &= n u_{n'} + n a_n \\ &= 5 (n a - n' a) + n a + n' a - a_0 \\ &= (6 n a - 4 n' a - a_0), \quad (26) \end{aligned}$$

from equations (22) and (24), and the propagation velocity of the wave point n' in the opposite direction at the same instant is

$$n' \left(\frac{dx}{dt} \right)_n = (6 n' a - 4 n a - a_0). \quad (26a)$$

The above position equations represent a particular pair of characteristics in the x - t or position diagram, and are associated with the characteristics $\frac{\Delta u}{\Delta a} = -5$ and $\frac{\Delta u}{\Delta a} = +5$, respectively, (see equation 25) in the u - a or state plane. With the aid of the above equations the problem of superimposition may now be analysed algebraically as follows.

The heads of waves A and B, in Fig. 1, meet at distance $0x$ from the origin at the instant $t = 0$. Point 0 is then propagated to the right with velocity a_0 , and, upon superimposition on point 1', its velocity of propagation, according to equation (26), changes to $\left(\frac{dx}{dt} \right)_{1'} = 5 a_0 - 4 a_1$, so that the mean velocity of

propagation in the interval $t = 0$ to $t = 0t_1$ may be taken as $3a_0 - 2a_1$. For the wavepoint 1', on wave B, the velocity of propagation remains unchanged in the same interval. Hence, if $1'x$ be the distance of 1' from the origin at $t = 0$, and $0t_1$ be the instant of superimposition of 0 on 1', $\{ (3a_0 - 2a_1) + (6a_1 - 5a_0) \} 0t_1 = (1'x - 0x)$, (27) the distance from the origin at this instant being denoted by $0x_1$.

Similarly, for superimposition of 0 on 2', if $2'x$ be the distance of 2' from the origin at $t = 0$, and $0t_2$ be the instant of superimposition of 0 on 2', $\{ (3a_0 - 2a_1 - 2a_2) + (6a_2 - 5a_0) \} 0t_2 = (2'x - 0x_1)$, (28)

the distance from the origin at the instant of superimposition being $0x_2$. The movement of point 0 across points 3', 4', 5' and 6' is evaluated in a similar manner.

A similar procedure is adopted for analysing the propagation of wave point 1 across the entire wave B, and, thereafter, of points 2, 3, 4, 5 and 6, until the network in the position diagram has been completed. Equations (27) and (28) may be generalised to apply to any point n on the wave A superimposed on a point n' on wave B:

$$\begin{aligned} &[6na - 2n'a - 2n_{-1}a - a_0][n't_n - n't_{n-1}] \\ &+ [6n'a - 2na - 2n_{-1}a - a_0][n't_n - n't_{n-1}] \\ &= n_{-1}x_n - nx_{n-1}, \quad (29) \end{aligned}$$

Any desired degree of accuracy may be attained by making the steps sufficiently small.

The significance of q in the linearised potential equation (12) may be seen from the following.

The total heat, H , of a gas at absolute temperature T and moving with velocity u may be defined as $H = C_p T + \frac{1}{2} u^2$, per unit mass, where C_p is the specific heat at constant pressure.

Since $\frac{\gamma - 1}{\gamma} C_p = R$, the gas constant,

$$\begin{aligned} H &= \frac{1.4}{0.4} R T + \frac{1}{2} u^2 \\ &= \frac{5}{2} a^2 + \frac{1}{2} u^2, \end{aligned}$$

because

$$\gamma R T = a^2.$$

But, from equation (14), $u = 5a - 5a_0$; hence

$$H = \frac{5}{2} u^2 + u a_0 + \frac{5}{2} a_0^2. \quad (30)$$

Comparing this with equation (20), namely,

$$q = -\frac{3}{2} u^2 - u a_0,$$

we obtain,

$$q = -H - \frac{5}{2} a_0^2. \quad (31)$$

Hence, a close connection exists between the state diagram, in u - q co-ordinates* and the total-heat/entropy diagram, a fact which makes the use of the parabolic state diagram of Sauer particularly appropriate in the calculation of processes involving large changes of entropy.

MEASURING THE VARIATION IN DIAMETER OF MACHINE-DRAWN GLASS TUBING.

By D. ANTRICH, B.Sc.(Eng.), A.M.I.E.E.,
and D. G. OSBORNE, B.Sc.(Eng. Met.)

Most of the glass-tubing produced in this country is manufactured by the Danner process of tube-drawing. In this process molten glass flows from an oil-fired furnace along a refractory trough, from which it then falls as a ribbon on to a rotating refractory sleeve. This sleeve is supported on a Nichrome mandrel and is inclined at approximately 18 deg. to the horizontal. The glass forms an outer sleeve, gradually flowing towards the nose of the mandrel, where it falls in the form of a catenary and is then drawn off horizontally over rollers by the drawing machine situated some 100 ft. to 150 ft. away. The bore of the tubing is maintained by blowing compressed air down the centre of the mandrel. A gas-fired muffle surrounds the mandrel and serves to keep the temperature of the refractory sleeve as uniform as possible. The process is a continuous one, operating over many weeks. Fig. 1, herewith, which is reproduced from a photograph taken in the Osram-G.E.C. Glass Works, shows the glass leaving the mandrel, and Fig. 4, on page 426, is a diagram of the process.

For the glass tubing used in surgical and physical instruments, chemical apparatus, fluorescent lamps and certain other applications, it is necessary to draw the tubing to close dimensional tolerances. As a first step towards ensuring that the required accuracy in tube-drawing was achieved, a programme of experimental work was commenced at the Osram-G.E.C. Glass Works, to determine the extent of any variations in the diameters of the tubing drawn there. Measurements on the diameter were made by hand with a micrometer. It was decided, however, that an accurate assessment of the variations in the tubing diameter could be obtained by making three measurements every ten minutes; the results obtained were then considered to be representative of the variations experienced in manufacture. This and other preliminary investigations indicated the existence of a tendency for the diameter variations to be cyclic in character.

To obtain more detailed information over extended periods, and to avoid the necessity for continuous attendance at the tube machine, an instrument was developed by the authors at the Research Laboratories of the General Electric Company, Limited, at Wembley, Middlesex, that would record continuously the diameter of the tubing as it was drawn.

The instrument had to comply with the following requirements, namely, to measure the changes in any diameter in the range 15 mm. to 40 mm., to measure changes of 0.1 mm. over a range of ± 2 mm., to record such changes continuously and allow for sudden increases in diameter outside the normal working range, to follow the tubing during its passage over the rollers, and to accommodate breaks, which occur occasionally during the process of manufacture.

The external appearance of the apparatus developed is shown in Fig. 2, on page 426, and the complete installation in Fig. 3. Fig. 5, on page 426,

* Sauer, *loc. cit.*

MEASURING VARIATIONS IN DIAMETER OF GLASS TUBING.

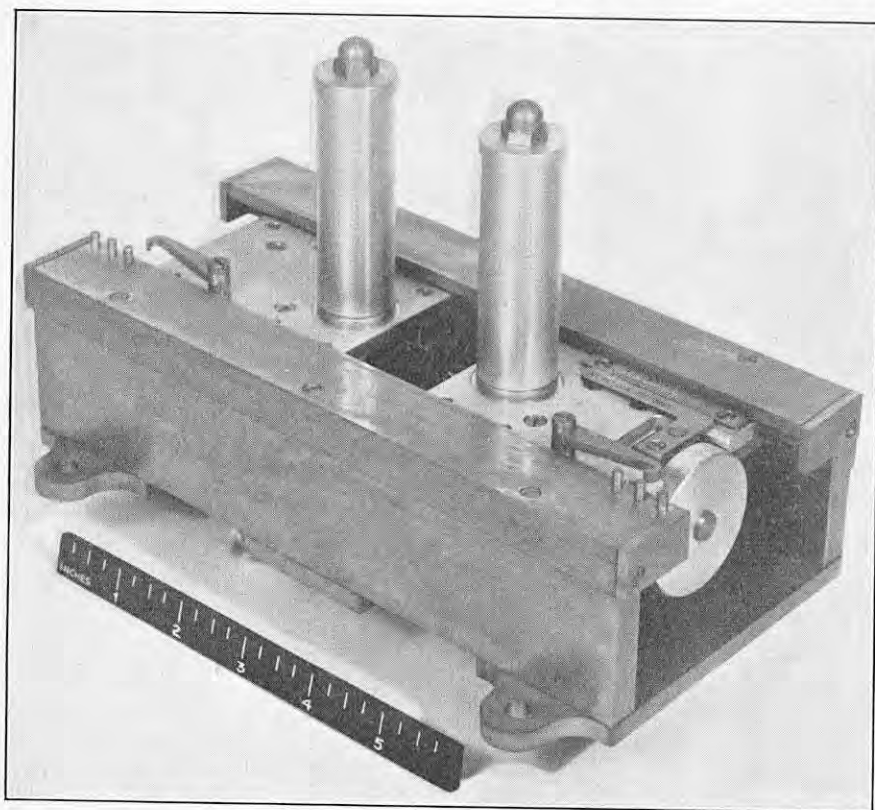


FIG. 2. INSTRUMENT FOR MEASURING VARIATIONS IN DIAMETER.

is a diagram giving the principle of operation. It can be seen that the glass tubing is made to pass between two anodised aluminium rollers, each roller being mounted on a movable plate. Two detector coils are attached to one plate and an armature to the other, the armature being arranged so as to move between the coils when the two rollers move relatively to each other. The movable plates are spring-loaded together, so that the rollers are always in intimate contact with the glass tubing. Any variation in the tubing diameter gives rise to a relative movement between the roller plates, and hence between the armature and the detector coils. Provision is made for altering the relative position of the armature with respect to the plate on which it is mounted by means of an adjusting knob, so that different sizes of tubing can be handled. The nominal diameter of the tubing to be measured is indicated on a scale plate, and a pointer may be moved to any desired position on the scale by rotating the knob. Each position of the pointer then gives the nominal diameter of the tubing in terms of the mean distance between the rollers.

The diameter of the tubing between the rollers may suddenly increase sufficiently to cause the armature to come in contact with the inner detector coil. If this occurs, any further movement of the armature in this direction causes springs on the guide rods holding the armature to be compressed, so that possible damage to the tubing is avoided. If the tubing should move sideways while passing between the rollers, the whole arrangement, including the rollers and the movable plates on which they are mounted, will move in the same direction as the tubing. This ensures that no spurious indications of variations in diameter are obtained. Any vertical movement of the tubing is also accommodated, in this case by the height of the rollers themselves. Finally, should a break occur in the tubing, the rollers may be moved sideways and held away from the glass by catches passed over pins in the main frame.

The detector coils are two laminated cores of similar shape, round which the magnetising windings are wound. These detector coils form two arms of the bridge network shown in Fig. 6, opposite, two unequal resistances forming the other two arms. The bridge is fed from the output of a constant-voltage transformer, the primary of which is connected to the mains supply. The circuit

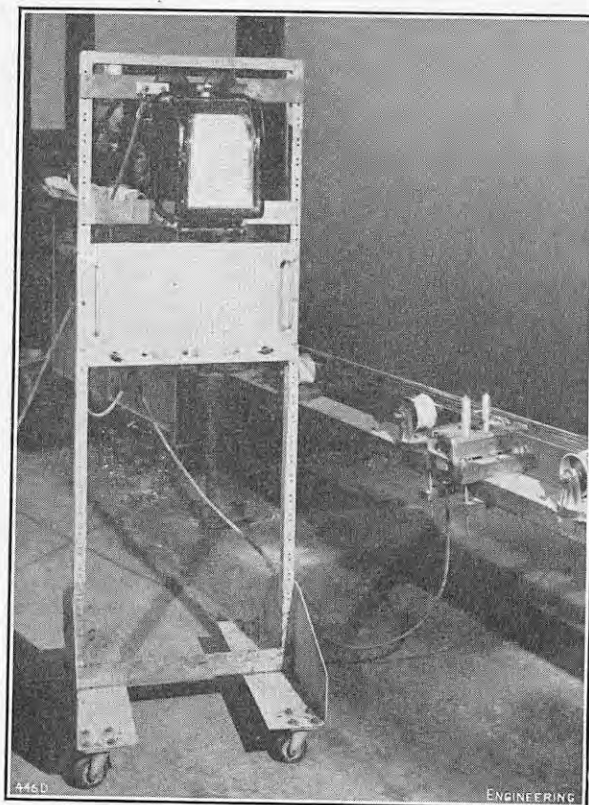


FIG. 3. INSTRUMENT AND RECORDING APPARATUS IN USE.

Fig. 4.

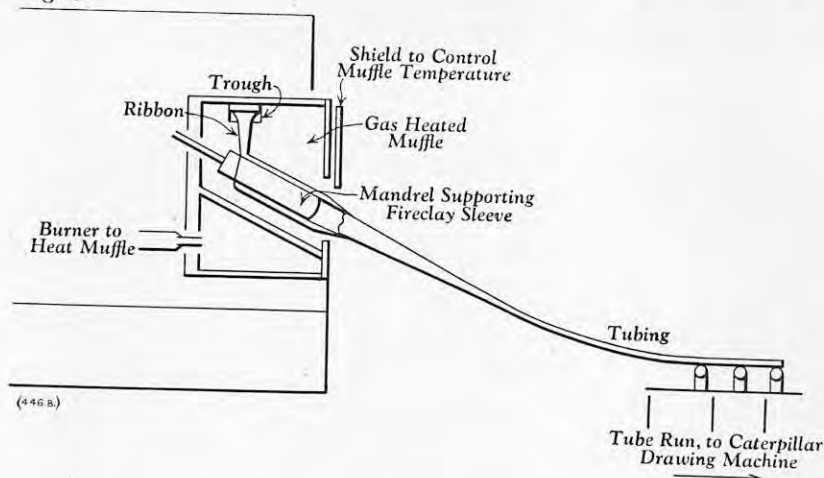
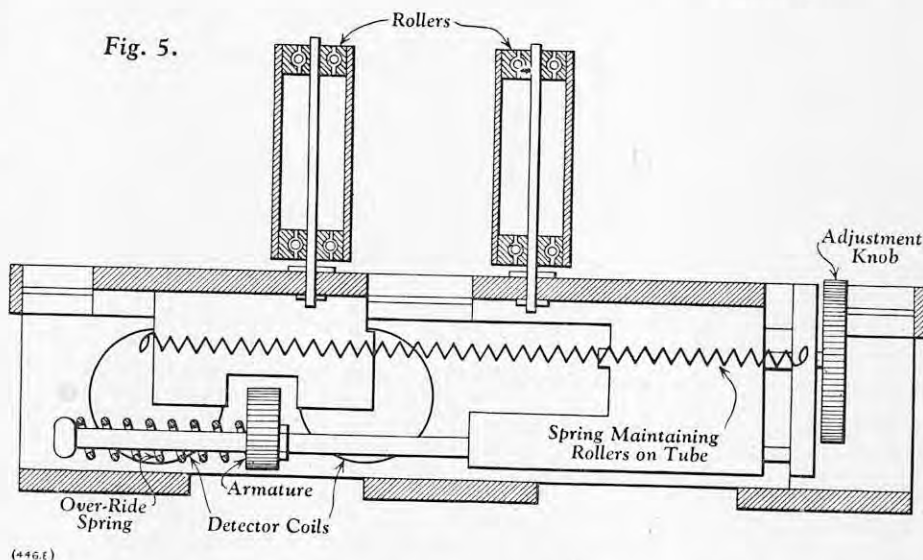


Fig. 5.



out-of-balance signal is full-wave rectified and the direct-current signal is fed into a magnetic amplifier. The amplifier signal then operates a recording instrument.

The bridge is so arranged that it is unbalanced when tubing of the nominal width is passing between the rollers, and the recording instrument then indicates centre zero on the scale. Any relative move-

MEASURING VARIATIONS IN GLASS TUBING.

Fig. 6.

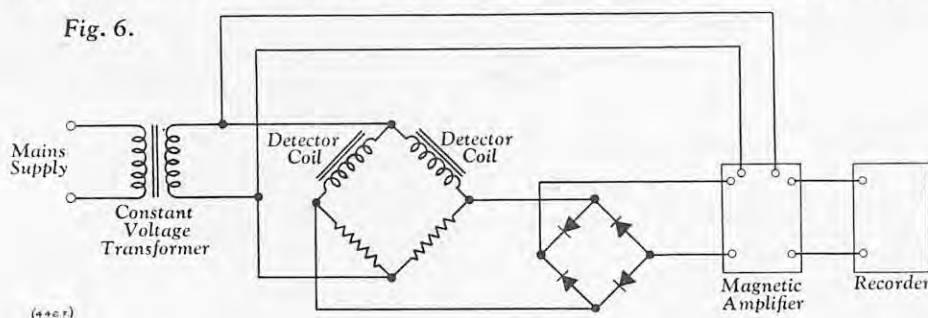


Fig. 7.

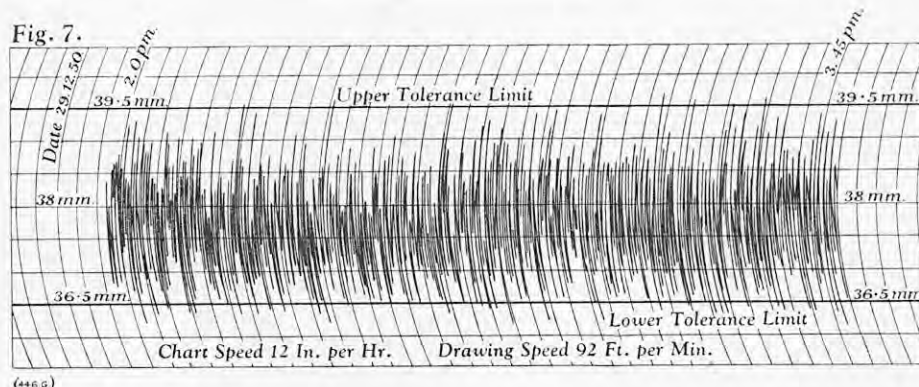


Fig. 8.

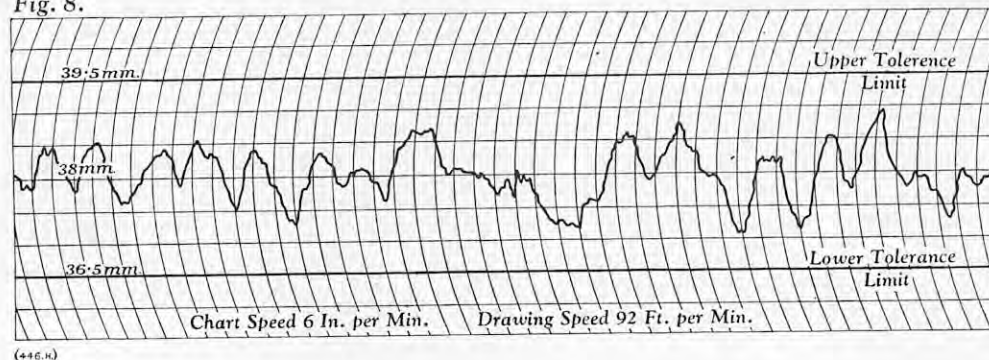
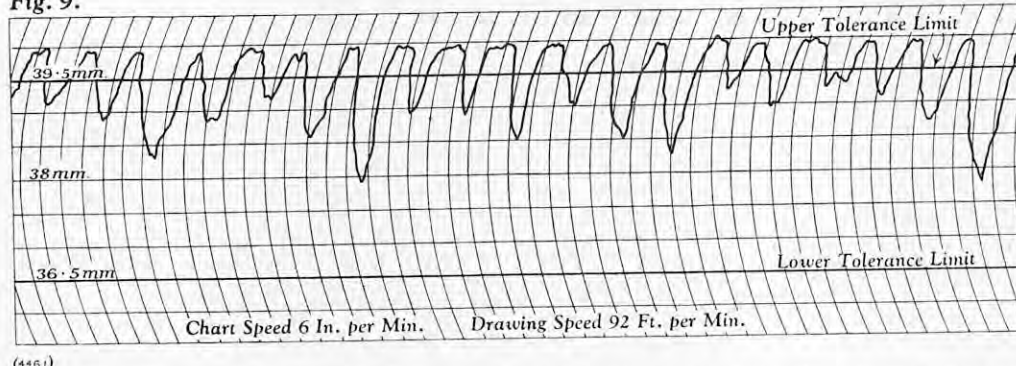


Fig. 9.



ment of the armature with respect to the detector coils, caused by changes in the tubing diameter, will then cause the out-of-balance voltage to vary. The output of the amplifier thus increases or decreases as the tubing diameter increases or decreases with respect to its nominal value.

The instrument was calibrated by means of a stepped brass shaft, accurately machined in steps of 0.2 mm. A calibration graph was obtained by plotting the various known diameters of the shaft against the corresponding recorder readings given when each diameter was placed between the rollers.

The recording instrument is capable of being operated at many different chart speeds, and care is taken to choose the optimum chart speed for each particular experiment. For example, a high chart speed is necessary if the proportion of outside tubing to total length of tubing drawn is to be calculated from the record on the chart. It is clear that the chart speed also affects the duration of the test that can be carried out. A more general picture of the variations in tubing diameter can be obtained

with a slower chart speed, but small variations cannot easily be distinguished by this means.

Fig. 7, herewith, shows the type of results obtained with a chart speed of 12 in. per hour. Tubing with a diameter of 38 mm. was required. For experimental purposes, the diameter tolerance shown on the chart is $\pm 1\frac{1}{2}$ mm., though tubing of this size is gauged with limits of ± 1 mm. during normal manufacture. The diameter of the tubing is usually within the tolerance limits, but variation within these limits is large. It can be seen that the small variations are not easily distinguishable and that measurements of total outsizes would be inaccurate. Figs. 8 and 9, herewith, show the types of result obtained with a chart speed of 6 in. per minute. In this case, all diameter variations are clearly distinguishable. Fig. 8 was obtained during a period in which all the tubing was within the tolerance limits, and, in Fig. 9, large quantities of the tubing are seen to be oversize.

As has been stated, the results obtained from the preliminary experimental work had suggested that the diameter variations which occur might be cyclic.

This expectation was fully confirmed by the pictorial records obtained with the continuous recording instrument. The number of peaks in the chart obtained during any one period of time appears to be constant. For the particular furnace and tube-drawing mechanism used, the number of peaks is nine to ten for every 6 in. of chart.

It is known that a number of factors may affect the size of the tubing drawn by the Danner process, the most important variables being the temperature of the glass on the mandrel; the viscosity of the glass, which is dependent both on its composition and the temperature; the speed of the drawing machine; the air pressure down the mandrel; speed of rotation of the mandrel; and the size of the mandrel.

It is not yet clear which of the variables listed above is mainly responsible for the cyclic nature of the irregularities in the tubing diameter. Attention must necessarily be directed towards any factors that are themselves periodic in character. It is likely, therefore, that the mechanical factors, such as the speed of rotation of the mandrel and possibly the air pressure down the centre of the mandrel, are those that require further investigation. The primary function of the instrument, therefore, and the one for which it is at present being used, is purely for experimental purposes, to correlate the variations in tubing diameter with variations in other relevant factors in the process. There is no doubt that the results obtained by using the continuous recorder, when interpreted, will help to establish the exact nature of any irregularity in the furnace or tube-drawing mechanism used. As a further project, certain changes in the design of the instrument could make it suitable for use as a permanent installation in the production process. The continuous recorder would then be used to indicate general trends in the variation or otherwise in tubing diameter, and so assist the operators engaged in the production of the glass tubing. A refinement that could be introduced is the placing of a number of instruments at various angular positions along the length of the tubing. The measurements made with one pair of rollers serve to indicate variations in the horizontal diameter of the tubing only; by adding further pairs of rollers, any variations in the ovality that might occur could also be recorded continuously.

LECTURES ON CHEMISTRY OF WATER TREATMENT.

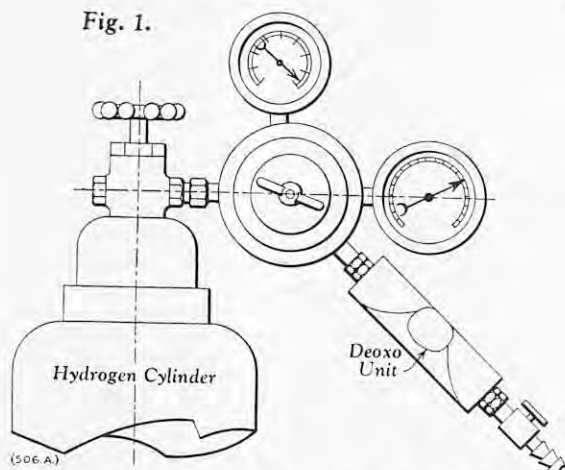
In October, 1950, a one-year post-graduate course in public-health engineering was instituted in the Department of Civil Engineering, University of Durham, King's College, Newcastle-upon-Tyne, 1. The course was designed for graduates in civil engineering who wish to enter the branches of the profession concerned with water supply and treatment, sewage treatment, district heating, and other subjects. The course leads to the College certificate in public-health engineering. In connection with the course for 1951, a series of 20 weekly lectures on the "Chemistry of Water Treatment," by Dr. A. T. Palin, have been arranged and are open to anyone interested. The subjects to be dealt with by Dr. Palin will include the chemical and physical examination of water, pollution and self-purification of surface waters, the control of algae, coagulants and coagulation, filtration, modern chlorination processes, chlorine-dioxide treatment, dechlorination, ozonation, the control of tastes and odours, corrosion control and plumbosolvency, water softening, demineralisation, the removal of iron and manganese, iodisation and fluoridation, boiler feed-water treatment, and the treatment of swimming-pool water. The 20 lectures will be delivered on Monday mornings from 10 to 11 a.m., in the civil-engineering lecture theatre of King's College, Newcastle. They will commence on November 5 and will continue until December 10, and will recommence on January 14, 1952, and go on until March 17. The final term will extend from April 28 until May 19. The fee for the course is 11. 1s.

ENGINEER BUYERS AND REPRESENTATIVES ASSOCIATION.—The membership of the Engineer Buyers and Representatives Association, 47, Victoria-street, London, S.W.1, is now about 470. In a note on page 267, *ante*, we referred to the first edition of the Association's guide and list of members, and stated that the membership was about 300, but we are informed by the Association that this figure is now misleading; the numbers have increased considerably since the publication went to press some months ago.

"DEOXO" CATALYTIC GAS PURIFIER.

BAKER PLATINUM, LIMITED, LONDON.

Fig. 1.



THE "DEOXO" METHOD OF GAS PURIFICATION.

A SIMPLE and convenient method of removing the relatively small quantities of oxygen or hydrogen which are usually present as contaminants in commercial gases has been developed in the United States by Baker and Company, Inc., of Newark, N.J., and we understand is extensively employed in that country. The equipment has been made available in Great Britain recently by Baker Platinum, Limited, 52, High Holborn, London, W.C.1.

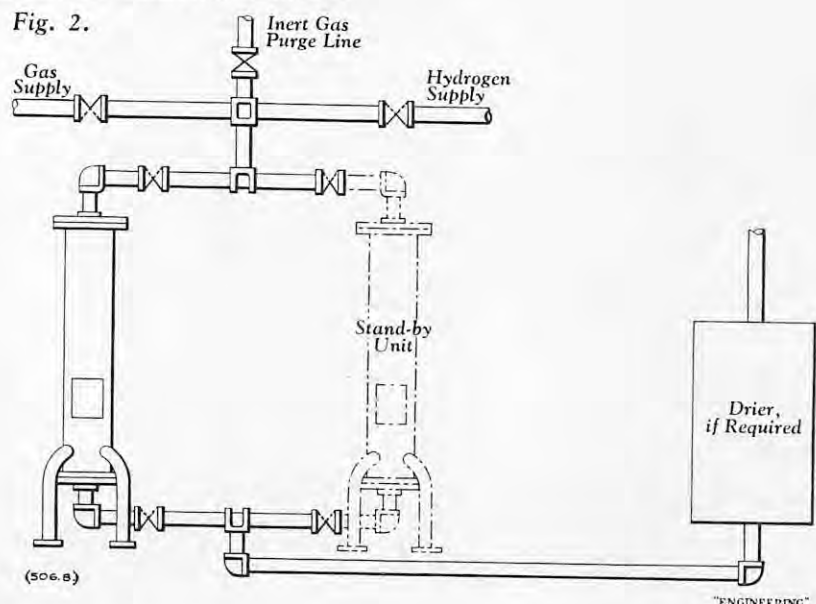
Many chemical and metallurgical processes require gases which are practically free from oxygen, as small quantities of this gas present may cause difficulties. Several methods of removing the unwanted oxygen are available, but the Deoxo process, as it is called, is claimed by the makers to have several important advantages over other methods of gas purification, and to give a product containing less than one part in a million of impurity. The process depends upon the combination of oxygen and hydrogen in the presence of a catalyst, the catalyst being one of the platinum group of metals deposited on a suitable support.

Five standard sizes of equipment are available with capacities ranging from 5 to 5,000 cub. ft. per hour, the maximum working pressure being 50 lb. per square inch in each case; but larger sizes can be supplied if required. Fig. 1 shows the arrangement of the smallest size, which is made up in cartridge form and is connected to a hydrogen cylinder through a reducing valve. The oxygen and hydrogen, of course, combine in the ratio of 1:2 by volume, to form water vapour and, if necessary, this can be removed by any convenient form of dehydrator. As the reaction is exothermic heat is generated and the temperature rise, it is stated, amounts to about 10 deg. C. for each 0.1 per cent. of oxygen removed. This reaction commences at room temperature, and therefore no auxiliary heating is required; water cooling is not necessary.

It will be obvious that oxygen can be removed completely only if there is sufficient hydrogen present for the reaction, so that if oxygen is to be removed from nitrogen, argon or other inert gases it is necessary to add hydrogen in the correct proportion. Fig. 2 is a diagram showing the general arrangement of a larger plant which is typical of all models having capacities greater than 200 cub. ft. per hour. It will be noticed that a stand-by unit is provided in parallel with the working unit if continuous operation is essential and that hydrogen can be added to the gas entering the plant if necessary. The drier shown is only fitted if the water vapour resulting from the combination of the oxygen and hydrogen must be removed. It is necessary to purge all models of the purifier with an inert gas before introducing hydrogen. In the case of the 5-cub. ft. per hour model, illustrated in Fig. 1, this is not necessary, provided the purifier is connected directly to the hydrogen cylinder.

We understand that work is now proceeding on the development of units to provide for the catalytic combination of oxygen and hydrogen in the presence of carbon monoxide, of oxygen and carbon monoxide to form carbon dioxide in gases that do not contain hydrogen, of carbon monoxide plus hydrogen to form carbon dioxide and water, provided sufficient oxygen is introduced to complete the reaction, and of carbon monoxide and hydrogen to form methane and water vapour. Baker Platinum, Limited, expect to be in a position to report on these new developments in the near future.

Fig. 2.



RESEARCH IN TELECOMMUNICATION.

THE first "open day" for three years was held at the Dollis Hill Research Station of the Post Office on Thursday, September 27, to give visitors an opportunity of seeing what is being done to improve the efficiency of the country's telecommunication services. The exhibits and demonstrations were selected to provide a general idea of the work now in progress, and included illustrations that were concerned with local telephone-cable distribution schemes, subscribers' telephones and the measurement of transmission. Electro-acoustics, hearing aids, telephone exchanges, switching and signalling, amplifiers and equalisers for long-distance land and sea cables, and telegraphic and radio transmission and reception were other matters which were demonstrated, while the application of piezo-electric crystals to frequency control and selection, the properties of thermionic valves and electronic circuitry were also illustrated.

Although outside the field of telecommunications mention may first be made of an automatic facing table, the object of which is to prepare mail for introduction to the stamp-cancelling machines. This preparation, which is at present effected manually, consists in arranging the letters so that their stamps all face one way in the same corner of the stack. The small letters are first separated from the large ones and the packets, and are then carried along conveyor belts resting on their longer edges. The back and front of the lower edge of each letter is next searched by a light beam and those with stamps near the edge actuate a photo-electric cell, so that they are inverted and can be re-examined, while letters with stamps in the right-hand top corner—the normal position—are passed on. Letters from both searches are finally automatically collected, cancelled and stacked ready for transport to the sorters. A second machine, which is in a less advanced stage, is designed to sort letters according to the colour of the stamps.

An important development which was on view is the deep-water submerged repeater designed for use on the 700-mile submarine coastal telephone cable between Newfoundland and Nova Scotia. This cable, which it is expected will be laid next year and will provide one high-quality telephone circuit and several teleprinter circuits, will follow the ocean bed at a depth of about 1½ miles and will contain five repeaters. Each of these repeaters will be housed in a steel cylinder about 5 ft. long and rather less than 1 ft. in diameter. These cylinders will contain all the apparatus necessary for operating the repeaters, direct-current power for the purpose being transmitted at 2,000 volts from the terminals over the communication circuit. The thermionic valves incorporated in the repeater are expected to have a life of at least ten years.

In the past, quartz was practically the only material that could be used for the production of the piezo electric crystals employed in certain kinds of telephone circuits. A method has now, however, been devised whereby such crystals can be grown by slowly cooling saturated solutions. For this purpose, seed crystals, which have been grown previously or cut from larger ones are mounted on arms radiating from

a spindle and are warmed up to a given temperature. A solution, containing as much dissolved salt as it can hold at that temperature, is then poured round them and is stirred by rotating the spindle. The direction of rotation is periodically reversed so that the growing faces of the crystals are in contact with fresh portions of solution. The temperature of the solution is accurately controlled and is automatically reduced by about 0.2 deg. a day. Crystals ranging from ½ lb. to 1 lb. can be obtained in this way in from 8 to 10 weeks.

To provide the thin slices of quartz required for piezo-electric purposes the quartz crystal was usually cut with saws loaded with diamond or carborundum powder. Although this method can also be employed on synthetic crystals, it has certain disadvantages. An alternative method, which was demonstrated, is to use a wet "string" of some suitable material, such as stranded steel wire. This string, which is stretched round three vertical rollers and driven by a motor, is moved continuously over the crystal along the line of the required cut and is washed in a stream of water at some point in its circuit. Under the right conditions, some of the water adheres to the wire by surface tension, so that when it reaches the crystal a minute amount of the latter is dissolved and carried away in solution. As the action consists entirely of dissolving, the pressure between the string and the crystal can be negligible and a very neat cut results.

To control precisely the frequencies of radio transmitters and long-distance coaxial cable systems as well as transmission of photographs by wire and of radar, stable quartz crystal-controlled oscillators and synchronous clocks, which can be compared with observatory time, are employed. Such clocks are accurate to about one millisecond a day and to make their readings generally available a daily service of standard frequency transmission is transmitted from Rugby radio station. These transmissions are accurate to one part in fifty million and are checked by the frequency standard at Dollis Hill with results which were demonstrated.

HELICOPTER PROJECTS.—We have received from Westland Aircraft, Limited, Yeovil, an illustrated brochure which, in addition to giving particulars of the S-55 10 and 12-seat single-engine helicopter now under construction, gives a brief outline of three new projects for which design studies have been made. These are the W.80, a 20-seat passenger helicopter with a single 75-ft. diameter three-blade rotor to be powered by two Alvis 14-cylinder engines mounted in outboard nacelles, having a cruising speed of 135 m.p.h.; the W.81, a 30-seat passenger helicopter with a single 75-ft. diameter four-blade rotor to be powered by an Armstrong Siddeley Double Mamba gas turbine, each developing 2,640 s.h.p. plus 810-lb. jet thrust for take-off, with an estimated cruising speed of well over 180 m.p.h.; and the W.85, a large military troop transport or freighter helicopter, capable of carrying 100 fully-equipped troops, with a single 104-ft. diameter three-blade reaction-driven rotor, to be powered by six Armstrong Siddeley Adder jet engines, each developing 1,100 lb. static thrust at sea-level, installed in the rotor tips.

MECHANICAL VIBRATOR FOR SIEVING.

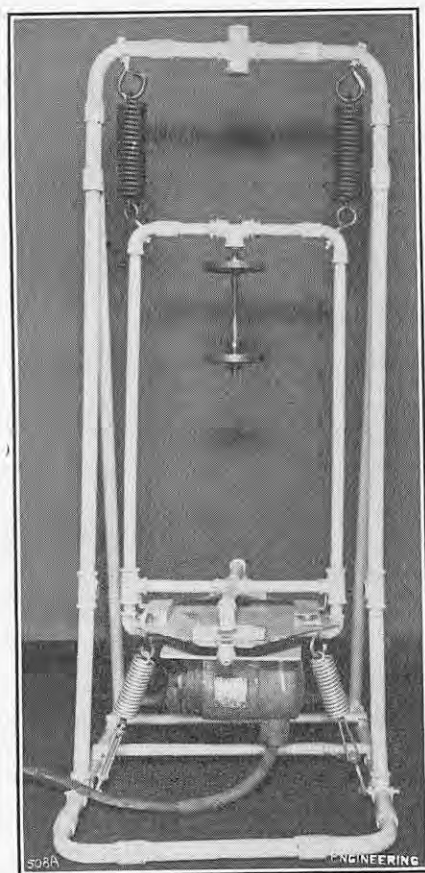


FIG. 1.

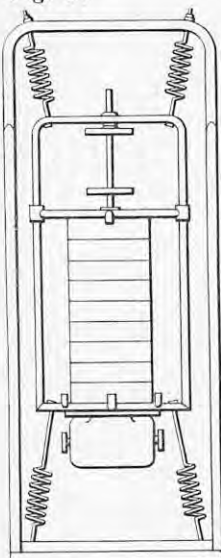
MECHANICAL VIBRATOR FOR SIEVING.

A SIEVING machine for soil size-distribution analyses, but with other possible applications, has been designed by the Western Region for use on all regions of British Railways. With seven sieves packed in a tier in the machine, the time required for stable conditions to be reached with a 200-gm. sample of sand, i.e., for sieving to be sufficiently complete, is from 5 to 15 minutes, depending on the shape of the particles. Sieving by hand would take a trained operator about 45 minutes.

Fig. 1 shows the machine, without sieves, and Figs. 2 and 3 show the construction. It will accommodate eight 8-in. or six 12-in. diameter sieves, together with a cover and bottom collecting pan. The sieves are held in a rectangular inner frame of steel tube, which is suspended by four 2-in. diameter helical springs, 6 in. long, from an outer frame. The tension in the springs is adjustable. A variable-speed 37-volt 160-watt electric motor of the type used for concrete vibrators is attached underneath the inner frame. An eccentric weight is mounted at each end of the motor shaft, with the weights relatively out of phase by 90 deg. The compound vibration induced by the weights shakes the particles of the sample round the sieves in a circular motion; it is found that the whole area of each sieve is used, thus minimising the wear on the sieves. The motion may be analysed thus: considering a horizontal axis through the nest of sieves and parallel to the motor shaft, the ends of the axis follow circular paths 90 deg. out of phase with each other, and the centre of the axis describes a circle of $\frac{1}{\sqrt{2}} \times$ the amplitude, 45 deg. out of phase with the ends. The sieves move vertically and horizontally, both motions being simple harmonic, with a maximum amplitude of 2 mm., and, due to the effect of the relative phase difference between the weights, rocking motions take place in the horizontal and vertical planes. The machine is simple and cheap to construct and it has proved to be entirely satisfactory in the year that it has been used.

To test its performance, a 200-gm. sample of Penderyn sand was sieved for various times and the weights retained on each sieve were noted, the sample being thoroughly remixed before each sieving to ensure uniformity of conditions. The results have been plotted in Fig. 4, herewith, which shows that stable conditions are reached within seven or eight minutes. Even after five minutes, the results differ by an average of only 0.14 per cent. from those obtained after 20 minutes. As results are normally required only to

Fig. 2.



(508.B)

Fig. 3.

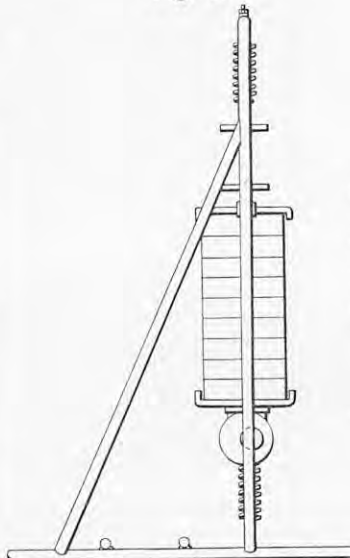
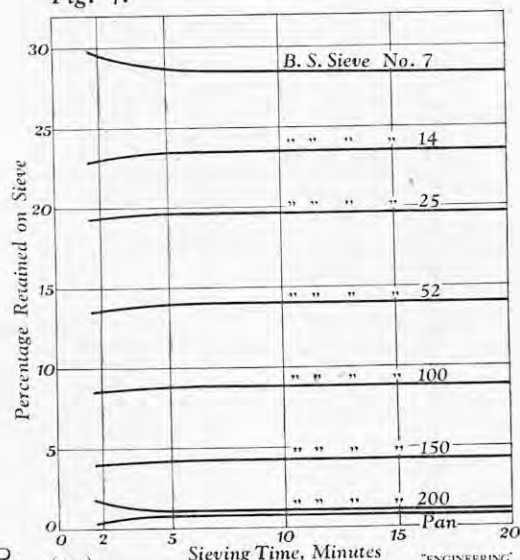


Fig. 4.



(508.C)

"ENGINEERING"

the nearest whole number, a sieving time of from 5 to 15 minutes, depending on the shape of the particles, is sufficient. Where the curves in a graph show an upward trend this indicates that particles are being received from the sieve above faster than they are being passed to the sieve below. The final grading of the test sample was as follows:—

B.S. Sieve No.	Percentage Retained.	Percentage Passed.
7	28.2	72
14	23.4	48
25	19.6	29
52	14.0	15
100	8.8	8
150	4.2	2
200	1.0	1
	0.8	0

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS.—We have received from the Society for Experimental Stress Analysis, Central-square Station, Cambridge 39, Massachusetts, U.S.A., the tentative programme of their annual meeting and exhibition, which is to be held at Bellevue-Stratford Hotel, Philadelphia, Pennsylvania, from November 28 to 30. The following technical papers will be presented: "Graphic Representation of State of Biaxial Plastic and Elastic Stresses," by MR. R. SCHILLING; "A Study of Residual Stresses in Flat Beams by Electropolishing Methods," by MESSRS. D. O. LEESER and D. J. DEMOREST; "Device for Applying Uniform Loading to Boundaries of Complicated Shape," by MESSRS. A. J. DURELLI, R. L. LAKE, and C. H. TSAO; "Application of Xenon Flashlight to Scattered Light Polariscopes," by MR. P. L. BALISE; "Elastic and Creep Properties of Stresscoat," by MR. WILLIAM F. STOKEY; "Measurement of Force-Time Relation in Racing Shells," by MESSRS. E. D. BAIRD and W. W. SOROKA; "Stress Concentration for Structural Angles in Torsion by Conducting Sheet Analogy," by MESSRS. N. S. WANER and W. W. SOROKA; "Hydrodynamic Pressures on Dams due to Earthquake Effects," by MR. CARL N. ZANGAR; "Automatic Control and Programming for a 200,000-Pound Fatigue Machine," by MESSRS. H. C. ROBERTS and V. J. McDONALD; "A Mechanism for Controlling a 50,000-Pound Fatigue Testing Machine," by MESSRS. G. K. SINNAMON and W. J. HALL; "A Variable Amplitude Fatigue Machine," by MR. A. E. MCPHERSON; "The Effect of Superposition of Stress Raisers on Members Subjected to Static and Repeated Loads," by MR. A. Q. MOWBRAY, JUN.; "Instrumentation and Fundamental Experiments in Plasticity," by MESSRS. D. C. DRUCKER and F. E. STOCKTON; "Effects of Work-Hardening in Experimental Stress Analysis of Magnesium Alloy Parts at High Stress Levels," by MR. E. H. SCHUETTE; "Performance Evaluation of a Magnesium Alloy Truck Wheel," by MR. M. H. POLZIN; "An Investigation of Thermal Stresses in Heat Exchangers at 2,500 deg. F.," by MR. SIDNEY MILLER; "Impulsive Loads on Beams," by MR. WM. H. HOPPMANN II; "Further Results on the Tuned Test Mass Method of Vibration Testing," by MR. SAMUEL J. LORING; "Measurement of Gas Turbine Stresses in the Laboratory, on the Test Bed, and in Flight," by MR. D. A. DREW; "Dynamic Calibration of Wire Resistance Strain Gages by Elastic Impact Wave," by MR. KURT FINK; and "Measurement and Acceleration in Human Motion," by MR. E. O. FELKEE.

CONTRACTS.

C. A. PARSONS & Co., LTD., Heaton Works, Newcastle-upon-Tyne, 6, among other contracts, have received orders for 100,000-kW turbo-alternator sets for Ferrybridge power station; repeat orders for three 60,000-kW sets for Stella, Leeds and Littlebrook power stations and five 30,000-kW sets, one for East Yelland, two for Connah's Quay and two for Belfast power stations. Orders have also been received for a 30,000-kW set for Medicine Hat and a 25,000-kW set for Saskatoon, Canada; three 50,000-kW sets for Lake Macquarie, Australia; two 60,000-kW sets for Taabos, South Africa; and a 30,000-kW set for Bulawayo, Southern Rhodesia.

THE BRITISH INSULATED CALLENDER'S CONSTRUCTION Co., LTD., have obtained a contract from the British Electricity Authority for the supply and erection of the 62-mile-long section of the 275-kV overhead line, from Newcastle to Thirsk. This forms part of the double circuit line which will run from Clyde's Mill to West Melton. The towers for the line have been designed by BLAW KNOX, LTD.

LEYLAND MOTORS LTD., Leyland, Lancashire, have received orders valued at 7,000,000L. from the Ministry of Supply. They cover heavy-duty lorries of various types, many with six-wheel drive, specially designed for the arduous transportation needs of the armed Forces. These orders, coupled with contracts concluded with civilian operators at home and overseas, bring the total value of orders secured by the company during a recent calendar month to over 13,000,000L.

PRECISION TIMING TRIALS OF "COMET" AIR LINER.—The Ministry of Civil Aviation has announced that a Comet jet-propelled airliner has demonstrated that high-speed jet aircraft can be accurately controlled by the standard traffic control methods in use at London airport. The Comet was brought down from cruising height and was "held" for two hours, at varying heights, over the Epsom radio range, prior to approach and landing at London airport; the aircraft kept to within one minute of its schedule.

NEW ELECTRODE FOR STEAM-PIPE WELDING.—The Quasi-Arc Company, Limited, Bilston, Staffordshire, have introduced a molybdenum-bearing electrode, for use in welding high-pressure steam pipes, consisting of steel containing 0.5 per cent. molybdenum or 1 per cent. chromium and 0.5 per cent. molybdenum. The covering of this new electrode contains sufficient alloy to ensure that the molybdenum content of the weld metal is from 0.4 to 0.6 per cent. It is of the fully-extruded type and complies with the relevant British and American standard specifications.

CONVERSION OF S.S. "GOTHIC."—Work has begun in the shipyard of Cammell Laird & Co., Ltd., Birkenhead, on the conversion of the Shaw Savill liner Gothic in preparation for the projected tour of Their Majesties the King and Queen, and Princess Margaret, to Australia and New Zealand in 1952. The conversion is being carried out under the direction of the Admiralty, in conjunction with the Shaw Savill Line, and is expected to be completed in December. The Royal apartments will be air-conditioned, and will be equipped mainly with furniture from the Royal yacht Victoria and Albert.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SCOTTISH COAL STOCKS.—The total coal stocks of all consumers at September 15 last were slightly below last year's level, namely, 1,244,000 tons against 1,260,000 tons in 1950. Industrial consumers were better off with 445,000 tons, compared with 405,000 tons, but concern has arisen on account of the shortage of large coal. A measure of priority to gasworks brought the total in reserve, at the above date, to 183,000 tons (195,000 tons last year), but domestic tonnages suffered, merchants' depot stocks amounting to 146,000 tons only, in contrast with 219,000 tons last year.

ORGANISATION FOR EXPORT OF COAL TO FRANCE.—The district organisation for Scotland in connection with the agreement reached between the Association Technique de l'Importation Charbonnière (A.T.I.C.) and the British Coal Exporters Federation, for the export of coal to France, will be known as the Scottish A.T.I.C. Committee, with offices at 12, Waterloo-street, Glasgow. Mr. J. Burns has been appointed co-ordinator of the committee.

LOAD-SHEDDING ARRANGEMENTS.—The South-West Scotland Electricity Board have announced arrangements for winter load-shedding. These follow broadly on the lines adopted last year. Each of the sub-areas has been divided into five zones, which have been put on a rota covering the period from Monday to Friday and showing the day on which the supply is liable to be cut in a particular zone.

ALUMINIUM FISH CONTAINERS.—Modified aluminium fish containers, which are claimed to be better and more hygienic than the old-style wooden boxes, and were first introduced to the Glasgow Fish Market by Presoturn, Ltd., two years ago, were demonstrated there again this week. They are more expensive than the wooden boxes, but can be more easily cleaned. One difficulty is the problem of arranging for their prompt return to the owners instead of circulating among other trawler owners and salesmen.

CLEVELAND AND THE NORTHERN COUNTIES.

THE LATE SIR ROBERT THOMPSON.—The death, on October 2, is announced of Sir Robert Norman Thompson, chairman of the shipbuilding firm of Joseph L. Thompson & Sons, Ltd., Sunderland, and a director of Sir James Laing & Sons, Ltd., and John Crown & Sons, Ltd. Sir Robert, who was 73 years of age, had been a prominent figure in North-East Coast shipbuilding circles for many years. He was a member of the Institution of Naval Architects and the North-East Coast Institution of Engineers and Shipbuilders, and was a liveryman of the Worshipful Company of Shipwrights. He received his knighthood in 1946.

ELECTRICITY LOAD-SPREADING.—Industrial firms in Northumberland and Durham have made a ready response to the electricity load-spreading schemes proposed by the North-East Regional Board for Industry. It has been announced that, up till the present, 80 per cent. of the 2,500 firms concerned have promised to introduce load-spreading measures in their works and factories. A joint announcement, recently issued by the Wear Shipbuilders' Association and the Wear Confederation of Shipbuilding and Engineering Unions, states that sufficient night work will be introduced into the Sunderland shipyards to enable them to attain the load-spreading target proposed by the Board.

LANCASHIRE AND SOUTH YORKSHIRE.

SHORTAGE OF YOUNG RECRUITS.—It has been emphasised, at the conference of steelworks foremen at Hope, Derbyshire, that there is a "desperate" shortage of young recruits in the Sheffield steel industry, particularly in rolling mills and forges, and that, to attract the right type, definite promises of promotion should be given. Mr. W. D. Hargreaves, secretary of the British Iron and Steel Federation area training committee, who sponsored the conference, said that the labour position was probably not due to any one particular reason. The imminence of National Service seemed to incline young men to seek lighter work until their call-up. He urged the need to concentrate on the recruiting of grammar-school boys.

LOW STEEL STOCKS.—Mr. T. G. Jameson, chairman and managing director of Hardypick, Ltd., Sheffield,

has stated that the firm's stock of steel, which consists of hundreds of different sizes, sections and qualities, was, at the close of the financial year, only half that held at the beginning. The firm have had to refuse thousands of pounds worth of orders for export because they had not the slightest prospect of executing them in a reasonable period, owing to lack of steel. Many expedients had been adopted to eke out supplies, but this had caused serious increases in the cost of manufacture.

GASWORKS EXTENSION.—It is understood that extensions now being carried out at Carr House gasworks, Rotherham, will be ready for operation by 1954. By that time, the plant will be able to deal with 600 tons of gas coal a day. Provision has been made for a 50 per cent. extension at a later date.

SMOKE ABATEMENT.—Sheffield's chief smoke inspector, Mr. J. Law, speaking at the National Smoke Abatement conference at Blackpool, thought it surprising, in 1951, to find persons who continued to advocate the hand-firing of boilers. The most effective method of securing smokeless operation was to reduce the human element to a minimum. This could only be achieved by mechanical devices, and, of improvements in the past 25 years he knew of no apparatus that had helped so efficiently to reduce pollution as the underfeed type of stoker.

SUBMARINE ENGINE FOR WORKS POWER STATION.—At the packing-machinery works of Rose Bros., at Gainsborough, the problem of power cuts is being solved by the installation of a 1,250-h.p. submarine engine to drive a generator to provide an emergency supply of electricity. The generators are expected to make the factory entirely independent of the national grid during peak periods.

HISTORICAL EXHIBITION OF ELECTRIC STORAGE BATTERIES.—In connection with the Dalton Lecture of the Royal Institute of Chemistry, which Lord McGowan, K.B.E., delivered in Manchester on September 27, on the subject of "One Hundred Years of Chemistry," a chemical exhibition was arranged by eight manufacturing firms, of whom Chloride Batteries, Ltd., contributed a sequence of exhibits tracing the development of the lead storage battery from Volta's pile, and the cells of Daniell, Leclanché and Plante, to the latest types. A parallel series of exhibits showed the evolution of the modern pasted plate from that of Camille Faure, introduced in 1881.

CASUALTIES IN THE WEEDON ACCIDENT.—We regret to record that, among the fatal casualties in the derailment of the Liverpool-London express on September 21, to which reference was made on page 403, *ante*, were two of the Kirkby research staff of Messrs. British Insulated Callender's Cables, Ltd. Mr. Cyril Cuttle Howis, M.Sc., who joined the company in 1945, had been manager of their chemical research laboratory for the past three years. He was 40 years of age, and was a member of the Chemical Society and the Society of Dyers and Colourists, and a Fellow of the Royal Institute of Chemistry. Mr. Frank Walker, who was 28 years old, had been employed since 1946 as a metallurgist in the same laboratory. He was a member of the Institute of Metals and of the Iron and Steel Institute, and was a licentiate of the Institution of Metallurgists.

THE MIDLANDS.

THE FUEL SITUATION.—Many opportunities have been taken by the electricity-supply authorities to point out that power generation will be unequal to the demand in the coming winter. It is clear, too, that coal supplies will present a difficult problem, particularly as the peak of the rearmament production has not yet been reached. Dr. J. Bronowski, director of the National Coal Board's Central Research Establishment at Stoke Orchard, near Cheltenham, has spoken of the very great possibilities in briquette production and has pointed out that something like 20 million tons of coal dust could be turned into usable fuel a year. That, however, is a long-term project, and, to meet the difficulties of the immediate future, many Midland firms have installed oil-firing equipment. The petroleum companies have stated that sufficient oil fuel will be available, though much of it is of a lighter grade and more expensive than the heavy fuel oil normally used in furnaces.

OUTPUT OF CARS AND TRACTORS.—The Standard Motor Co., Ltd., Coventry, have announced that, in the year ended August 31, their output of cars and tractors again showed an increase. Compared with the previous year, 11,108 more cars and 31,680 more tractors were turned out from the Coventry works. Production is now at the rate of more than 500 vehicles a day, but Sir John Black, the deputy chairman and managing director, says, in a letter to the company's staffs, that in view of the rearmament programme it is impossible to forecast future production.

STANDARDISATION OF FIRE HYDRANTS.—To meet the requirements of the Home Office in the matter of the standardisation of fire hydrants throughout the country, the City of Birmingham fire and ambulance service is converting its street hydrants to the round-thread outlet covered by British Standard Specification No. 336. The conversion will be undertaken in the three weeks commencing October 10. The chief officer of the Fire Service, Mr. H. W. Coleman, Corporation-street, Birmingham, 4, is prepared to give advice and assistance to owners of private fire-fighting equipment who will be affected by the change.

INDUSTRIAL VISITS SCHEMES.—The Wednesbury, Darlaston and District Manufacturers' Association, which was responsible for inaugurating the series of three-day industrial visits by school teachers to local factories, has stated that the scheme has proved an unqualified success. Requests have been received from all the parties concerned for the scheme to be continued and extended next year, and Mr. H. P. Court, secretary of the Association, states that it is hoped to expand the scheme considerably.

LOW-TEMPERATURE RESEARCH PLANT.—A Midland firm, Carter Refrigeration and Air Conditioning, Ltd., of Bordesley Green, Birmingham, 9, have produced a pilot refrigeration plant for research into the behaviour of aircraft fuel-injection systems at very low temperatures. The plant can operate down to -100 deg. F. At a later date, a plant will be produced to accommodate a complete engine. Another experimental plant, built by the same firm, is for air-conditioning in a large Birmingham chocolate factory.

MINE DETECTORS USED BY ARCHÆOLOGISTS.—A new use for army mine detectors has been tried on the Malvern Hills, in Worcestershire. Malvern district is known to have been the site of camps dating back to the early Iron Age, and the mine detectors have been used to sweep areas where metal objects might be expected to be buried. Many articles have been located.

PLANNING A FOREIGN CAPITAL.—A Midland firm of architects, Harris & Gard, of Edgbaston, Birmingham, 16, have been commissioned by the Abyssinian Government to prepare plans for a new capital to replace Addis Ababa. The proposed new city, which is intended to house a population of 100,000, will be at Bahrdar, about 250 miles north of the present capital. The site is swampy in parts, and some considerable engineering problems will have to be overcome. The designs will be prepared at the firm's Birmingham office.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEW INDUSTRIES IN SOUTH WALES.—Opening a new factory of Super Oil Seals & Gaskets, Ltd., at Cardiff, Mr. J. Twomey, general manager of Spillers, Ltd., claimed that "we are moving into an entirely different South Wales, thanks to a greater diversity of industry." Much had been achieved, he said, but prosperity was not a static thing and much remained to be done. He criticised South Wales road communications and added that the present position, with the main means of communication secured by the Severn Tunnel only, could be tolerated no longer. The company have acquired the present new large modern factory for developments in connection with the manufacture of synthetic rubber products. The new factory, which has a floor area of 60,000 sq. ft., will employ between 400 and 500 when in full production.

SOUTH WALES IMPORT AND EXPORT TRADE.—The trade of the South Wales ports has again shown an upward trend. In the four weeks ended September 9, according to official returns, the seven ports, between them, dealt with 1,666,485 tons of merchandise, 311,583 tons more than in the corresponding period of last year. Imports were 250,000 tons above the level for the corresponding four weeks of 1950, there being a big rise in arrivals of oil and spirit and iron ore, while timber, grain, flour, general cargo, chemicals, and building and road-making materials all showed increases. Exports rose by more than 60,000 tons to 883,217 tons. Larger shipments of oil and some improvement in the coal-export trade were responsible. From January 1, to date, the ports dealt with 13,623,442 tons of merchandise against 12,931,233 tons in the same period of 1950.

PIT PROPS FROM FINLAND.—A coal pit-prop barter scheme has been concluded between Finland and Great Britain, it has been reported on the Cardiff coal market. Under this, Britain will supply about 42,000 tons of coal, mostly Welsh central-heating qualities, in return for pit props for the Welsh mines. Arrangements were being made in the past week for deliveries to begin immediately. It has been reported that the stocks of mining timber available locally are rather low.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre*: Monday, October 8, 6 p.m., Grand Hotel, Birmingham. Chairman's Address by Mr. W. H. Brent. Annual General Meeting, and Conversation. *Western Centre*: Monday, October 8, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Chairman's Address, by Mr. J. W. Elliott. *North-Eastern Centre*: Monday, October 8, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Chairman's Address, by Mr. E. C. Rippon. *North Midland Centre*: Tuesday, October 9, 6.30 p.m., Hotel Metropole, Leeds. Chairman's Address, by Dr. E. C. Walton. *East Midland Centre*: Tuesday, October 9, 6.30 p.m., Loughborough College, Loughborough, Leicestershire. Chairman's Address, by Mr. A. W. Hirst. *Northern Ireland Centre*: Tuesday, October 9, 6.45 p.m., Presbyterian Hotel, Belfast. Chairman's Address, by Mr. S. McCracken. *Scottish Centre*: Tuesday, October 9, 7 p.m., Institution of Engineers and Shipbuilders, Glasgow. Chairman's Address, by Mr. Percy Butler. *Southern Centre*: Wednesday, October 10, 6.30 p.m., R.A.E. College, South Farnborough, Hampshire. Discussion on "Electrical Measurements by Thermal Effects." *District Meeting*: Wednesday, October 10, 7 p.m., Electricity Showrooms, Southern Electricity Board, 37, George-street, Oxford. "Radar Principles and Measurement," by Professor A. Lee. *Institution*: Thursday, October 11, 5.30 p.m., Savoy-place, London, W.C.2. Presidential Address, by Sir John Hacking.

INSTITUTE OF FUEL.—*North-Eastern Section*: Monday, October 8, 6.30 p.m., King's College, Newcastle-upon-Tyne. Joint Meeting with the Coke Oven Manufacturers' Association on "Pore-Size Analysis of Metallurgical Coke," by Dr. J. Gilchrist and Dr. A. Taylor. *Yorkshire Section*: Wednesday, October 10, 6.30 p.m., The University, Leeds. Chairman's Address, by Professor A. L. Roberts. *North-Western Section*: Thursday, October 11, 2.30 p.m., Radiant House, Bold-street, Liverpool. "Boilers," by Mr. H. E. Partridge.

INSTITUTION OF PRODUCTION ENGINEERS.—*Sheffield Section*: Monday, October 8, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. Lecture by Mr. G. Flather. *Yorkshire Section*: Monday, October 8, 7 p.m., Hotel Metropole, Leeds. "Some Aspects of Materials Handling in Industry in the U.S.A.," by Mr. E. G. Taylor. *Liverpool Section*: Wednesday, October 10, 7.15 p.m., North Western Gas Board, Radiant House, Bold-street, Liverpool, 1. "Work Assignment and Incentive Payment on Semi-Automatic Machines," by Mr. T. F. O'Connor. *Eastern Counties Section*: Friday, October 12, 7.30 p.m., Suckling House, St. Andrews Plain, Norwich. Inaugural Meeting. "Valid Incentives," by Mr. E. C. Gordon England.

INSTITUTION OF THE RUBBER INDUSTRY.—*Midland Section*. Monday, October 8, 6.45 p.m., James Watt Institute, Great Charles-street, Birmingham. "Some Factors Influencing the Road Wear of Tyres," by Dr. R. D. Stiehler.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Central London Branch*: Monday, October 8, 7 p.m., St. Ermin's Hotel, Caxton-street, London, S.W.1. "Television," by Mr. G. W. Godfrey. *North-West London Branch*: Monday, October 8, 7.45 p.m., Prince of Wales Hotel, Kingsbury-road, London, N.W.9. "Oil Switchgear Failures and Their Causes," by Mr. N. Elliott. *South-West London Branch*: Tuesday, October 9, 8.15 p.m., St. George's Hall, St. George's-road, Wimbledon. "High Frequency Heating," by Captain J. Wharton. *Bradford Branch*: Wednesday, October 10, 7.30 p.m., Midland Hotel (Room 14), Bradford. Open debate, "Any Problems." *York Branch*: Wednesday, October 10, 7.30 p.m., Feasgate Restaurant, Feasgate, York. "Electric Water Heating," by Mr. Philip Honey. *Bristol Branch*: Friday, October 12, 7.30 p.m., Grand Hotel, Bristol. "Energy from the Atom," by Mr. A. F. Possnett. *Nottingham Branch*: Friday, October 12, 7.30 p.m., Demonstration Theatre, Electricity Showrooms, Smithy-row, Nottingham. "Relays and Remote Control," by Dr.-Ing. W. L. Stern.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, October 9, 5.30 p.m., Burlington House, London, W.1. Discussion on "The Education of the Chemical Engineer by Part-Time Study."

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 9, 5.30 p.m., 85-88, The Minories, London, E.C.3. "Refractory Materials for Marine Boilers," by Mr. F. H. Clews.

INSTITUTION OF MECHANICAL ENGINEERS.—*Automobile Division*: Tuesday, October 9, 5.30 p.m., Storey's Gate, St. James's Park, London, S.W.1. Annual General

Meeting, followed by Chairman's Address, by Mr. C. B. Dicksee.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 9, 6.30 p.m., 39, Elmbank-crescent, Glasgow. Presidential Address by Sir Andrew McCance.

INSTITUTE OF METALS.—*South Wales Local Section*: Tuesday, October 9, 6.30 p.m., University College Metallurgy Department, Singleton Park, Swansea. "Metallurgical Problems of Atomic Energy," by Dr. H. M. Finnieston. *Manchester Metallurgical Society*: Wednesday, October 10, 6.30 p.m., Engineers' Club, Albert-square, Manchester. Presidential Address by Mr. A. B. Ashton. *Liverpool Metallurgical Society*: Friday, October 12, 7 p.m., Lecture Theatre, Electricity Service Centre, Whitechapel, Liverpool. "The Problem of the High-Temperature Oxidation of Metals," by Professor A. Preece.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, October 9, 7 p.m., 4, Hamilton-place, London, W.1. "Power Operated Controls," by Mr. C. F. Joy. *Graduates' and Students' Section*: Thursday, October 11, 7.30 p.m., 4, Hamilton-place, London, W.1. "Airships," Lord Ventry.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Slough Section*: Tuesday, October 9, 7.30 p.m., Lecture Theatre, High Duty Alloys, Limited, Slough. "The Running and Feeding of Castings," by Mr. H. B. Farmer. *West Riding of Yorkshire Branch*: Saturday, October 13, 6.30 p.m., Technical College, Bradford. "Brains Trust."

ROYAL SANITARY INSTITUTE.—*London Sessional Meeting*: Wednesday, October 10, 2.30 p.m., 90, Buckingham Palace-road, London, S.W.1. "Some Preliminary Experiments in the Filling of Waterlogged Pits with Refuse," by Mr. A. S. Knolles.

ROYAL UNITED SERVICE INSTITUTION.—Wednesday, October 10, 3 p.m., Whitehall, London, S.W.1. "H.M.S. *Theseus* in the Korean War, and some Special Problems of Naval Aviation in that Theatre," by Captain A. S. Bolt.

INSTITUTE OF PETROLEUM.—Wednesday, October 10, 5.30 p.m., Manson House, 28, Portland-place, London, W.1. Symposium on "Acid Sludge, its Utilisation and Prevention."

NEWCOMEN SOCIETY.—Wednesday, October 10, 5.30 p.m., Science Museum, Exhibition-road, South Kensington, S.W.7. "Chapman's Locomotives, 1812-1815," by Mr. E. A. Forward.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, October 10, 6 p.m., 9, The Temple, 24, Daic-street, Liverpool. "The Technical Education of the Part-Time Engineering Student," by Dr. R. H. Grundy.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, October 11, 5.55 p.m., 11, Upper Belgrave-street, London, S.W.1. Presidential Address, by Mr. Walter C. Andrews.

INSTITUTION OF CIVIL ENGINEERS.—*Birmingham Branch*: Thursday, October 11, at 6.30 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. Chairman's Address, by Mr. M. R. Vincent Daviss.

LAUNCHES AND TRIAL TRIPS.

S.S. "RHODESIA CASTLE."—Twin-screw passenger and cargo liner, with accommodation for 530 passengers in one class, built and engined by Harland and Wolff, Ltd., Belfast, for the Union-Castle Line, London, E.C.3. First of a series of three similar vessels. Main dimensions: 540 ft. between perpendiculars by 74 ft. by 35 ft. 6 in.; gross tonnage, about 17,300. Parsons triple-expansion condensing double-reduction geared turbines and three Babcock and Wilcox oil-fired water-tube boilers. Trial trip, September.

M.S. "PENHR."—Single-screw cargo vessel, with accommodation for six passengers, built and engined by Ateliers et Chantiers de Bretagne, Prairie-au-Duc, Nantes, for the Compagnie Nantaise des Chargeurs de l'Ouest, Nantes, France. Main dimensions: 249 ft. 4 in. between perpendiculars by 39 ft. 3 in. by 24 ft. 4 in.; deadweight capacity, 1,650 tons on a draught of 14 ft. 10 in.; gross tonnage, 1,672. M.A.N. eight-cylinder single-acting four-stroke Diesel engine, developing 1,800 h.p. Speed in service, 13 knots. Launch, September 22.

S.S. "BRUNSWICK WHARF."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1. First vessel of an order for three. Main dimensions: 257 ft. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a draught of 17 ft. 1 in. Direct-acting triple-expansion steam engine of reheat design, developing 800 i.h.p. at 78 r.p.m., constructed and installed by George Clark (1938), Ltd., Sunderland, and one forced-draught coal-burning boiler. Speed on trial, 11 knots. Trial trip, September 26.

PERSONAL.

SIR JAMES CHADWICK, M.Sc., Ph.D., F.R.S., has been awarded the Franklin Medal, the highest honour in the gift of the Franklin Institute of Philadelphia, for his contributions to the science of radioactivity.

AIR COMMODORE F. R. BANKS, C.B., O.B.E., has been elected President of the Junior Institution of Engineers, 39, Victoria-street, London, S.W.1. He will be inducted on December 14 by the retiring President, ENGINEER REAR-ADMIRAL D. J. HOARE, C.B., M.I.Mech.E.

MR. N. P. NEWMAN has been elected chairman of the British Valve Manufacturers' Association, 32, Victoria-street, London, S.W.1, in succession to Mr. E. BRUCE BALL.

MR. K. PRESTON, chairman and managing director of J. Stone & Co. (Holdings), Ltd., has resigned from the board of the Superheater Co., Ltd., and Mr. W. J. RUSTON, director of J. Stone & Co. (Holdings), Ltd., and chairman of Ruston & Hornsby, Ltd., has been appointed in his place. Mr. L. C. SOUTHCOTT and Mr. E. LAWTON have been appointed special directors of the Superheater Company.

MR. R. G. A. DIMMICK, B.Sc., M.I.E.E., A.M.I.Mech.E., A.M.I.N.A., has been made manager, industrial motor sales department, the British Thomson-Houston Co., Ltd., Rugby, vice Mr. C. A. HALL, M.C., B.Sc., A.M.I.E.E., who recently accepted an appointment with B.E.A.M.A. Mr. H. R. CANNING, is to take over the position of manager of the marine department, previously held by Mr. Dimmick. Mr. A. G. W. CANNON, A.M.I.P.E., has been appointed manager of the Birmingham works of the Company.

MR. C. T. SCARF has been appointed chief engineer, industrial control department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17, as from September 1. He succeeds Mr. G. L. NEWMAN, who is transferred to the staff of the chief electrical engineer, for special duties. Mr. G. D. HARRADINE, Assoc. I.E.E., has been appointed assistant sales manager in the industrial control department.

The Minister of Supply has now announced the names of the radio-industry representatives on the Radio Rearmament Advisory Committee. They are Mr. A. G. CLARK, of the Plessey Co., Ltd., Mr. L. T. HINTON, of Standard Telephones & Cables, Ltd., Mr. M. M. McQUEEN, of the General Electric Co., Ltd., Mr. F. S. MOCKFORD, of Marconi's Wireless Telegraph Co., Ltd., Mr. E. J. POWER, of Murphy Radio, Ltd., Mr. J. W. RIDGEWAY, of Edison Swan Electric Co., Ltd., Mr. E. E. ROSEN, of Ultra Electric Ltd., and Mr. C. O. STANLEY, of Pye Ltd.

MR. J. E. ARMSTRONG, chief engineer, Canadian Pacific Railway, retired on October 1, after 39 years of service. His successor is Mr. R. A. EMERSON, of Montreal.

MR. G. N. WARD, M.A., at present a senior lecturer in mathematics in the University of Manchester, has been appointed to the newly-created chair of mathematics in the Department of Aerodynamics, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. He is expected to take up his duties in December, 1951.

MR. R. S. ATKINSON, A.M.I.Mech.E., A.M.I.E.E., a generation engineer (operation) in the South Eastern Division of the British Electricity Authority, has been appointed Group I generation engineer (operation) in the London Division.

MR. F. H. ELIOT, assistant for outdoor machinery to the executive officer (electrical engineering new works and development), Railway Executive headquarters, retired on September 19 at the age of 65.

MR. M. W. BARLOW has resigned his position of sales manager to British Electro Metallurgical Co., Ltd., Sheffield, to join Foundry Services, Ltd., Long Acre, Nechells, Birmingham, 7, as manager of their newly-established ferro-alloy division.

MR. L. B. STONE, Riversley, Cashes Green-road, Cains-cross, Stroud, has been appointed honorary branch secretary of the Institution of Engineering Draughtsmen and Designers, for the Gloucester area.

MR. H. C. WEINGARTNER has been elected vice-president and general manager, equipment division, National Research Corporation, Cambridge, Massachusetts, U.S.A.

SUNVIC CONTROLS LTD., have acquired a new factory, on the industrial estate at Harlow New Town. The works and offices, at 132-135, Long Acre, London, W.C.2, have removed to Harlow, but the sales department is still at the Long Acre address. The registered office remains at 10, Essex-street, Strand, W.C.2.

To facilitate the development of overseas trade, BRADES & NASH TYZACK INDUSTRIES, LTD., have formed a separate company, BRADES & NASH TYZACK INDUSTRIES OVERSEAS, LTD. The directors are LT.-COLONEL R. A. WIGGIN, MESSRS. C. F. N., W. C. L., and PETER BOULTON, MESSRS. G. HOWARD and W. TREVOR HEATON and Mr. G. L. ROWBERRY. Mr. Peter Boulton is managing director and Mr. G. L. Rowberry, Brades Steel Works, Oldbury, near Birmingham, director in charge.

CENTRIFUGALLY-APPLIED CEMENT LINING FOR WATER MAINS.

CENTRILINE CORPORATION, NEW YORK, U.S.A.

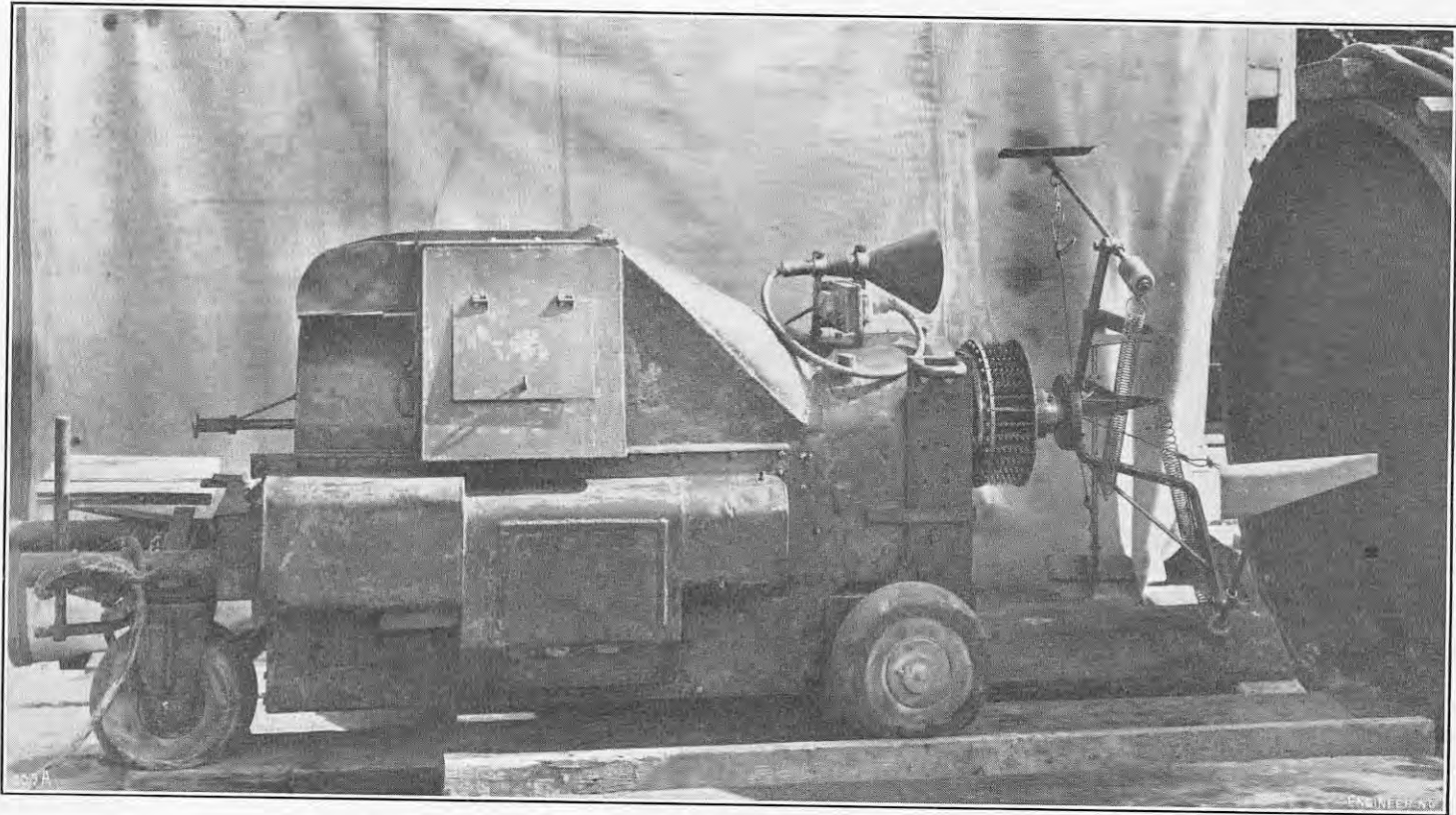


FIG. 1. MACHINE READY FOR LINING 48-IN. CAST-IRON WATER PIPE.

CEMENT-MORTAR LINING OF WATER MAINS.

A MACHINE for applying a cement-mortar lining to steel or cast-iron water mains has recently been brought to this country from the United States and demonstrated to a number of interested engineers. The demonstration was arranged by Messrs. John Mowlem and Company, Limited, 91, Ebury Bridge-road, London, S.W.1, at a Metropolitan Water Board site at Stoke Newington, London, where the Board are constructing the first section of a 75-in. tunnel main, 22½ miles long. This main, together with a 60-in. surface pipeline, will eventually connect the River Thames at Hampton to Chingford reservoirs, and the Board wished to examine the Centriline method, as it is called, before deciding on the types of pipelines to be used. Fig. 1 shows the machine at one end of a 48-in. cast-iron pipe, which was placed at ground level for demonstration purposes, and Fig. 2 shows it in the 75-in. steel water main which has been laid in a tunnel below ground.

The machine is electrically driven. It runs on three rubber-tyred wheels and is propelled backwards through the pipe while the cement-mortar, fed from a hopper by a worm, is thrown centrifugally from a rotating head (Fig. 1) on to the inside of the pipe. The head runs at about 1,000 r.p.m. Two or more arms, with trowels attached to their ends, are rotated slowly so as to smooth the surface of the mortar after it has been applied. The arms are adjustable to suit the diameter of the pipe, and by varying the speed at which the machine travels the thickness of the lining can be controlled. During the demonstration run through the 48-in. pipe, the thickness of lining was ¼ in. and the speed of travel was over 6 in. per minute, though the normal speed for lining varies between 1 ft. and 3 ft. per minute, depending on the thickness of the lining and the diameter of the pipe. The mortar is mixed in a Centriline mixer, using carefully prepared sand and cement, and is conveyed through the pipe in small trucks to the lining machine; the trucks are designed so that the returning "empties" can be lifted and run over the advancing full trucks. The lining machine can be steered round bends and kept in line in a straight pipe. It can be used in pipes as small as 24 in. in diameter, and has been used in a 123-in. pipe.

The Centriline Corporation, 140, Cedar-street, New York, 6, U.S.A., who are responsible for the process, have completed about 1,500,000 linear ft. of pipe-lining since the process was introduced in 1935. The lining can be applied to cast-iron or steel pipes, including smooth-bore welded steel pipes, lock-bar and riveted steel pipes, and riveted and wrought-iron pipes. The

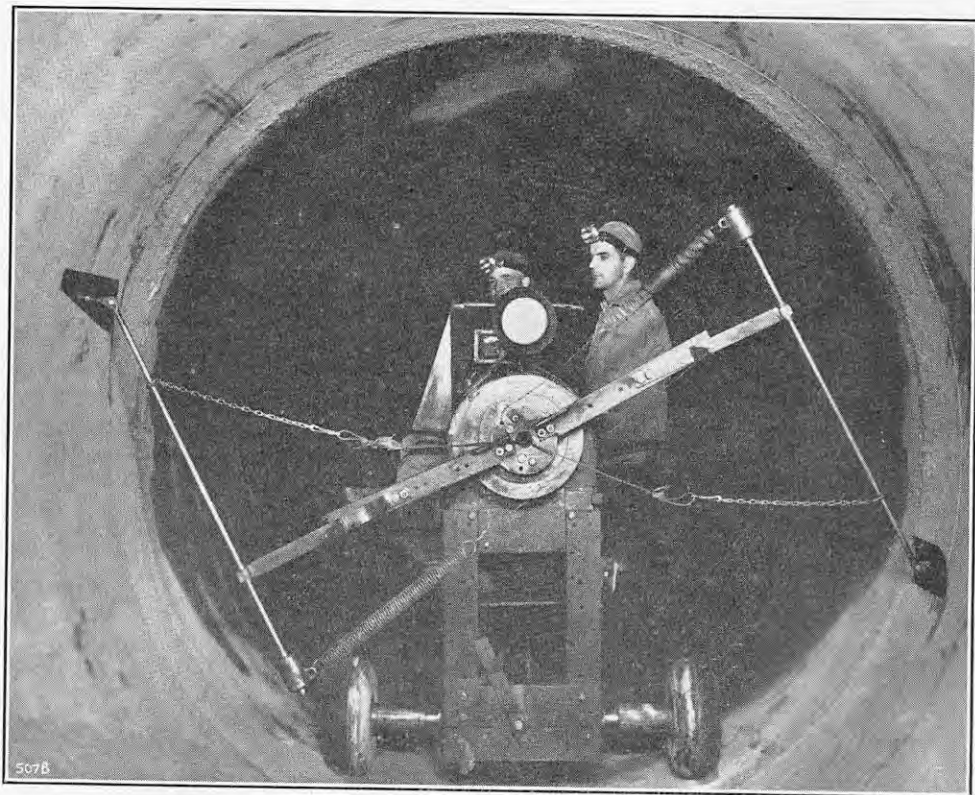


FIG. 2. LINING 75-IN. WATER MAIN.

work can be carried out on new pipes under or above ground, or old pipes can be reconditioned. In the latter case, the thickness of lining can be adjusted to suit the varying conditions throughout the length of the pipe, and the Corporation claim that the flow capacity of some pipes has been increased by more than 100 per cent. due to the improvement in the surface of the pipes. The coefficient C (in the Williams-Hazen formula) for a 30-in. cast-iron pipe in Atlanta, Ga., which was 53 years old at the time of relining, was increased from 60 to 142—a gain of 136 per cent. The Centriline process prevents corrosion or tuberculation, it stops leaks in steel pipes and in joints, in cast-iron pipes, and prevents leakage due to corrosion

from the exterior. Old pipes are cleaned, generally by a hydraulic machine, prior to lining. No compressed air is used in mixing or applying the cement-mortar.

BROADCAST NOTICE OF POWER CUTS.—The British Broadcasting Corporation have agreed, at the request of the Ministry of Fuel and Power and the British Electricity Authority, to broadcast information about the areas which will be affected by electricity cuts a few minutes before these take place. From a date to be announced later, the warnings may be given on a wavelength of 1,500 metres at any time between 7.30 a.m. and 12.3 p.m., and 3 p.m. and 6 p.m.

ENGINEERING,

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

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

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SUBSCRIPTIONS.

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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 are 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 $2\frac{1}{4}$ 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; $12\frac{1}{2}$ per cent. for thirteen; 25 per cent. for twenty-six; and $33\frac{1}{2}$ per cent. for fifty-two insertions.

TIME OF RECEIPT FOR ADVERTISEMENTS.

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

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

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

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ENGINEERING

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No. 4471.

DYNAMIC BRAKING OF LOCOMOTIVES.

To show something familiar in a new light, to reveal unsuspected qualities, to find interest in things that were not thought to be worth looking at—these acts of the imagination are characteristic of poets and artists rather than engineers and scientists; yet the best scientists are poets in their science and the best engineers are artists in their engineering. They do not accept things as they are, or simply carry on where their predecessors left off; they bring fresh minds to old problems, and in proportion as they challenge accepted beliefs so, with luck, they lay the foundations of greater advances. Indeed, technological progress may be said to depend on the frequency of arrival of newcomers who take past learning in their stride and then reach forward while their imaginations are still lively. Past learning to-day, however, is so vast that it is only by the exercise of exceptional intellectual powers that the newcomer, who cannot hope to absorb it all, can pick out the faulty foundations and proceed to build a new structure.

In engineering, the prospect is not so forbidding as in pure science; a number of advances made on narrow fronts can be as profitable as a major sweep on a broad front, and the opportunities for improvements in detail are certainly multiplying, as the columns of technical journals show. Some old problems remain, though they have been raised often before. The brakes of steam locomotives, regarded in the light of present-day engineering, possess that prime virtue of design, simplicity; but they are crude to a degree which would excite

more adverse criticism, were they not so familiar. The brake-block attached by a single pin to the hanger, suspended idly when out of action, and pressed against the tyre when the brake is applied, is a crude device which has to be renewed frequently, wears out the tyre sooner than is necessary, is the cause of expensive inspection work, and is responsible for much of the dust and dirt of railway-traffic operation. With steam locomotives, there is at present no better method of braking that can usefully be adopted for the traffic and tracks of British Railways, but with electric, Diesel and gas-turbine locomotives, improved methods are widely used. In a paper on "Dynamic Braking of Steam, Diesel and Gas-Turbine Locomotives" which he presented to the Institution of Locomotive Engineers on September 19, Mr. J. L. Koffman reviewed the problem. He suggested that the increases in train weights and speeds during the past 50 years have multiplied by 20 the momentum which has to be absorbed in braking. According to some statistics of pre-war German industry, the cost of the energy used to overcome friction amounted to about eight times that of lubricating oils, and railways were responsible for much of this waste.

The successful operation of dense railway traffic, especially in suburban areas, depends as much on efficient braking as on rapid acceleration. Only where electric traction is employed, however, has any significant advance been made in using a less destructive and wasteful method of braking, but, as Mr. Koffman's paper showed, there are improved methods for steam and Diesel locomotives, and gas-turbine locomotives should be adaptable to dynamic braking. The power to be absorbed with modern fast and heavy trains is considerable, and the temperatures reached on conventional brake-blocks are high. Mr. Koffman calculates that the braking power of brake-blocks is limited to about 1,400 horse-power per axle, and the martensitic structure which is observed on tyre treads is regarded as evidence that a temperature of 1,500 deg. F. is reached. As this structure is generally not more than $\frac{3}{32}$ in. deep, it is clear that the temperature gradient radially through the tyre is very steep. The maximum coefficient of adhesion between the wheel and the rail is taken to be 0.15, though with dynamic braking this figure might be increased to 0.17, according to Mr. Koffman. Above 100 miles an hour, the coefficient drops. In a paper on "The Measurement of the Temperature of Sliding Surfaces, with Particular Reference to Railway Brake Blocks," presented to the Institution of Mechanical Engineers on November 7, 1947, the authors, Dr. R. C. Parker and Dr. P. R. Marshall, concluded that the block and tyre undergo thermal expansion over localised areas of contact, with the result that contact is confined to one or more thin strips along the length of the block. The tyre is distorted in a complex manner, bulges forming between the spokes of the wheel.

The braking of trains by placing the valve gear of the locomotive in reverse was practised from the early days of railways, but it is not surprising that the overheating of packings, the forcing of gases into the boiler and of steam and gases into the injector, and the introduction of ash and cinders into the cylinders and steam chests "could render the locomotive due for overhaul after three to four minutes of continuous application." A counter-pressure brake suitable for descending long grades must incorporate means for preventing the aspiration of combustion gases, providing sufficient cooling during compression, preventing gases from entering the boiler, and for controlling the pressure of the compressed gases. Several methods were tried in the middle of the Nineteenth Century, and in 1865 M. le Chatelier initiated experiments with a counter-pressure brake, using steam as the working fluid and introducing water to reduce the operating temperature. Although the "drill" that had to be

followed to apply or release the brake was rather complicated, this system was fitted to several thousand locomotives on the Continent. It was used particularly on mountain lines in Central Europe and in Russia. In this country, it was tried on the London and North Western Railway and the Midland Railway about 1870, but, according to the late E. L. Ahrons, "the failure . . . of an apparatus which has been successfully used for many years in France may be partly ascribed to want of care on the part of the drivers." British drivers and firemen, it seems, have always exercised a restraining and conservative influence on experimentally-minded chief mechanical engineers.

The Riggbach brake, originally introduced on the Vitznau-Rigi rack railway in 1869, uses air as the working fluid. The regulator is closed, the blast pipe is shut for exhaust purposes, but opened by a valve to the atmosphere, and the reversing screw is placed in full back-gear. Thus, air is drawn into the cylinders, compressed, and then exhausted through a restricting valve controlled by the driver. A silencer is fitted at the end of the exhaust pipe, and boiler water is injected into the cylinders for cooling purposes. The application of a simple Riggbach brake is tedious and cumbersome. The procedure is: release the wheel brake, open the exhaust-air valve, shut the blast-pipe, shut the by-pass, reverse the valve gear, apply water injection to limit the cylinder temperature to 550 deg. F., and then control the braking effort by means of the exhaust valve. Releasing the brake requires a similar sequence, in reverse. This method is complicated enough on engines that have to descend long gradients continuously, but it is obviously impracticable for ordinary traffic conditions. The automatic control proposed by Mr. K. Ewald and described by Mr. Koffman is ingenious, but is at a disadvantage in its large number of moving parts. Trains running down gradients of 1 in 16 at speeds not exceeding 15 miles an hour can be controlled by the Riggbach brake with slight assistance from the ordinary brake, but a heavy train cannot be stopped by dynamic braking alone. The chief limitation to the power of the Riggbach brake is the high temperature generated.

Diesel locomotives with electric transmissions are readily adapted to dynamic braking by using the traction motors as generators and dissipating the energy in rheostats. Mr. Koffman, however, describes at some length the use of the Diesel engine as a compressor absorbing energy and thereby braking the train. Braking power is also provided by the normal tractive resistance of the train, by transmission losses and by the power required to drive auxiliaries. Some dynamic-braking tests carried out with a six-wheel motor lorry by the Ministry of Supply and described by Mr. Koffman encouraged the view that the exhaust brake is a desirable fitting for heavy road vehicles, particularly those intended for use on long down grades overseas, where the "fading" of ordinary brakes presents difficulties.

In the gas-turbine locomotive Mr. Koffman sees great possibilities for dynamic braking and he stresses the importance of considering this feature of design in the preliminary stages rather than as an afterthought when the general design of the gas turbine has been settled. Referring to the possible use of radial inward-flow, or centripetal, turbines for railcars of about 300 h.p. to 500 h.p., he points out that, for braking purposes, the turbine could act as a centrifugal compressor.

Dynamic braking is justified and often necessary on any type of locomotive that is to be used on long continuous down grades, but under ordinary conditions the complication of design and the increased capital and running costs are likely to be too much. Certainly with steam locomotives it will need to be a very simple dynamic brake for it to be acceptable to British Railways.

HOT-DIP GALVANISING.

MUCH has been written and said about the mental attitude of American workpeople and their willingness to accept, and make full use of, all appliances which assist and increase output. This matter might almost be described as the text of most of the reports prepared by the productivity teams which have visited the United States. Usually this phenomenon appears to be accepted as a leading factor in American industry without any attempt to explain it. If its cause were understood, it might help in attempting to create conditions leading to the adoption of a similar point of view by British labour. It is accordingly of interest that the report* of the hot-dip galvanising team does suggest an explanation of the American attitude. It is pointed out that it is not so many years since pioneers were pushing forward into the unknown; the possibilities of expansion seemed to be unlimited, and the idea of a constantly expanding market which was created still endures. Until recent years, there was a copious flow of immigrants who brought with them little more than their willingness to work; they helped to enforce and sustain the doctrine that success in life depends on personal effort.

This explanation, although interesting, it is to be feared, carries no lesson which can be applied in this country. There is, however, another factor in American industry which is incidentally touched on in the report, which does something towards explaining the startling difference between the levels of United Kingdom and United States outputs. The former country has a population density of more than 500 per square mile; the latter has one of about 45. The large area of the United States is also rich in minerals of great variety and this natural wealth, coupled with the great areas available, for utilisation and exploitation, have resulted in practices which may fairly be described as industrial extravagance. Concentration on production and neglect of conservation, or far-sighted husbandry, may well give figures of output which could not be attained in a small country less naturally endowed and in which raw materials, home-produced or imported, must be used with care. One of the striking examples of American industrial recklessness was furnished by the destruction of the United States softwood forests. That country uses half the lumber supply of the world, but four-fifths of its newsprint is of Canadian origin; yet there is no evidence of any attempt to restrict, say, Sunday newspapers, to a reasonable size.

There are one or two matters mentioned in the hot-galvanising report which illustrate this output-at-all-costs attitude of mind. For pickling before galvanising, most firms in the United States use hot sulphuric acid. The pickle is used until the iron content reaches 5 per cent. to 6 per cent.; it is then "dumped in the sewer." It is stated that in a few cases on small rivers or near the Great Lakes, "some attempt" is made to neutralise the acid, but in general it is run to waste. The formulation of regulations concerning the pollution of rivers is a matter which is in the hands of the individual States, so that the conditions with which a works will have to comply will depend on its situation. The general question of works effluents is now being given some attention in the United States and it may be that, in the future, galvanising firms will have to pay more attention to the treatment wastes. If this were done, it would presumably result in a somewhat smaller output of galvanised articles per employee. From the point of view of good husbandry, the present procedure, as the report points out, results in a waste of acid. Zinc is another raw

material of which the present world shortage may affect some examples of American practice. Only large galvanisers at present have plant for recovering zinc from residues. In this connection, however, at least one firm has a zinc-economy incentive scheme in operation; details are given in the report.

The general conclusions drawn from the tour of the productivity team is that, chemically and metallurgically, American hot-dip galvanising procedure does not greatly differ from British, the main distinction being a preference for hot sulphuric acid pickling in place of the cold hydrochloric acid commonly used in this country. The main reason suggested for this difference is the greater cost of heating the sulphuric acid in Great Britain. A further difference between the practice of the two countries is that in America extensive use is made of timber for the construction of pickling vats. The cost of timber in this country is sufficient explanation for this difference in practice. The composition of metal in galvanising baths was much the same as in Great Britain, but for repetition work the galvanising temperature was frequently higher. One reason for this appeared to be that the baths were relatively small in terms of the work passed through them. This involved a rate of passage higher than is usual in British practice and the bath had to be held at a higher temperature to induce a faster absorption of heat.

One matter which is stressed has formed an item in almost every productivity report which has been published. This is the lavish provision of handling devices of many kinds, such as travelling gantries, monorail hoists and conveyors. Much attention is also given to special lifting and holding hooks or frames designed for the particular class of work being handled. Some of them appear to be such obvious conveniences that it might be assumed that they, or something very like them, would be designed and used in any works. As, however, the compilers of the report have thought it desirable to deal with some matters of this kind in detail, it must be assumed that such appliances are not so common in this country as they might be.

It is a little surprising to read in the report that "There are no arrangements for co-operative metallurgical research for the American galvanising industry comparable with those provided by membership of the research associations in Great Britain." Some particular problems such as the corrosion of galvanised coatings by water and the continuous galvanising of steel strip were being investigated under the auspices of the American Iron and Steel Institute, but the American Hot Dip Galvanizers' Association has no facilities for conducting research. The American Zinc Institute, which acts as a meeting ground for exchange of technical information, has no technical staff. In distinction from this state of affairs in the research field, however, the team was impressed by the high standard of technical knowledge possessed by many of the foremen. Most companies went to considerable pains in training their supervisors and assistance was furnished by the technical services programme of the American Hot Dip Galvanizers' Associations. It is proposed in the "recommendations" contained in the report that this particular factor in American practice should be copied in this country, and that the Hot Dip Galvanizers' Association should consider arranging special classes for the instruction of supervisors. It is also recommended that "interchangeability of labour in galvanising should be made possible by courses of instruction within firms." This appears a reasonable suggestion and the procedure if it were adopted would be of much value, but actually it raises the whole question of trade demarcation which is such a handicap to British industry. If the hot-dip galvanising team has done anything towards breaking down present trade-union rigidity in this matter, it will have served many branches of industry as well as its own.

* *Hot Dip Galvanizing of General Work. Report of a visit to the U.S.A. in 1950 of a Specialist Team representing the Hot Dip Galvanizing Industry.* Anglo-American Council on Productivity. U.K. Section, 21, Tothill-street, London, S.W.1. [Price 3s. 6d., post free.]

NOTES.

SUMMER SCHOOL ON SYNTHETIC-RESIN ADHESIVES.

A SUMMER school for the reading and discussion of papers on synthetic-resin adhesives and their applications has been held this year by Messrs. Aero Research Limited, of Duxford, near Cambridge, from September 23 to 29. Two courses of lectures were given in the mornings, in the University Department of Engineering, Trumpington-street, Cambridge, the courses being of special interest, respectively, to the woodworking industries and the engineering, electrical-manufacturing and allied industries. The lectures were followed, in the afternoons, by demonstrations and practical work in the Duxford establishment. The school which, we believe, is the first of its kind to have been held, was attended by 170 members, about one-third of the total number coming from overseas. To mark its successful conclusion, a dinner was given at the Dorothy Café, Cambridge, on the evening of Friday, September 28, at which Dr. N. A. de Bryne, managing director of Aero Research Limited, presided. Dr. de Bryne proposed the toast of "The Guests" and in doing so, paid special tributes to St. Catherine's College for the accommodation provided and to the Department of Engineering for the use of the lecture rooms and engineering laboratory. The response was made by Professor J. F. Baker, O.B.E., Head of the Department of Engineering of Cambridge University, who expressed pleasure that people who did something in the world had some regard for those who just taught. It had been said, however, that his Department did mass-production work to the extent of some 200 engineering graduates in a year; but these were turned out only as a semi-finished product. They must then go into other hands to be finished. He was convinced that post-graduate education was an essential part of the education of the engineer. Starting with an undergraduate school concentrating on the fundamentals of physical and engineering science in a course of three years' duration, the products of this school would go out into the world, first to undergo a graduate apprenticeship and then to take some responsibility in industry, in order to learn the nature of the problems encountered and the difficulties of applying science in a form which industry could make use of. After this, the majority would need no further instruction, but those who were to occupy the really important positions would feel the need for further study, and they should return to the University for about a year of advanced and concentrated study. Thanks to the support of the University Grants Committee, a number of universities were now supporting such post-graduate courses. At Cambridge, the first course, covering structures and materials, would open shortly and had been over-subscribed. All the experienced engineers required as students had been sent by their firms. If the system was successful, it would greatly reduce the time-lag in passing on new knowledge. The only other toast of the evening, that of "The University," was proposed by Ing. Don Santiago Garriga, of Madrid, and the response to this was made by Captain C. R. Benstead, M.C. We understand that it has not yet been decided whether or not the Aero Research summer school will be held next year, although this year's school has been highly successful from all points of view.

ANNUAL COMPETITION FOR APPRENTICES.

The Physical Society announce that, as in previous years, it will hold a competition in craftsmanship and draughtsmanship in conjunction with its annual exhibition of scientific instruments and apparatus, which is due to take place in London in April, 1952. The society attaches much importance to the maintenance of high standards of craftsmanship and draughtsmanship, and the object of the competition, which is open to both sexes but restricted to those under 22 years of age on March 31 next, is to encourage high-grade work by apprentices and learners. The awards are of only nominal value, but the standard of work submitted is traditionally high and much honour attaches to the prizewinners and to their employers or teachers. Work may be submitted under the headings of

scientific instruments and components, tools and gauges, optical components and systems, blown-glass and silica ware, patterns and functional scale-models of scientific interest, and draughtsmanship. Employees of firms, research associations and institutions which have exhibited at the Society's annual exhibition at least once during the past three years, employees in the workshops or drawing offices of educational establishments, and students attending recognised courses in workshop practice or machine drawing at technical schools or colleges are eligible to enter. Further details, including conditions of entry and entry forms, may be obtained from the secretary, Physical Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. Entry forms will be accepted up to February 21, 1952.

HOLLAND-DENMARK SUBMARINE TELEPHONE CABLES.

A submarine telephone cable link between Oostmahorn on the north coast of Holland and the Danish island of Romo, was officially opened on Thursday, September 27, and embodies several features of technical interest. The link comprises two coaxial cables, each 142 nautical miles long, which were manufactured in this country by Submarine Cables, Limited, 22, Old Broad-street, London, E.C.2. These cables have an inner coaxial conductor, consisting of seven copper wires with a total diameter of 0.23 in. over which a single copper tape, 0.775 in. wide and 0.015 in. thick, is closely wrapped. The interstices of this conductor are filled with a viscous compound, and it is insulated with two solid coverings of Teleothene, the diameter of the first being about 0.6 in. and of the second 0.935 in. The outer conductor consists of a layer of six copper tapes, each of which is 0.475 in. wide and 0.015 in. thick. These tapes are laid directly on the surface of the insulation with a lay of about 15 in., and a copper binder tape 1.375 in. wide and 0.004 in. thick is lapped over them. Two servings of tarred jute yarn are then applied, followed by an armouring of 15 No. 2 galvanised iron wires and finally by a second serving of tarred jute yarn. The overall diameter of each completed cable is about 2 in. and the total weight in air is 12.7 tons per nautical mile. Each cable will be used for transmission in both directions and will provide 36 complete telephone circuits. It will embody two submerged repeaters, manufactured by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2, and these will operate in conjunction with special equipment in the two terminal stations at Romo and Leeuwarden. The signals in both directions will be amplified by the same amplifier, frequency bands of 24 to 168 kilocycles and 208 to 352 kilocycles, respectively, being used for this purpose. A power supply for the amplifiers will be obtained through the central conductors of the cables at 260 volts from a battery at Oostmahorn, in conjunction with an accurately regulated rectifier voltage of about 280 volts at Romo, the circuit being completed through the sea. The voltage drop across the valve heater supply will be employed as the anode voltage. The repeaters are fitted with supervisory apparatus, so that the gain and linearity of the amplification can be measured at the terminal stations. The shore ends of the cables were laid by Danish and Dutch cable ships and the main cable by H.M.T.S. Monarch; the splicing was completed in September, 1950. The cables will provide an important link in the network connecting the Scandinavian countries with the rest of Europe.

THE NEWCOMEN SOCIETY'S AUTUMN MEETING.

The autumn meeting of the Newcomen Society for the study of the History of Engineering and Technology, which was held on Friday, September 28, was devoted to a tour of the remaining traces of the Surrey Iron Railway (the first public railway in the world, incorporated 150 years ago) and its continuation, the Croydon, Merstham and Godstone Railway. Under the guidance of Mr. Charles E. Lee, to whose researches much of the known history of these railways is due, a party of 30 proceeded by motor coach from Westminster to Wandle Bridge, Wandsworth, where the Surrey Iron Railway terminated beside a dock now used by

the South-Eastern Gas Board, and thence along the course of the line to Mitcham, where old plans and maps were studied in the office of Messrs. Chart, Son and Reading, architects and surveyors, with the aid of a commentary by Mr. Christopher Chart. The tour was then continued through Hackbridge—with a halt to visit the Eagle Leather Works of Messrs. John S. Deed and Sons, Limited, at Mitcham, containing fulling and other machines driven by water wheels—and on to Croydon, where lunch had been arranged. In the afternoon, the party proceeded along the route of the Croydon, Merstham and Godstone Railway (opened in 1805) through South Croydon to Purley, where an exhibition of maps, rails, sleepers and other relics, assembled in the Coudson and Purley library by the librarian (Mr. K. M. Newbury), is on public view until October 20. The remains of a fairly lofty embankment were inspected in the grounds of Cane Hill Hospital, and the railway cutting, containing the remains of three overbridges, was followed to the terminus of the line in the Greystone Lime Works at Merstham, where the members were received by Major E. W. Taylerson, M.I.Mech.E. Halts were made en route to visit the former "Fox" public house (now "Fox Shaw," the residence of Mr. J. Francis) where, on July 24, 1805, Sir Edward Banks, the contractor for the line, tested the "draw-bar pull" of a horse on the railway; and at Chipstead Church, where Banks is buried. His memorial in the church includes reliefs of typical arches of Waterloo, Southwark and London Bridges, all of which he built.

THE ASSOCIATION OF CONSULTING ENGINEERS.

The report of the Committee of the Association of Consulting Engineers (Incorporated) for the year ended April 30, 1951, records a total membership of 327 at the end of the period, an increase of 24 over the corresponding figure for 1950. The number of members of the Association has been registered as not exceeding 500, but the Committee have power to register an increase whenever they think fit. A special committee which has been engaged on the revision of the model forms of agreement has also dealt with inquiries from members regarding the professional rules and practice, and negotiated with Government departments on these and cognate questions. Agreement has been reached with the War Office on a scale of fees on a time basis for small works. The Institution of Civil Engineers are revising their professional rules, and as it is desirable that the professional rules of the Association and the Institution should correspond as closely as possible joint discussions on the matter are being held. A small committee is preparing a memorandum of the Association's views on the taxation of professional classes (retirement benefits), for submission to the Tucker Committee, which is investigating this question. Close touch has been kept with the South African Advisory Committee, and it is learnt that steps are being taken to consider the formation of a South African Society of Consulting Engineers. Following on Colonel A. S. Lowe's visit to Canada on behalf of the Association, the Committee believe that the time is ripe for individual members or groups of members to consider setting up offices in Canada.

STREET LIGHTING.

In a circular issued on Thursday, September 27, to local authorities throughout the country, the Minister of Transport "views with some concern certain tendencies which have developed during the past two or three years in the relations between Street Lighting Authorities and Area Gas and Electricity Boards." These authorities are therefore reminded that new street-lighting works, which come under Defence Regulation 56A, should not be carried out without the authorisation of his Department. Area Gas and Electricity Boards, and more particularly contractors, have no power to give this authorisation, even where the lighting is provided on a rental basis. It is further recommended that when lighting authorities decide upon a new scheme, they should purchase and not hire the necessary apparatus. They should also bear in mind the importance of competitive tendering. Moreover, where new or improved schemes of lighting are contemplated, the divisional road

engineer of the Ministry should be consulted at an early stage. Finally, as the Minister attaches great importance to the contribution which good street lighting, adequately maintained, can make to traffic safety, he considers the more closely lighting authorities are identified with the administration of the lighting systems the more easily will this objective be attained.

THE INSTITUTION OF PRODUCTION ENGINEERS.

The annual dinner of the Institution of Production Engineers was held on Tuesday, October 2, at the Dorchester Hotel, London, W.1, the chair being taken by the President, Major-General K. C. Appleyard, C.B.E. After the loyal toasts had been honoured, the President proposed that of "The English-speaking Peoples," emphasising the closeness of the links between them and the common desire which animated their respective nationals, to be their own masters wherever possible. Commenting on the general tone of the reports by the productivity teams which had visited the United States, the President pointed out that many British firms could do much more to improve their general efficiency of production, by the avoidance of waste, without incurring any capital outlay. The Hon. W. R. Herod, Co-ordinator of North Atlantic Treaty Defence Production, who replied, reviewed the resources of the peoples forming the North Atlantic Treaty Organisation, showing that "the aggregate material potentialities are predominantly in favour of the N.A.T.O. countries"; though he quoted statistics showing that significant increases had been made by the U.S.S.R. in the production of steel, coal, oil and electric power supplies. Comparing the resources of the two groups of nations—the twelve N.A.T.O. countries, and the U.S.S.R. and its satellite territories (excluding China)—Mr. Herod said that the respective populations were about 340 millions and 300 millions; the ratio of incomes was about 3 or 4 to 1, and of steel production and electricity production, 4 or 5 to 1, and in "total energy used for productive purposes . . . electrical, mechanical, animate and inanimate," about 3 to 1 in 1948, the most recent year for which figures were available. It would appear, however, that the Soviet Union had increased its industrial production in 1950 about 23 per cent. over the level of 1949, and 73 per cent. over that of 1940. On the invitation of the President, Mr. Barry Benson, Commercial Attaché at the United States Embassy, made a farewell speech to the members before leaving London for another appointment. Sir Cecil Weir, K.B.E., responded to the toast of "The Guests," proposed by Mr. Harold Burke, vice-chairman of the Institution Council.

LETTERS TO THE EDITOR.

MAXIMUM TORSIONAL STRESS IN A GROOVED SHAFT.

TO THE EDITOR OF ENGINEERING.

SIR,—The torsion problem of a bar with varying circular section has been treated by several investigators from early times. Usually, the solution covering all points in a shaft is found first and then the maximum stress is obtained. Accordingly, the analysis is generally complicated and so only a few cases have been treated completely. It is essential from the technical point of view, however, to find the stresses around a notch rather than the stresses at every point in a shaft. This induced the writer to propose a simple method for the approximate determination of the stresses and torsion on the surface of a shaft with a circumferential notch. In this method the lines of shearing stress near the surface are replaced by the corresponding streamlines of a two-dimensional uniform flow in an infinite domain. Theoretically this approximation is permissible only in the limit where the dimensions of the notch are infinitely small compared with those of the shaft.

As an example, the problem of a shaft with a semi-circular notch was solved numerically. Contrary to expectations, the results agreed closely with those of the exact solution, even when the notch was moderately large. This shows that the lines of

shearing stress at the points near the surface are not affected appreciably by the relative dimensions of the notch when the dimensions of the notch are comparatively small compared with those of the shaft. This conclusion makes the further analysis considerably simpler, since the streamlines for various cases have been investigated extensively in the past and those results are immediately applicable to the present problem.

In this manner, the writer derived a formula for the maximum stress which occurs at the bottom of the notch, when the depth and the radius of curvature of the notch are specified. This formula is

$$\tau_{\max.} = \frac{2T \left(1 + \sqrt{\frac{b}{\rho}} \right)}{\pi r (r - b)^2} \quad (1)$$

where $\tau_{\max.}$ is the maximum stress, T is the twisting moment acting on the end of the shaft, r is the radius of the shaft, b is the depth of the notch and ρ is the radius of curvature at the bottom of the notch.

For a semi-circular notch, the formula (1) becomes

$$\tau_{\max.} = \frac{4T}{\pi r (r - b)^2} \quad (2)$$

The values of the maximum stress for various values of $\frac{r}{b}$, calculated from (2), are shown by a curve in the accompanying figure. The results obtained earlier by other investigators are also shown in the same figure. From the figure, it will be seen that the approximate values of the maximum stress, calculated from (2), agree more closely with the exact ones obtained by Willers, than do those of any of the previous investigators. Formula (1) has been derived from the result for a semi-elliptic notch and is given in a form covering all values of the ratio $\frac{b}{\rho}$. The validity of the formula, however,

is restricted to the case of moderate values of $\frac{b}{\rho}$ (which are likely to be those of practical importance), since its accuracy is confirmed only for the particular case $b = \rho$. A detailed report on the subject will be published later in a periodical for applied mechanics. The other work referred to is by F. A. Willers, *Z. Math. Phys.*, Bd. 55, S. 251 (1907); R. Sonntag, *Z. angew. Math. Mech.*, Bd. 9, S. 3 (1929); and H. Neuber, *Kerbspannungslehre*, S. 127 (1937).

Yours faithfully,

H. OKUBO,
Professor.

Institute of High-Speed Mechanics,
Tohoku University,
Sendai, Japan.

BOILER AND TURBINE TESTING.

TO THE EDITOR OF ENGINEERING.

SIR,—I was very interested in the letter contributed by Sir W. Valentine Ball, on page 404 of your issue of September 28. In compiling the history of the first municipal electricity undertaking (Bradford), parts of which have already appeared as a series in the *Journal of the Electrical Power Engineers' Association*, I came across the name of Mr. John Waugh a number of times in connection with the testing of steam plant. His reports were clear and straightforward and his replies to laymen members of the Gas and Electricity Supply Committee (there was no Electricity Committee in the early years, 1889-1899) were delightfully to the point.

Yours faithfully,

T. H. CARR, M.I.C.E.

Bradford,

October 1, 1951.

ELECTRIFICATION OF RAILWAYS IN GREAT BRITAIN.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issues of March 30 and April 13, 1951 (pages 386 and 445), you give an abstract of *Electrification of Railways*, the report of a committee appointed by the Railway Executive and the London Transport Executive. Engineers interested in and working with railway electrification consider that

some statements in this report would possibly mislead your readers. For instance, in any electrification scheme, the cost of the overhead equipment is a major portion of the total capital cost and thus any substantial reduction in this can affect a decision on economic grounds for any particular system.

Every railway that has so far adopted the high-tension single-phase system has found that the cost of the overhead equipment has been half, or less than half, that required for a direct-current scheme. A further substantial saving has been shown on the cost of alternating-current substations due to the better utilisation and consequently smaller number of these. It is for these reasons that railways have been able to justify an alternating-current system. It is, therefore, amazing to find in the report that the committee consider that alternating-current overhead track equipment is just as costly as that provided for direct current. The cross-sectional area of copper required is a function of the current flowing in the conductors, which is likewise a function of the voltage of the system. The copper required for an alternating-current system is thus frequently found to be one quarter that necessary for a direct-current system. With copper prices at the present level and with a reduction in the size of supporting structures possible, the cost of overhead equipment must very obviously be considered less than that required for any direct-current system.

The committee again seems to have been at some pains to show that the world trend to-day is away from alternating-current systems. The reader is led to believe that during the last 20 years the only railways (with three exceptions) to decide on alternating current are those already heavily committed to this type of electrification. In fact, the very opposite is the case, and countries already heavily committed to direct-current schemes, such as France and New Zealand, have decided that future electrifications will be on the high-tension single-phase system. Quite possibly direct current is the correct choice for Great Britain, but it should be possible to justify that decision on its merits and not be necessary to belittle the universally-accepted advantages of another system. There was a time when alternating-current locomotives cost quite a percentage more than their corresponding direct-current alternatives. When this was true, then obviously the traffic density of any scheme had a large bearing on the choice of a system. The additional cost of rolling stock, if large quantities were required, could quite easily outweigh the savings obtained from the less expensive overhead. However, even this excuse can no longer be used, for several Continental manufacturers are now in a position to quote for alternating-current locomotives at a lower price than the equivalent direct-current locomotives.

The single-phase alternating-current system of railway electrification has come to stay, and many readers will come to regard the *Electrification Report* as the swan song of a system that few will soon be able to afford.

Yours faithfully,

C. A. MACKERSEY,
A.C.S.E., M.I.E.E.
Electrical Engineer.

New Zealand Government Railways,
Wellington, C.I.,
New Zealand.
September 27, 1951.

OBITUARY.

MR. J. E. MACLAREN.

It is with much regret that we record the death on October 2, at his home in Birmingham, of Mr. J. E. MacLaren, managing director of the B.S.A. Tools group of companies. Mr. MacLaren, who was only 53 years of age, had been in rather indifferent health for a year or more, but his death was unexpected and will be widely regretted.

James Edward MacLaren was born in Nova Scotia on November 4, 1897. He received his general education in the town of New Glasgow and in the United States, at schools in New Hampshire and Rhode Island, and his technical education at the

technical college of Providence, Rhode Island. His apprenticeship was served with the Brown and Sharpe Manufacturing Company, which he left in 1917 to come to England, taking up an appointment in 1918 as instructor in a Ministry of Munitions training centre. On the conclusion of the first World War, he was engaged by Buck and Hickman, Limited, as sales manager, especially for Brown and Sharpe tools, a position which he held with notable success for 19 years. In 1938, he was appointed a director of the firm, and remained on the board until 1946. In 1945, he went to Iserlohn, Germany, as deputy chief, under Sir Percy Mills, of the Economic Division of the Control Commission. He had previously served, during the war, as chairman of the Machine Tool Committee for the Midlands Area, from 1939 to 1941; and, from 1941 to 1944, as Regional Controller for the Ministry of Supply, for the same area.

In 1946, on his return to England, Mr. MacLaren was made managing director of the B.S.A. Tools group of companies, comprising B.S.A. Tools, Limited, the Index Automatic Machine Company, Burton Griffiths and Company, the Leo C. Steinle Company, Cardiff Foundry and Engineering (1947), Limited, and B.G. Machinery, Limited. He continued to hold that office until his death. In addition to his duties as managing director, he was active in many associated directions, being a member of Council of the Gauge and Tool Makers' Association, and of the Machine Tool Trades Association; as Sir Patrick Hannon disclosed in an appreciation which appeared in *The Times* yesterday, he would have become President of the latter Association, had he lived. He was also a member of the Institution of Mechanical Engineers and of the Institution of Production Engineers, of the American Society of Mechanical Engineers, and of the Institute of Welding and the Institute of Industrial Administration.

MAJOR L. DE ZINOVIEFF.

WE regret to record the death at the early age of forty-six of Major Leo de Zinovieff, who was one of the victims of the railway accident at Weedon on Friday, September 21.

Leo de Zinovieff was born in Russia on February 13, 1905. After being educated privately, he attended the City and Guilds (Engineering) College, London, and obtained the diploma of associateship in 1925. He received his practical training with Siemens-Bau-union and was subsequently engaged with them as chief assistant to a sectional engineer on the construction of the River Shannon Hydro-Electric Scheme. While holding this position, he worked on a five-mile stretch of the head race and prepared designs for the necessary retaining walls, locks and bridges. After being associated for short periods with Messrs. Christiani and Neilsen, Limited, and Messrs. Bierrum and Partners as a reinforced-concrete designer, he began to practice as a consulting engineer in 1932. A year later, however, he joined Flooring Contracts, Limited, of which firm he later became chief engineer and director. From 1936 to 1940, he was technical director and chief engineer of Messrs. MacLeod and Zinovieff, Limited.

In 1940, he joined Messrs. Sandford Fawcett and Partners as chief assistant engineer. During the last three years of the war, however, he served first with the Royal Marines (Engineers) in Iceland, where he was responsible for the construction of aerodromes and piers, and then with a special engineering section of the Admiralty, which was engaged on work in connection with the "Overlord" operations. He rejoined his firm on the conclusion of hostilities and became a partner in 1948. He was responsible for the structural work at a number of large water-supply, sewage-disposal and flood-relief works, including the Maple Lodge scheme of the Colne Valley Sewerage Board, near Rickmansworth. He was also engaged on the design of a new sewage-treatment works at St. Helens, the effluent from which will be used for cooling in the new 60-MW power station of the British Electricity Authority at Bold.

Major Zinovieff was elected an associate member of the Institution of Civil Engineers in 1930 and was transferred to the class of members in 1947.

THE SIXTH INTERNATIONAL CONFERENCE OF SHIP TANK SUPERINTENDENTS.

THE practice of holding periodical conferences of the Superintendents of the numerous ship-model experiment tanks was initiated before the war, but naturally fell into abeyance while hostilities continued. After the war, however, the conferences were resumed, to the great benefit of those who have to compare results from different tanks, and to co-ordinate programmes and methods of research. This year, for the sixth Conference, the United States, as the host country, invited to Washington delegates from the organisations possessing experiment tanks or having a special interest in ship and ship-model research. The next Conference is to be held in 1954, at Gothenburg.

The sixth Conference opened on September 5 with a visit to the David W. Taylor Model Basin at Carderock, Maryland, and was followed by a reception given by the Secretary to the United States Navy, the Hon. Dan A. Kimball. The representative British delegation included Dr. J. F. Allan and Dr. G. Hughes, from the Ship Division, National Physical Laboratory; Mr. R. W. L. Gawn, O.B.E., from Haslar; and Professors L. C. Burrell, A. J. Sims and E. V. Telfer. Mr. F. S. Burt, of the Royal Naval Scientific Service, also attended, and Mr. K. C. Barnaby, Mr. J. M. Ferguson and Mr. W. P. Walker represented, respectively, the private firms of J. I. Thornycroft and Company, John Brown and Company, and William Denny and Brothers, Limited.

Among well-known European delegates were Professors M. L. Acevedo, F. Horn, E. Högnér, J. K. Lunde, C. W. Prohaska, L. Troost, H. F. Nordstrom and G. Vedeler; together with Mr. W. P. A. van Lammeren and Mr. L. Pehrsson. The American Towing Tank Conference was, of course, especially well represented. The David W. Taylor Model Basin, a most impressive establishment, possesses the two largest towing tanks in the world. The larger of the two is about five-eighths of a mile in length, and the instrumentation and workshops, etc., are on a similar vast scale. The chief naval architect at the "D.T.M.B." is Dr. F. H. Todd, who was for many years at the National Physical Laboratory before going to Washington.

The next two days, September 6 and 7, were occupied by meetings of the Society of Naval Architects and Marine Engineers. These did not form part of the Conference proper, but they served as a useful curtain-raiser, especially as several papers dealt with tank subjects. The opening papers on Thursday morning were by Professor J. K. Lunde and Dr. René Guillon, the latter being ably read, in the absence of the author, by Professor B. V. Korvin-Kroukovsky. Both papers dealt with methods of calculating the wave resistance of ships, Professor Lunde dealing with "The Linearised Theory of Wave Resistance for Displacement Ships in Steady and Accelerated Motion," and Dr. Guillon with a "Potential Theory of Wave Resistance of Ships, with Tables for its Calculation." While very great progress has been made since the original proposals of J. H. Michell in 1898, it is doubtful, however, if these decidedly abstruse methods will ever replace the comparatively simple tank test.

The afternoon papers did not require the consideration of such advanced mathematics. Mr. Allan B. Murray, Mr. Edward V. Lewis and Professor B. V. Korvin-Kroukovsky, who are all associated with the Stevens Model Basin, were the joint authors of a paper dealing with "Self-Propulsion Tests with Small Models." They did their best to dispel the prevalent belief that, because of scale effect, the results with very small models were unreliable. Mr. R. W. L. Gawn then dealt with "Results to Date of Comparative Cavitation Tests of Propellers." This was in the nature of an interim report, but interesting comparisons were made of results at Haslar, Carderock, Teddington, Massachusetts, and Kristinehamn. Mr. Gawn was followed by Professor Telfer, whose paper was entitled "Economic Speed Trends." This was a useful reminder that model tests can only supply part of the answer to a ship-owner's problems.

The morning papers on Friday, September 7, were "Manœuvring of Ships," by Captain R. Brard, of the Paris Model Basin, and "The Organisation of Merchant Shipbuilding Research in Great Britain," by Dr. S. Livingston Smith, Research Director of the British Shipbuilding Research Association. The latter paper was especially appreciated, as it appeared that, in the United States, there is no organisation comparable with the B.S.R.A.; research is mainly in the hands of the Navy, with specific work entrusted to the Stevens tank or to various university groups.

The closing papers of the meeting both dealt with Conference subjects, namely, "Turbulence Stimulation on Ship Models" (by Dr. G. Hughes and Dr. J. F. Allan), and "Skin Friction Resistance and the Effects of Surface Roughness" (by Dr. F. H. Todd). These papers undoubtedly influenced Conference decisions. The Society's very successful two-day meeting closed with a cocktail party and reception, followed by an informal dinner.

The Conference of Ship Tank Superintendents opened on September 10 and lasted a full week. The subjects discussed were under the seven headings of (1) Reynolds Number for model propeller experiments; (2) skin friction; (3) comparative cavitation tests on propellers; (4) turbulence stimulation in models tests; (5) scale effect on self-propulsion factors; (6) sea-going qualities of ships; and (7) the presentation of resistance and propulsion data.

At each session, the proceedings were opened by the presiding officer and the special reporters for the subject in question. Formal written statements were then read by the delegates and these were followed, after a short recess, by a more informal discussion. In contrast to the usual methods of the Institution of Naval Architects, where prepared statements are discouraged, this meant that the same delegate usually spoke twice on each subject. The summaries leading to the agreed decisions commenced on Friday, September 14. These final sessions were under the able guidance of Captain H. E. Saunders, U.S.N. (ret.), Technical Assistant to the Chief of the Bureau of Ships. The more important decisions, numbered to agree with the headings above, were as follows.

(1) A proposed minimum propeller diameter of 8 in. for self-propulsion tests was not accepted, but the Conference affirmed its belief that the performance of marine propellers could be predicted with practical accuracy from self-propulsion tests. The Conference recognised the need for further experiments on scale effect, and four testing establishments agreed to co-operate with the testing of propeller "geosims," i.e., propellers of the same design but to different scales. Points of special importance in such testing, it was emphasised, were the insuring of completely laminar flow and the effect of surface roughness.

(2) The problem of skin friction was, perhaps, the most important as well as the most controversial of the subjects discussed. It will be remembered that, at the last Conference, the American delegation made a strong plea for the adoption of the Schoenherr formulation in place of the Froude constants which had been used so long. The decision then arrived at was that it was recognised that the general basis of the Schoenherr constants was correct in being based on Reynolds Number and that it was necessary to change to this basis. At the same time, they could not agree, without further investigation, to this special formula with a proposed roughness allowance of 0.0004. It was decided, therefore, to permit the use of both types of friction calculation. While this was a breakaway from the rigid position of the earlier Paris Conference, it was not altogether satisfactory.

The decisions of the 1951 Conference were that, in view of the large number of relevant investigations proceeding in different countries, the present alternative use of the Froude and Schoenherr coefficients should continue; and that the evidence available at present was insufficient to justify any change in the ship roughness allowance of 0.0004 used in association with the Schoenherr curve, when applied to clean new ships. It was also agreed that in all published work, model or ship data should be corrected to a standard temperature of 59 deg. F. (15 deg. C.). The correction should be that agreed upon at Paris when the Froude

PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.

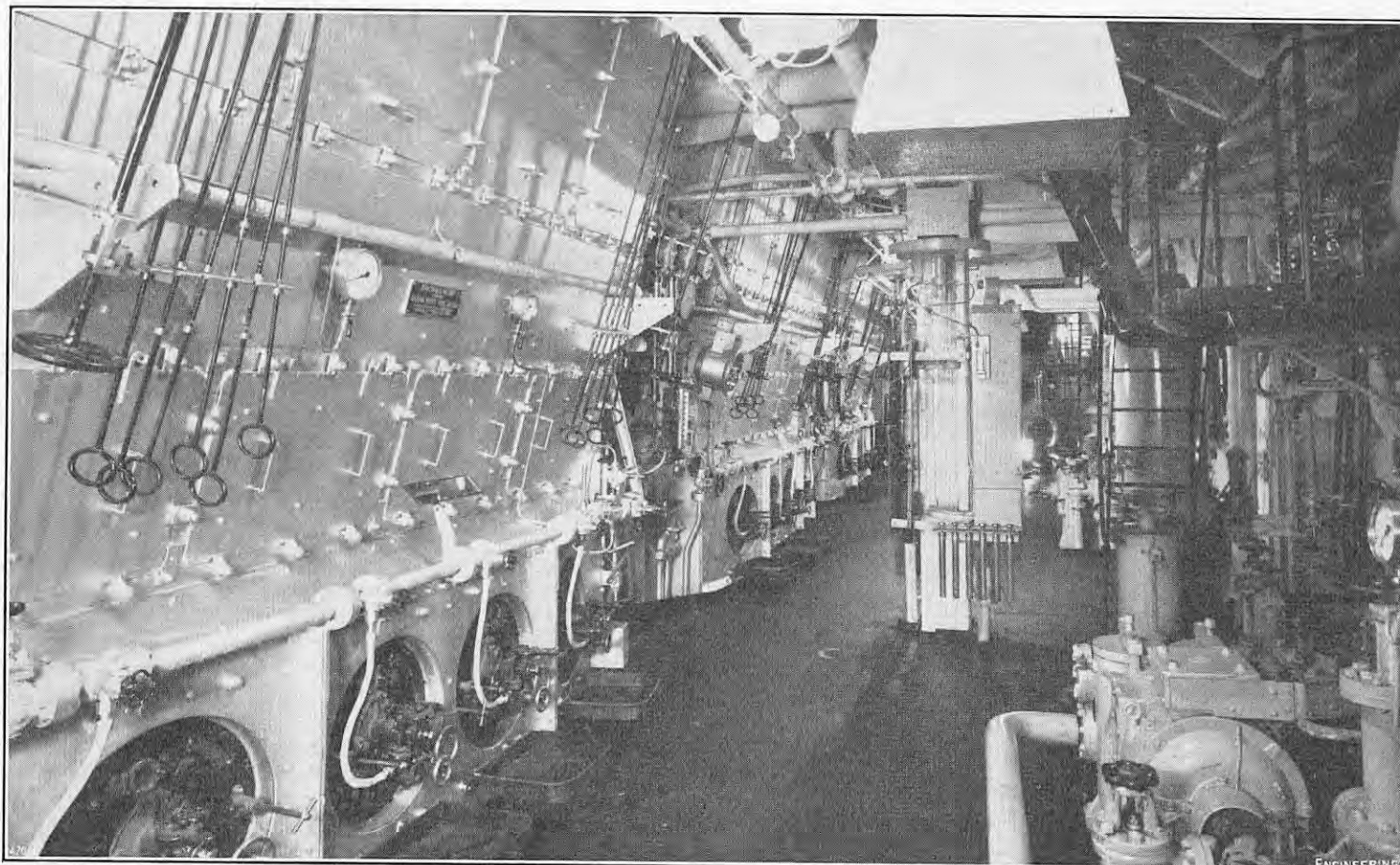


FIG. 20. BOILER ROOM.

coefficients were employed, and with the Schoenherr method it should be made by the correct value of the kinematic viscosity in the Reynolds Number. The length to be used should be that on the load waterline; the wetted surface to be used should be calculated without any correction for fore and aft obliquity (i.e., it should be the product of girth and length) and that the values of kinematic viscosity and mass density approved by the American Towing Tank Conference should be used.

(3) No change in the standard cavitation number was proposed, despite views that radial velocity and, alternatively, the gas content ought to be included. The permanent Cavitation Committee were instructed, however, to consider the plotting of some results on the basis of a cavitation number to include the gas content.

On (4), no very definite recommendations were made. In the course of the discussions, it was generally agreed that internal stimulation was more satisfactory than external. The main advantage of the external method of using struts is, of course, that the additional resistance is not necessarily included with the model as in the case of trip wires or pins. Though trip wires have been so widely used, there was agreement with the preference of the National Physical Laboratory for pins. "Overstimulation," it was decided, was to be examined. This term is generally considered to mean the supply of more energy to the boundary layer than is required to effect complete turbulence.

(5) The Conference considered that "the programme of geosim experiments outlined by the Netherlands tank, to be carried out on a Victory ship series, is of the utmost value in connection with our understanding of the fundamentals of propulsion scale effect." Various detailed suggestions were also made regarding the need for the utmost accuracy in geometrical similarity, etc.

(6) Some doubts had been expressed, whether "The Seagoing qualities of Ships" formed a suitable subject for such a highly specialised Conference, and whether it was not outside its scope.

The agreed decision was that "The Conference recognises seaworthiness as a subject coming within the field of its interest. Its concern is primarily with the model testing aspects of the subject, but it accepts the importance of maintaining close liaison with studies of full-scale ships at sea."

The Conference recognised that much work remained to be done with existing types of facilities, involving waves having a single component, but that the logical next step was to introduce waves having two or more components, travelling in the same direction. Professor K. S. M. Davidson had put in a plea for more complex waves involving components in different directions; the objection to this proposal was the necessity for wider tanks than are available at present.

Under the heading (7) "Presentation of Resistance and Propulsion Data," a number of detailed recommendations were made. A very interesting point was the statement that "For comparative purposes, the Conference is of the opinion that the Froude (C) and (K) constants provide a suitable basis for defining the merits of different hull forms of the same or nearly the same displacement." Thus, though the Froude friction method seems to be nearing its end, the Froude circular constants are to take on a new lease of life. Up to now, they have not been widely used outside Great Britain as the Taylor method for calculating residuary resistance as a separate item has been preferred, especially in the United States. A valuable recommendation was that a list of symbols proposed by the Interim Committee was to be accepted as a tentative international standard for use in all published work. This list and the B.S.R.A. list of symbols are now in very good agreement. This satisfactory result is due to efforts on both sides of the Atlantic, notably by Captain Saunders in the United States and by the B.S.R.A. and Mr. J. M. Ferguson in Great Britain. The very complete survey by Señor Acevedo, of the Madrid tank, was also helpful.

THE PASSENGER AND CARGO LINER "KENYA."

(Concluded from page 394.)

WE conclude below our description of the liner Kenya, built and engined by Barclay, Curle and Company for the British India Steam Navigation Company's service between London and East Africa, by giving particulars of the main propelling machinery and auxiliaries, illustrated by Fig. 20, on this page, and Figs. 21 to 32, on Plates XXXII to XXXIV.

The main engines, of 11,200 shaft horse-power, consist of two sets of Parsons steam turbines, each set having a high-pressure, intermediate-pressure, and low-pressure turbine, driving through single-reduction double-helical gears. The high-pressure turbine is of the impulse-reaction type, the reaction portion being fitted with stainless-iron end-tightened blading. A nozzle belt is fitted for use when the maximum power is required. The intermediate and low-pressure turbines are fitted with reaction blading throughout; the blading in the intermediate-pressure turbine is all of the end-tightened type. The propeller shafts, at the service power, make 125 r.p.m. The astern turbines are designed to give a total power of 65 per cent. of the normal service power. The high-pressure astern impulse wheel is in the intermediate ahead turbine casing and separated from it by a diaphragm, and the low-pressure astern turbine is at the exhaust end of the low-pressure ahead turbine. At the manoeuvring valves, the steam pressure is about 430 lb. per square inch and the temperature about 750 deg. F. The astern turbines are designed to take steam at this pressure and temperature, but provision is made, by fitting attempters in the steam drums of the boilers, to give a final steam temperature of about 600 deg. F.

The superheat temperature is controlled by an oil relay system and by means of a cock at the starting platform, the relay valves in the boiler room admit-

TWIN-SCREW PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.

(For Description, see Page 438.)

FIG. 21. STARTING PLATFORM.

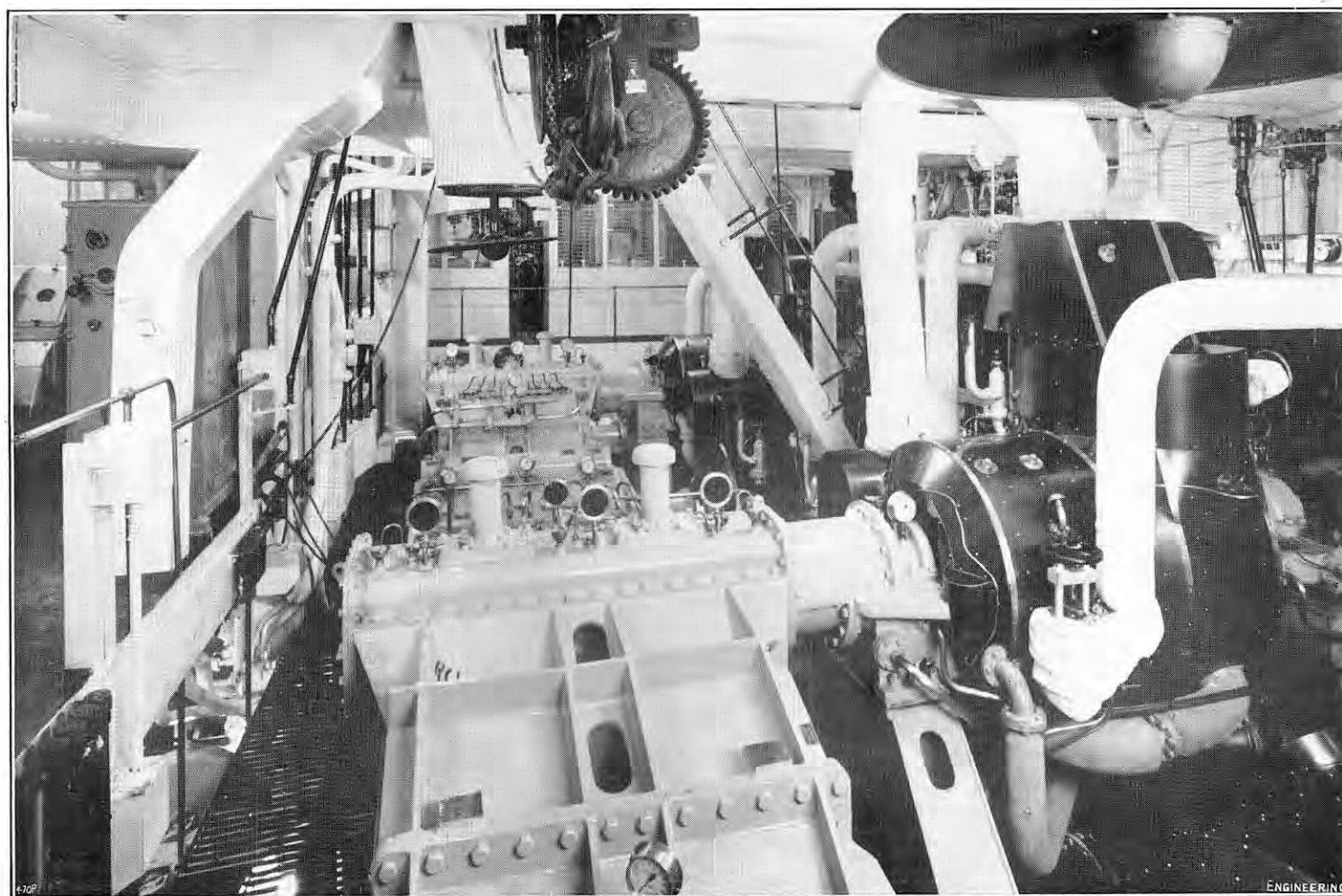


FIG. 22. ENGINE ROOM, SHOWING GEARCASES.

TWIN-SCREW PASSENGER

BARCLAY, CURLE AND

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Fig. 23. SECTION THROUGH ENGINE ROOM BOILER ROOM & UPTAKES.

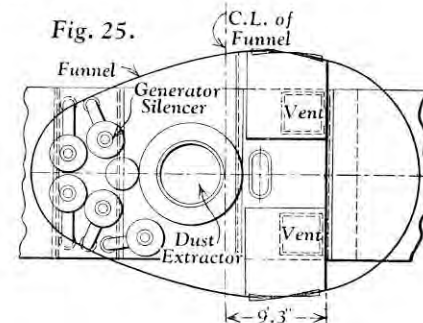
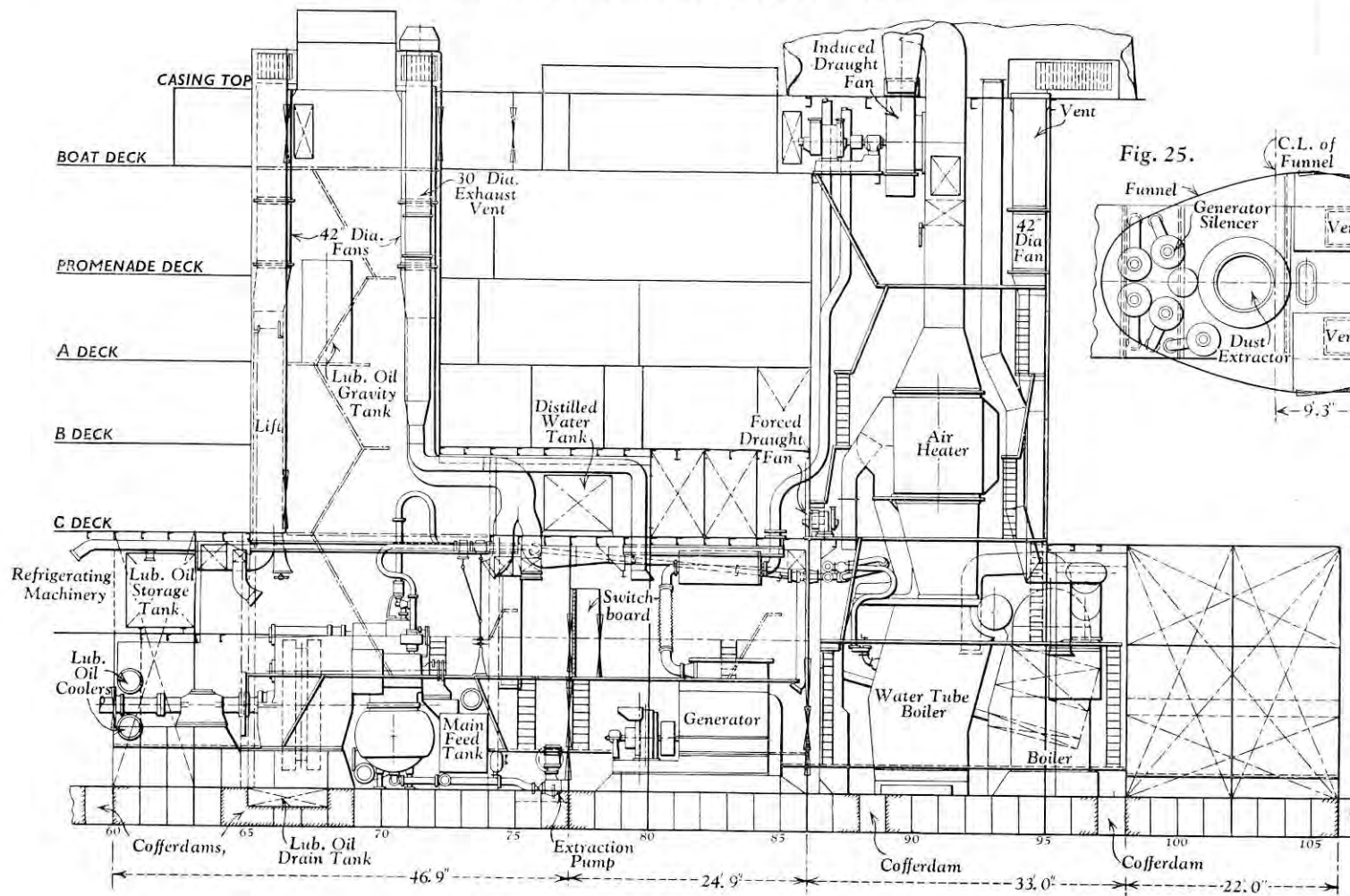
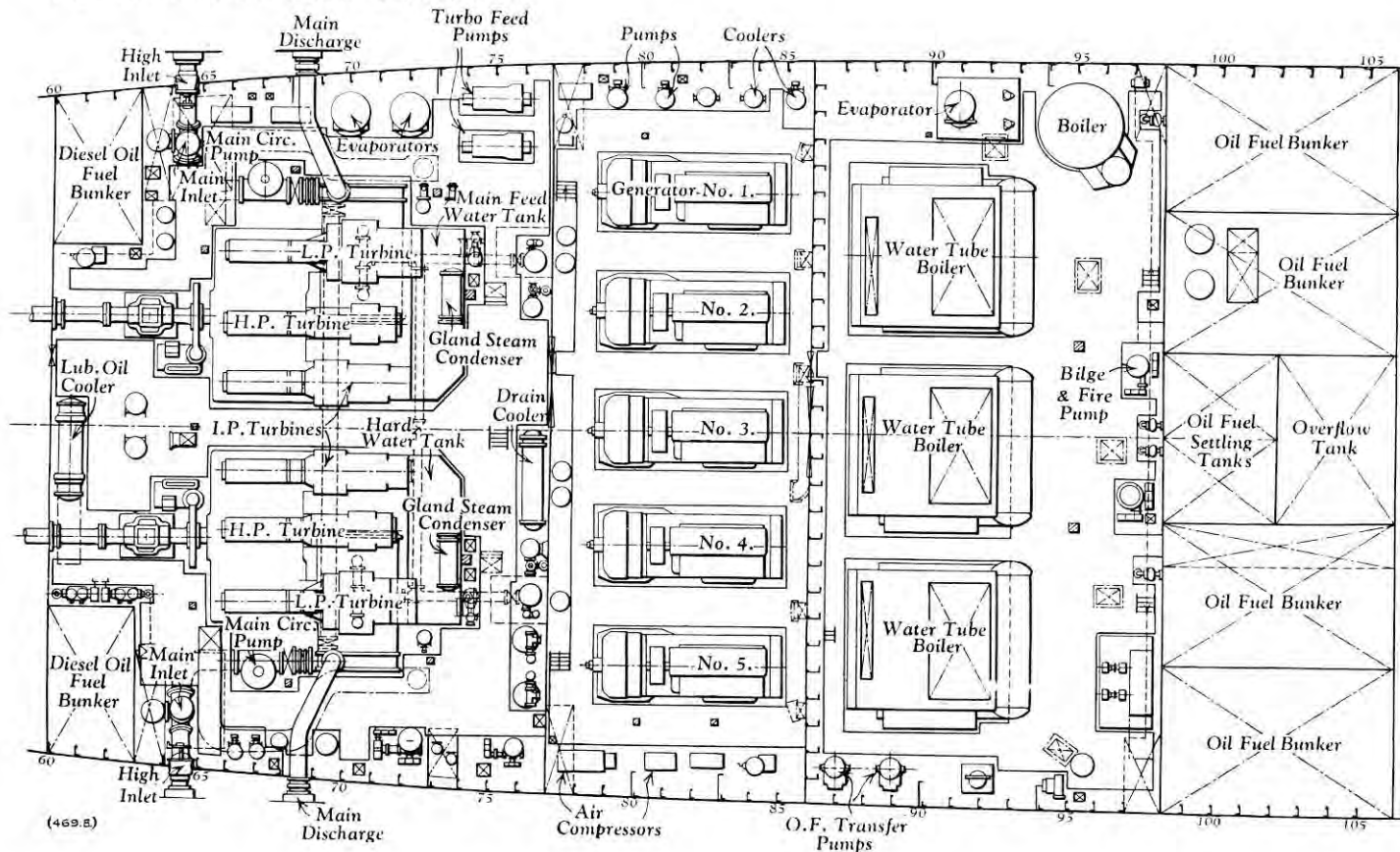


Fig. 24. PLAN OF ENGINE ROOM & BOILER ROOM.



CARGO LINER "KENYA."

Y, LIMITED, GLASGOW.

Page 438.)

Fig. 26. SECTION AT FRAME 64
LOOKING FORWARD.

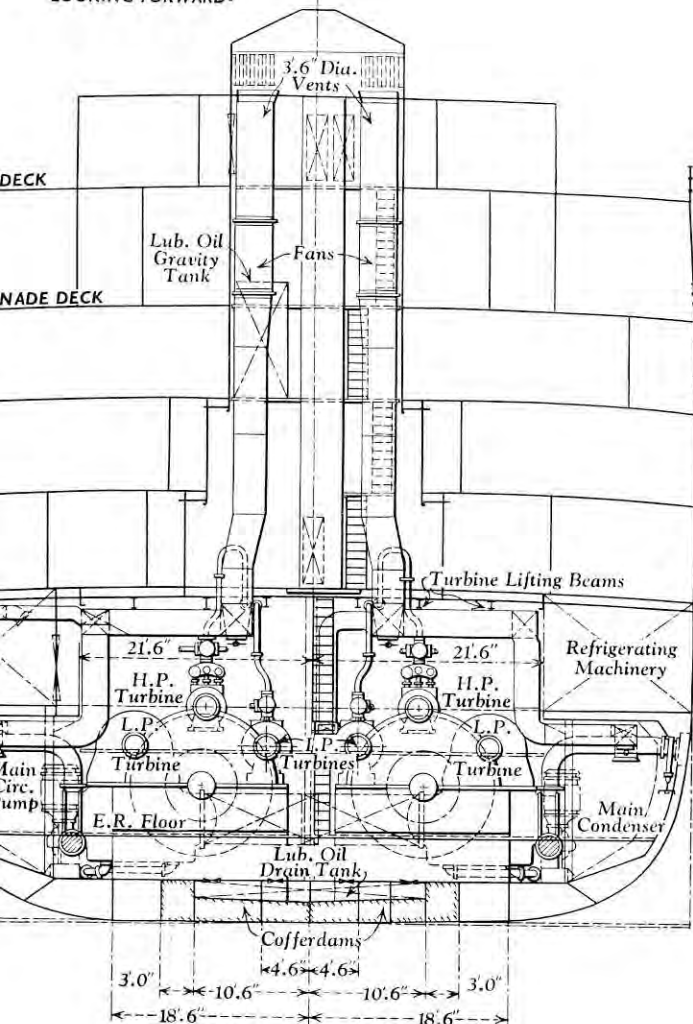


Fig. 27. SECTION AT FRAME 72
LOOKING FORWARD.

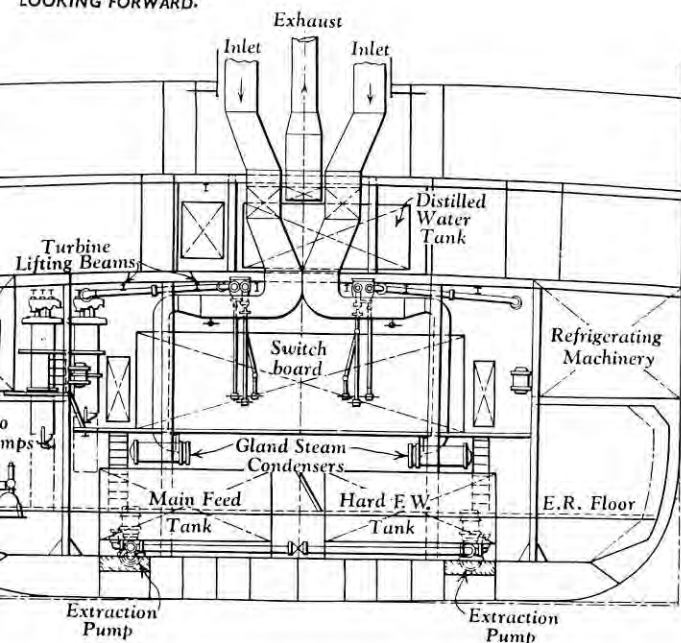


Fig. 27.
SECTION AT FRAME 86
LOOKING FORWARD.

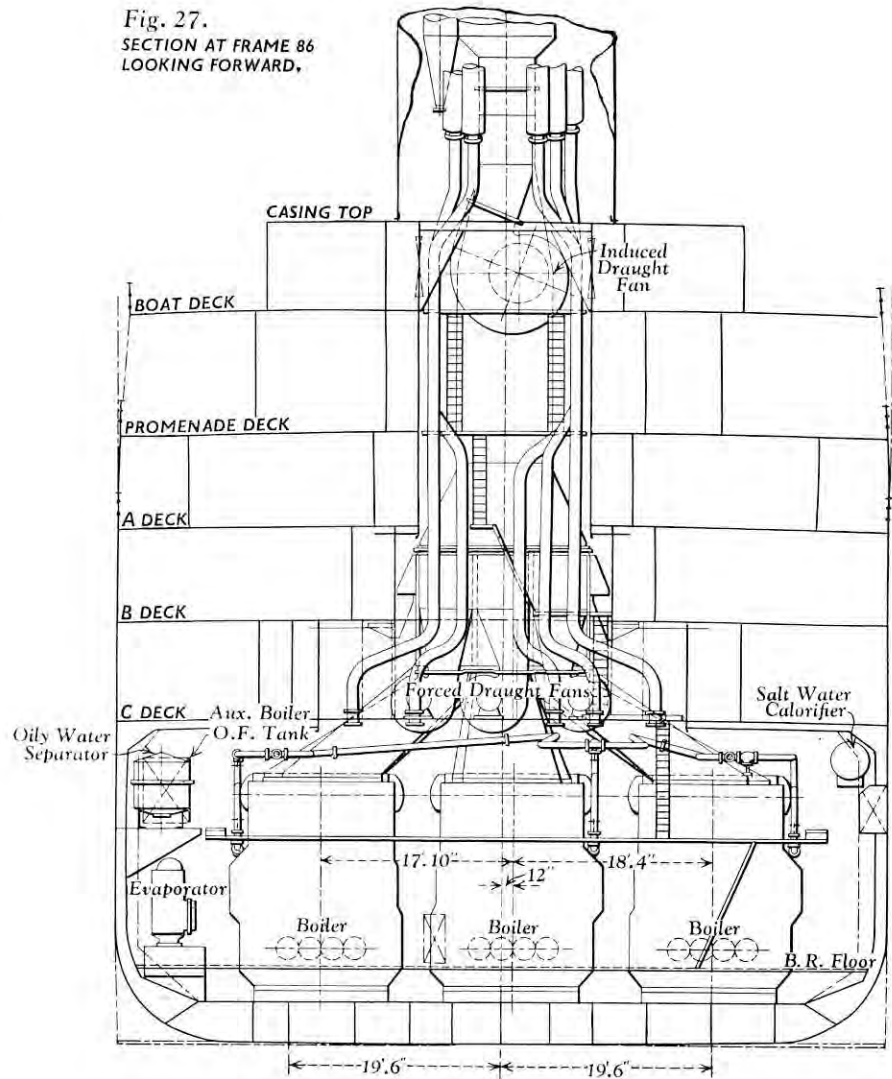


Fig. 29. SECTION AT FRAME 70
LOOKING FORWARD.

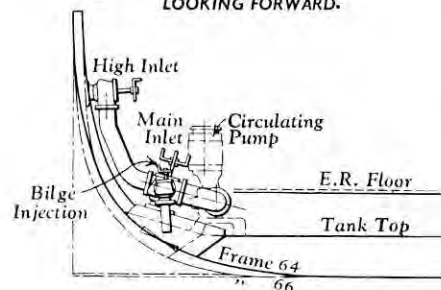
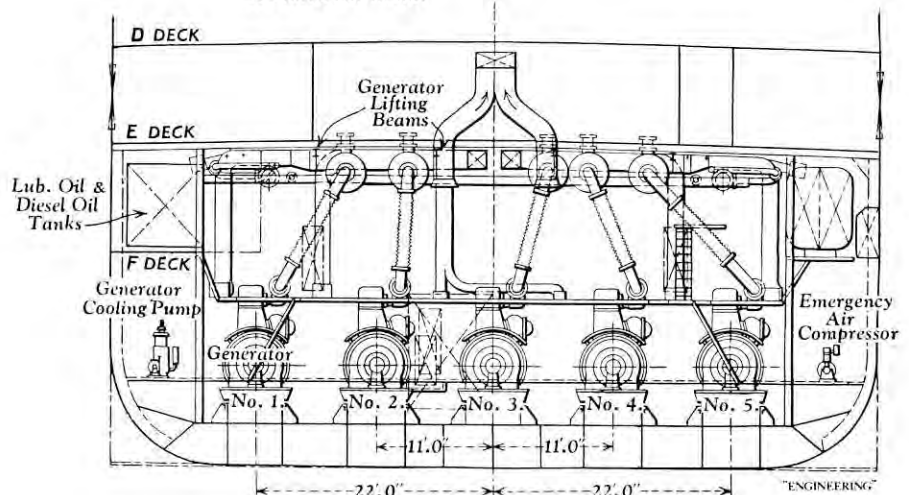


Fig. 30. SECTION THROUGH GENERATOR ROOM
LOOKING FORWARD.



TWIN-SCREW PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURTLE AND COMPANY, LIMITED, GLASGOW.

(For Description, see Page 438.)



Fig. 31. Turbines.



Fig. 32. Generator Room.

ting steam to the attemperators for reducing the temperature. The same cock operates the control valves in the boiler room, to shut the steam off from the attemperators and supply steam at full superheat to the turbines. The turbines are operated by Cockburn manoeuvring valves, mounted with the ahead and astern valves in one casting, and there is a separate master shut-off valve on the astern range. Aspinall governor gear is fitted, and operates through the forced-lubrication system which supplies lubricating oil to the bearings of the turbines and gears; sprayers supply oil directly to the gear teeth. The turbines are stopped automatically if, from any cause, their speed exceeds a predetermined limit, or if the oil supply should fail, or if the vacuum in the condenser becomes too low. A hand control valve is fitted, so that the turbines can be stopped quickly in an emergency.

Steam is supplied by three Babcock and Wilcox boilers designed for a working pressure of 480 lb. per square inch, and having a total heating surface of 21,117 sq. ft. They burn oil fuel under a balanced-draught system. There are three forced-draught fans, one for each boiler, and a single induced-draught fan, capable of dealing with the waste gases of all three boilers at maximum evaporation. This fan discharges through a Howden dust collector of the latest dry type, which extracts all grit and soot from the waste gases. The grit and soot are discharged into a hopper flushed with sea water, and the mixture is led overboard below the sea level. Because of the corrosive nature of this mixture, the discharge pipes and valves normally have to be rubber-lined, but in the Kenya special rubber hose with embedded armouring has been adopted instead of rubber-lined steel pipes.

The closed-feed system is of Messrs. G. and J. Weir's latest design, with motor-driven condensate-extraction pumps; there are two of these pumps, one for each set of engines, each being capable of dealing with the condensate from the two sets of turbines. These pumps discharge through the usual air ejectors, gland-steam ejector and condenser, and drain cooler to the main feed pumps, which are turbine-driven and exhaust to the low-pressure feed heater. The feed-heating is in two stages, the high-pressure heater receiving bled steam from the intermediate-pressure turbine at a pressure of 90 lb. per square inch absolute. The supply of bled steam can be augmented by live steam if required.

The auxiliary machinery, comprising main circulating pumps, forced-lubrication, ballast, bilge and fire, fresh-water, hot salt water and sanitary pumps, etc., are all electrically driven, and are all supplied by Drysdale and Company, Limited. The pumps which discharge overboard have push-button stops fitted in a convenient position at the boat deck, so that, should it be necessary to use the lifeboats, in an emergency the pumps can be stopped to prevent the discharge flooding the lifeboats. The fresh-water supply, both hot and cold, operates on Messrs. Drysdale's "Pneupress" system, and the pumps supplying the water start and stop automatically. There are two pumps; should one be unable to cope with the demand, the second pump automatically comes into action. The sanitary and salt-water system is also automatic, but in this case a supply tank is fitted high enough in the ship to give a suitable delivery at the highest tap in the ship. The sanitary pumps are automatically started and stopped, according to the level of the water in the tank. The power for these pumps, the steering gear, and the deck machinery and services is supplied by five Diesel-driven generators, each of 390 kW capacity, built by W. H. Allen, Sons and Company. Three generators are capable of meeting the maximum electric load. There is also a 50-kW emergency set. There are about 500 electric motors in the ship. The generators are installed in a separate compartment between the engine and boiler rooms, as shown on Plate XXXII, with the switchboard fitted behind and on the same level as the starting platform, as can be seen in Fig. 21, on Plate XXXII.

For the ventilation of the machinery space, an installation of Thermotank fans and trunking has been fitted. There are four torpedo-type motor-driven fans in the engine room, each capable

of delivering 20,000 cubic feet of air per minute at a pressure of $1\frac{1}{2}$ in. water gauge. Branches are led into the generator room, and there is also an extraction fan for removing foul air from this compartment. For the boiler room, two fans are fitted; these also are of the torpedo type and each delivers 20,000 cubic feet of air per minute. Trunks are led to all points where the air might otherwise become too hot or stagnant. A feature of the system is that there are no cowls on the vent intakes; the openings are in the form of spray and rain screens which prevent water from entering the air trunks. In the engine room, they are arranged on the casing sides, and for the boiler-room vents the screens are fitted on the side of the funnel.

Dampers are fitted in each ventilation trunk and are geared so that the air supply to the machinery space can be cut off in case of fire. The operating gear is fitted outside the machinery space, to be accessible in any circumstances. Any fire which might be started by oil escaping from pipes or tanks in the machinery space can be controlled by shutting off all connections to the oil tanks by quick-closing valves, which can be instantly shut from a position outside the machinery space. In addition, a fire foam system of the Pyrene type is fitted, which can completely cover the area of the boiler room. Two 30-gallon engines, also of the Pyrene make, are installed, together with a number of portable extinguishers for dealing with a small outbreak of fire. The installation includes pressure alarms, low-level alarms for the boilers, distance-reading water-level indicators and temperature gauges, salinometers and electric torsionmeters.

There is a main CO_2 refrigerating plant, comprising three machines, to deal with the ship's provisions, the cargo spaces and air-conditioning requirements. All cargo spaces are air-cooled, and there are five insulated spaces with a total capacity of 25,000 cubic feet. The vessel can carry 9,650 tons dead-weight. There are nine insulated ship's storerooms and five insulated cupboards.

THE OLD CENTRALIANS.—The next monthly luncheon of the "Old Centralians"—former students of the City and Guilds Engineering College—will be held on Monday, October 15, at the restaurant "Chez Auguste," 47, Frith-street, London, W.1. Sir Frederick Handley Page, C.B.E., F.C.G.I., will pay a tribute to Professor Silvanus Thompson, formerly Principal of the Finsbury Technical College, the centenary of whose birth occurred this year, on June 19.

JUNIOR INSTITUTION OF ENGINEERS.—The Council of the Junior Institution of Engineers have made a number of awards in respect of papers and lectures delivered during the session 1950-51. These include the Institution Premier Award to Mr. T. F. Luck, for his paper, "Engineering Practice in the Production of Tyre Moulds"; the Institution Prize to Mr. S. J. Button, for his paper, "Soil Testing and its Application to Foundation Problems"; the Vickers Prize to Mr. R. A. Benson, for his paper, "The Erection of a Spirally-Guided Gas Holder"; the Tooke Award to Mr. F. M. Panzetta, for his paper "Rubber in Aircraft"; the Past-Secretary Dunn Award to Mr. S. C. North, for his "lecturette," "A Review of Modern Basic Machine Tools"; the North-Western Section Award to Mr. W. H. G. Powell, for his paper, "A Marine Engineer's First Voyage"; and the Sheffield Section Award to Mr. G. F. H. Peacock, for his paper, "The Science and Practice of Dust Collection as Applied to Industry."

THE AVENUE COKING PLANT OF THE NATIONAL COAL BOARD.—A contract has been entered into between the National Coal Board and the Woodall-Duckham Vertical, Retort and Oven Construction Company (1920), Limited, Brompton-Road, London, S.W.1, for the erection of a coking plant at Avenue, Wingerworth, near Chesterfield. The installation will consist of 106 ovens with a total output of 500,000 tons of coke per annum, as well as of large quantities of gas, which will be distributed locally. Extensive coal blending facilities and a normal primary by-product plant will be provided, and there will also be plant for tar distillation, gas purification and sulphuric acid manufacture. It is estimated that about three million gallons of crude benzole and six million gallons of crude tar will be produced annually. The start of this important project was made the occasion of a ceremony at the offices of the National Coal Board on Wednesday, October 3, when the chairman (Sir Herbert Houldsworth) handed the order to proceed to Mr. T. C. Finlayson, chairman of the Woodall-Duckham Company.

FUEL RESEARCH IN THE COMMONWEALTH.

In 1946, the British Commonwealth Scientific Official Conference met to consider ways for ensuring the fullest possible collaboration between the Government scientific organisations of the Commonwealth and Colonial territories. One of their recommendations was that specialist conferences should be held from time to time to consider certain scientific fields. In 1950, therefore, a specialist conference on fuel research was held in London, from July 24 to 28, at which delegates representing the United Kingdom, Canada, Australia, New Zealand, South Africa, India, Southern Rhodesia, Central Africa, Nigeria, and the Colonies were present; their report has been published recently by H.M. Stationery Office, Kingsway, London, W.C.2, price 9d. net.

They have recommended that a Commonwealth Committee on Fuel Research be set up under the chairmanship of Dr. A. Parker (who was chairman of the specialist conference), with a secretariat in London. Future specialist conferences, they consider, should meet at intervals of three or four years. The effort devoted to fuel research is not sufficient, and the conference recommends that its expansion in the Commonwealth should be implemented as rapidly as possible. The surveys of fuel resources in the Commonwealth should if possible, be intensified. In some countries there are insufficient facilities for obtaining degrees, especially research degrees, externally or by part-time university courses, and it is recommended that selected research laboratories should be recognised as centres at which work for post-graduate degrees can be carried out. It is also recommended that fuel research organisations should encourage members of their staff to enter for post-graduate fellowships and scholarships, and, when possible, to take them up in other countries. Measures for the revised distribution of research reports and the exchange of information are recommended, and it is suggested that financial provision should be made by the Commonwealth Governments to enable fuel research workers to visit other countries to study the latest developments.

Fuel research in the Commonwealth, it is recommended, should be divided into broad divisions, each under a Chief Co-ordinator, who would arrange for periodical reviews to be issued to the London secretariat. The following subject divisions are to be set up immediately: sampling and chemical analysis, physical testing and petrographical work, brown coal, coal washing and preparation, gasification, synthetic liquid fuels, industrial gas turbines, and carbonisation and the production of coke.

The National Coal Board have offered to provide Commonwealth countries with a report on the Board's standard techniques for sampling and testing coals for washability and for testing coal-washing systems. To supplement this report, the Conference have recommended that each Commonwealth fuel-research organisation should submit a report on its own facilities and problems, from which a composite report would be drawn up to be circulated to other organisations. It is also recommended that, in order to supply a basis for research on the production of coke for metallurgical processes, specifications for the cokes used in the various countries should be prepared and circulated in the same way. It is considered that there is, at present, no need to undertake further experimental work on underground gasification, but the question should be reviewed when sufficient progress has been made in the investigation carried out by the United Kingdom. Each country should, however, continue to investigate the complete gasification of coal, coke, or lignite for producing town's gas and other fuel gases, and special steps should be taken to ensure collaboration and exchange of information; the United Kingdom and Australia should offer guidance on the technical and economic aspects of gasification. On the development of oil from coal by synthetic processes, such as the Fischer-Tropsch or hydrogenation processes, the Conference consider that additional research work should be undertaken by Commonwealth countries.

CONFERENCE ON ELECTRIC TRACTION AT INDUSTRIAL FREQUENCIES.—A conference on electric traction at industrial frequencies has been organised by the Société Nationale des Chemins de Fer Français and will be held at Annecy from Friday, October 12, to Monday, October 15. Annecy is situated on the line from Aix-les-Bains to La Roche-sur-Foron, which was experimentally converted to 50-cycle electric traction in May. Proceedings will be opened by M. Louis Armand, Directeur Général de la Société Nationale des Chemins de Fer Français, after which papers will be read describing the new method of traction, the technical problems to which it gives rise, and the present position of the investigations that have been made by the railway authorities and the manufacturers concerned. Opportunities will be provided for inspecting the rolling stock and other equipment.

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.

Hexagon Bolts, Screws, Nuts and Washers.—At an important conference between industrial and Service delegates from the United Kingdom, Canada and the United States, held in London in April, 1951, under the ægis of the British Standards Institution, agreement was reached, in principle, on the basic dimensions of hexagon bolts, screws and nuts, and overall limits were established for two series, namely, normal and heavy. Two specifications, embodying the decisions of the conference, have just been issued. The first is B.S. No. 1768: 1951 and covers "Unified Precision Hexagon Bolts, Screws, Nuts: Unified Coarse (UNC) and Unified Fine (UNF) Threads: and Plain Washers: Normal Series." The second specification, B.S. No. 1769, covers the corresponding "Heavy Series." The nominal sizes of the normal series range from $\frac{1}{4}$ in. to 1 in., and the tolerances prescribed are those appropriate to engineering work where a good standard of dimensional accuracy and performance is necessary. The nominal sizes of the heavy series range from $\frac{1}{2}$ in. to 2 in. The tolerances are somewhat wider than those for the normal series, but it is recognised that bolts and nuts of the heavy dimensions may be required with a higher grade of finish for certain applications. Accordingly, clauses are included in respect of machined nuts and bolts faced under the head and machined on the shank. [Price of B.S. No. 1768 (normal series), 3s., and of B.S. No. 1769 (heavy series), 2s. 6d., postage included in both cases.]

Carbon-Steel Castings for Surface Hardening.—A new specification, B.S. No. 1760, covers carbon-steel castings for surface hardening and is one of a series under preparation for steel castings for general engineering purposes. It deals with castings which require to be surface hardened by a local heating and quenching process. Two grades of steel are specified, namely, grades A and B, the first of which is to contain between 0.40 and 0.50 per cent. of carbon, and to show a tensile strength of 40 tons per square inch, and a surface hardness, after hardening, of 550 diamond-pyramid numbers. Grade B is to contain between 0.55 and 0.65 per cent. of carbon, and to show a tensile strength of 45 tons per square inch, and a surface hardness, after hardening of 600 D.P.N. Inspection and testing are covered in detail and an appendix contains recommendations on the repair of castings by metal-arc welding. [Price 2s., postage included.]

Glossary of Terms used in Plastics Industry.—One of a series of glossaries of terms used in various industries has just been issued. This, B.S. No. 1755, constitutes a glossary of terms used in the plastics industry. It has been compiled by the British Plastics Federation and is to form a basis for discussions on an international level by "Technical Committee 61—Plastics" of the International Organisation for Standardisation. The terms are grouped in sections, to cover chemistry, industrial applications, constituents, properties, moulding processes, and other manufacturing processes. All the terms contained in the glossary are fully defined. [Price 6s., postage included.]

Knurling Wheels.—Prepared in response to a request from the Gauge and Tool Makers' Association, a new specification, B.S. No. 1759, relates to knurling wheels having straight and spiral teeth which can be arranged to produce any normal knurling, including the diamond form. Details of four grades are given, these being differentiated by the number of teeth per inch, while a fifth grade, suitable for use in hand-knurling tools, is also included. The specification contains details of the main dimensions and tolerances, and stipulates certain manufacturing and material requirements. The appendices include notes on knurling operations and give illustrations of some of the popular designs of complete knurling tools used on capstan and automatic lathes. Various forms of wheels are illustrated, while details of wheels intended for use in hand-knurling tools are also furnished. Notes on hand-knurling are included in a separate appendix.

Road Stone and Chippings.—A third revision of B.S. No. 63, covering single-sized road stone and chippings, has now been published. It deals with aggregates for use in the construction and maintenance of roads and contains requirements for grading and particle shape as well as methods of sampling and test. The most important change in the revision is the adoption of a "flakiness" test for particle shape, instead of the elongation test formerly specified. In addition, a glossary of rock and mineral names and a method of classification into groups, are also included. [Price 3s., postage included.]

LABOUR NOTES.

EUROPEAN workpeople, from 17 countries benefiting under the Marshall plan, are to be sent to the United States each year for twelve months to study American methods of production, according to a scheme developed by the office of the special representative in Europe of the Economic Co-operation Administration and announced in Paris on Tuesday last. It is expected that up to 2,000 skilled and semi-skilled employees, between the ages of 20 and 33, will be able to visit the United States every year under the terms of this arrangement. A commencement will be made in January, 1952, when some four hundred young workpeople will leave Europe for the United States. Work will be found for them on their arrival in America and, from the time that they obtain positions there, they will be responsible for paying their own living charges, study fees and taxes. Their travelling expenses to and from the United States and certain incidental expenses, however, will be shared equally between the Economic Co-operation Administration and the students' countries of origin.

The scheme aims at providing both comprehensive courses of instruction in American methods of increasing productivity, and opportunities for studying the American way of life. In addition to the benefits to be derived from their employment in the United States, the visitors will be expected to attend classes in a number of subjects. The United Kingdom and Austria are each being asked to provide two hundred nominees a year for these tours, and larger numbers of participants are being invited from France, Italy and West Germany. Holland, Belgium, Denmark, Norway, Turkey, Greece, Eire, Sweden, Portugal and Yugoslavia will send smaller parties. Trieste has been invited to send twenty workpeople each year and Iceland ten. It is understood that, in all, more than two thousand persons have applied to be included in the first group of 400 due to leave for the United States in January next.

Renewed and more intensive efforts are to be made by officials of the National Union of Mineworkers to encourage greater willingness on the part of British miners to accept Italian recruits. Although miners at some pits have agreed to take Italians, those at many others have intimated through the local branches of the union that they are not willing to do so. It is stated by the National Coal Board that, at the present time, there are vacancies and accommodation for foreign workmen at 41 collieries in the South-Western Division, 46 collieries in the North-Eastern Division, and 27 collieries in the West Midlands Division. The same state of affairs exists at an unspecified number of pits in the North-Western Division. The Board estimates that places for about five thousand Italians could be found in British mines before the end of the present year but, owing to the men's objections, not more than one thousand will be sent to the coalfields during the next four months.

Up to the end of September, 786 Italians had arrived in Britain for employment in British coal mines and a further 71 were due to arrive last Wednesday. Consent to the employment of Italians has been given by miners at 11 collieries in the West Midlands Division, at 14 collieries in the North-Eastern Division, and at several pits in the North-Western Division and the South-Western Division. These collieries have agreed to accept between them a total of 1,026 Italians, of whom 300 will go to the pits in the North-Western Division and 279 to the pits in the North-Eastern Division. As previously stated in these columns, various reasons have been given for the opposition to the use of Italian man-power in British coal mines, such as the men's distrust of foreigners as fellow employees, and the fear of their being used to reduce wages or debase working conditions. Officials of the N.U.M. have pointed out that the union has consented to the employment of Italians in the mines only on the understanding that each man joins the union and that the Italians are to be the first to be discharged in the event of a surplus of labour arising in the industry.

Difficulties threatening the coal-mining industry were referred to by Lord Hyndley, G.B.E., formerly chairman of the National Coal Board, at a luncheon of the Coal Industry Society in London on Monday last. He had, he said, held the opinion for a long time that a great deal of coal was lost in Britain every year owing to its not being used to the best advantage. This wastage of an essential material occurred not only in the domestic field, but also in a large number of factories. It was his opinion, also, that a much higher degree of efficiency could be obtained in the coal mines themselves. On the same occasion, Mr. Oliver Lyle, a director of Tate and Lyle, Ltd., stated that Britain at the present time should be exporting coal at the rate of at least 20 million tons more per annum than,

in fact, she was doing. There was a gap in the home trade which amounted to more than 30 million tons yearly and the plans of the National Coal Board were such that the increase in production would not reach this level until after the lapse of another ten to fifteen years. Mr. Lyle considered that, if P.A.Y.E. was a factor in reducing coal production, the tax should be abolished.

Another Post Office wage claim was submitted to arbitration in London on Monday last. The Post Office Engineering Union applied to the Civil Service Arbitration Tribunal for increases of 1l. 13s. a week for telephone mechanics and of 1l. 3s. a week for assistant mechanics employed at Post Office factories. On behalf of the Department, it was stated that the Postmaster General had offered increases of 11s. a week to telephone mechanics and of 5s. 6d. a week to assistant mechanics. The union, however, it was stated, had rejected these offers as inadequate. More than eighteen hundred Post Office employees in London, Birmingham, Edinburgh and elsewhere are involved in this claim.

There was some decline in the total industrial production during July, as is usually the case, but the month's figures were an improvement on those for July last year. The index-of-industrial-production figure for July, 1951, is estimated provisionally at 139, against 149 for June. In 1950, the comparative figures were 134 for July and 143 for June. The Central Statistical Office, which is responsible for the preparation of the index, notes that the figures for July are affected every year by the incidence of the annual holidays. For the same reason, it is expected that there will be some worsening of the position during August, 1951. On the basis of information received to date, the Central Office anticipates that the provisional figure for all industries for that month will be between 127 and 128.

Production in the manufacturing industries, which include engineering and shipbuilding, reached an index level of 146 during July, 1951, compared with 157 during June, 1951. In 1950, the figures were 139 for July and 150 for June. The building and contracting industries maintained a level of only 135 for both June and July this year, compared with an index figure of 139 for June, 1950, and of 140 for July, 1950. In the mining and quarrying group of industries, levels of 117 during June, 1951, and of 107 during July, 1951, were attained. The corresponding figures for this group during June and July last year were 112 and 106, respectively. Gas, electricity and water services recorded productivity figures of 109 for June, 1951, and of 106 for July, 1951, against levels of 101 and 100 during June and July, 1950, respectively. The index figures are adjusted in each instance for the number of days, excluding Sundays, in each month. No allowance is made, however, for public or annual holidays. The index was commenced at the beginning of January, 1947, productivity during 1946 being taken as 100.

Increases took place in the full-time weekly-wage rates of some 1,165,000 workpeople during August, resulting in a total net wage increase of 324,000l. a week. The principal increases, according to the *Ministry of Labour Gazette* for September, affected workpeople in the iron and steel industry, electricity-supply undertakings, laundries, and the baking and brick-making trades. Other groups receiving increases included certain engineering, supplies and motor-transport employees of the Post Office, and operating staff employed by the Road Haulage Executive. During the eight months from January to August last, some 8,502,000 persons received net increases in their full-time weekly-wage rates amounting to a total of 3,618,000l. During the corresponding months of 1950, the number of workpeople to benefit by increased wages was only 2,818,000 and they shared a net weekly increase of only 521,000l. between them.

There was some increase in the severity of industrial disputes in the United Kingdom during August. The total for the month was 151, of which 139 were commenced during the month and 12 were in being when the month began. Altogether, some 22,300 workpeople were involved in the stoppages during August and about 73,000 working days were lost. During July last, 112 stoppages were in progress, 17,200 persons took part in them, and over 42,000 working days were lost. The comparative figures for August, 1950, were 106 strikes in progress, with 18,400 persons involved and 53,000 days lost. Of the total of 151 stoppages occurring during August last, 88 took place in the coal-mining industry. Some 11,700 miners participated in them and they caused a loss of 23,000 days. In the engineering industry there was a total of five strikes during August last; 1,800 persons took part in them and 24,000 days were lost.

HIGH-SPEED HYDRODYNAMIC DEVELOPMENT.

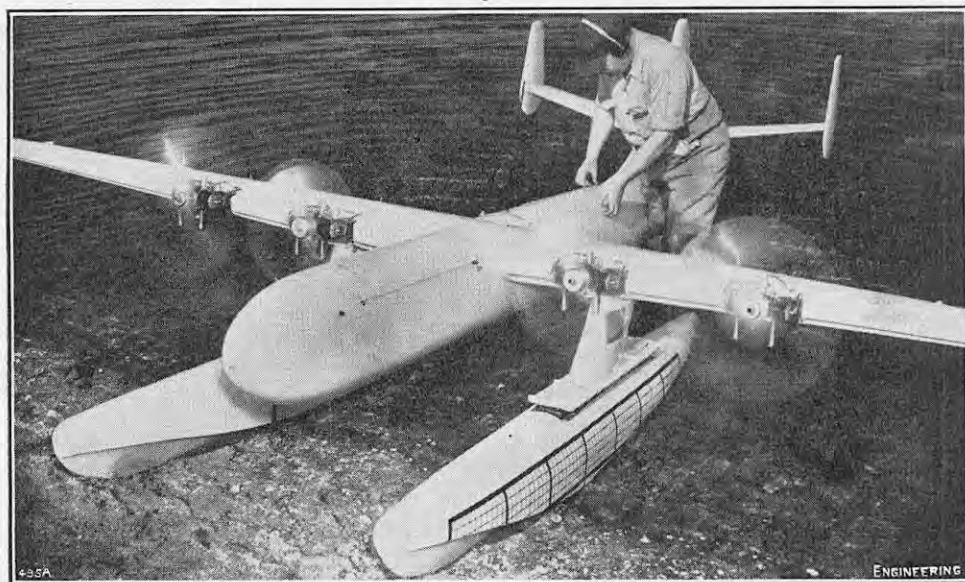
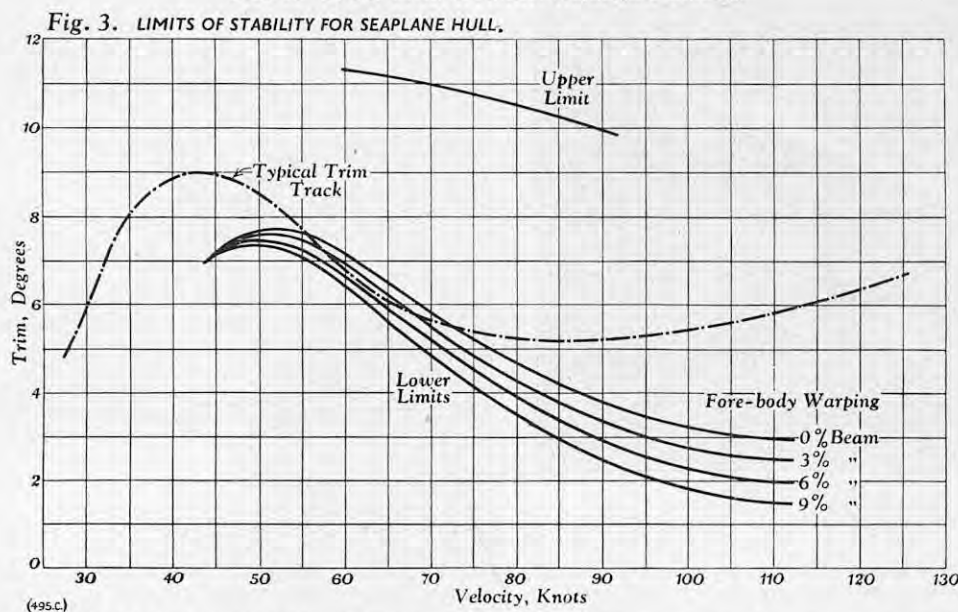


FIG. 1. 21-FT. SPAN DYNAMIC-RESEARCH MODEL.



A REVIEW OF HIGH-SPEED HYDRODYNAMIC DEVELOPMENT.*

By ERNEST G. STOUT, B.S.M.E., A.F.I.Ae.S.

EARLY efforts to construct water-based aircraft naturally drew heavily on the technology and experience of the naval architect, and for the most part followed the trend of highly-refined displacement-type hulls, which favoured the large, efficient load-carrying type of aircraft almost to the exclusion of other categories which depended largely on high speed.

The advent of world unrest forced upon aeronautical development the full exploitation of its greatest asset—speed. The aeronautical designers met this challenge by producing airframes and engines of amazing performance and reliability. When coupled with the best hydrodynamic designs available these aerodynamic developments resulted in efficient but slow aircraft. From a tactical and strategic standpoint, the full utilisation of the vast areas of readily available and bomb-proof water bases was desirable, but the large performance penalties which accompanied operation from water could not be accepted, and the seaplane was relegated to those functions where water-based operation was mandatory and outweighed other performance considerations.

In the years just before the second World War, it became apparent that the research methods of the naval architect, who visualised water-based aircraft as boats with wings, had to be replaced by a new concept. It was reasoned that all aircraft of a category should be highly-refined aerodynamic configurations having, in general, the same appearance, regardless of the means adopted for transition from the ground,

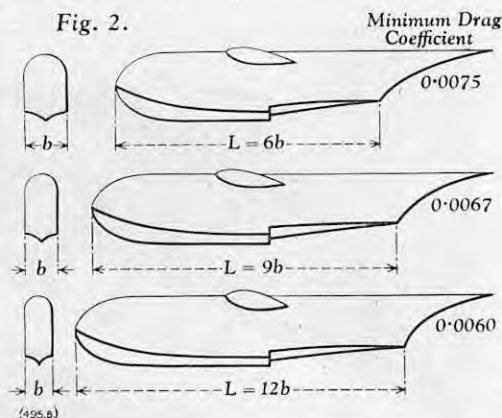
* Paper presented at the Third Anglo-American Aeronautical Conference at Brighton on September 5, 1945.

or water, to the air, and that there need be no difference in the performance of a land or water-based aircraft having the same aerodynamic mission.

The first step was to plan comprehensive research programmes to investigate new forms and principles of hydrodynamic sustentation, and a research technique employing dynamically similar models was developed. Since this method was adopted in the United States in 1938 by the author, it has resulted in steady improvement in water-based aircraft performance, and the Consolidated Vultee hydrodynamics laboratory initiated a programme in 1943 to develop free-body dynamically-similar models to be self-propelled and remotely controlled by positioning multi-channel radio. By May, 1945, a programme of correlation studies with a full-scale flying boat was completed.

The U.S. Navy sponsored studies to link the development of propeller-turbine power with a high-performance water-based aircraft design. The use of propellers precluded a drastic reduction in seaplane frontal area, since adequate water clearance required a relatively deep hull; however, it was believed that an appreciable reduction in drag could be achieved by reducing the large beam that had become characteristic of conventional flying boats.

In order to establish the relationship of hull length to beam with regard to hull load coefficient, stability and spray, a large 21-ft. span radio-controlled dynamic model, shown in Fig. 1, was built. This model used submerged piston engines which drove the propellers through extension shafts, in order to simulate a turbo-propeller installation. The engines were capable of producing power loadings equivalent to those anticipated in the new turbine-power plants, so that the important dynamic parameter of longitudinal acceleration could be reproduced. In order that precise determination of the equivalent hull size could be made, the wing and tail unit of this model were removable,



thereby allowing each hull configuration to be evaluated with the identical airframe and propulsive system. In all, 21 hull configurations were evaluated, covering a wide range of length-to-beam ratio, form and proportion. Concurrent with the free-body dynamic-model studies was a programme of tank tests run at the Stevens Institute of Technology, using a family of hulls identical in form to the 21 configurations investigated by Convair.

A new hull load criterion was thereby established which provided a measure of hull size when both beam (b) and length (L) were variables. Earlier studies had shown that increasing the length-to-beam ratio (L/b) resulted in marked improvements in resistance, spray and load-carrying ability.

The findings from both the Stevens Institute and Convair confirmed the fact that length-to-beam ratio had a powerful influence on the allowable magnitude of the load coefficient, CA (i.e., the load divided by the product of the density of water and the cube of the beam b), for constant spray and resistance. It was found also that, as the L/b ratio increased, the limiting value of CA increased in direct proportion to the function L^2/b , resulting in a smaller beam and overall volume of hull for a given load. This was a fundamental finding of immense importance, for it established the fact that hulls of varying length-to-beam ratio will have equivalent resistance and spray characteristics if a load coefficient similar to CA , but based on L^2/b instead of b^3 , is held constant. The results of an investigation to determine the aerodynamic effect of length-to-beam ratio is presented in Fig. 2. It will be noted that the anticipated reduction in drag is significant.

During the take-off of a seaplane, after it has passed the hump speed, the planing trim must remain between two limiting curves of trim or it will encounter instability known as "porpoising," a cyclic oscillation in pitch and rise; if allowed to persist it may become divergent and result in the destruction of the seaplane. The upper and lower limiting trim curves, between which the aircraft will be stable, are shown in Fig. 3 plotted against speed. The upper trim limit is a function of the after-body form and position. The lower limit depends almost solely on fore-body lines and increases rapidly to higher trim angles with increase in loading. Lower-limit porpoising has always been a problem in highly-loaded hulls; dynamic model tests during the second World War established that for best performance the fore-body contacted by the water during planing must be free of all longitudinal curvature. At speeds just beyond the hump, where lower-limit porpoising is most likely to be encountered, this wetted length has been found to extend approximately $1\frac{1}{2}$ beams forward of the step. As a consequence, it had become rigid design practice to maintain an area of constant dead-rise in this region, commonly called the "fore-body flat."

It was anticipated therefore that any great increase in hull load coefficient would result in severe stability problems in these new hulls. When load coefficients 200 to 300 per cent. above conventional practice became feasible, it was found that not only was the lower trim limit of stability rising rapidly, but that the long hulls were getting progressively more stiff in trim, which aggravated the condition. What appeared at first to be an insurmountable problem actually resolved into a straightforward solution when the rule-of-thumb criteria that had dictated fore-body design in the past was carefully analysed. It was demonstrated that straight buttock elements ahead of the step need not necessarily be accomplished through the use of constant dead-rise. It was a relatively simple matter to warp the fore-body flat area by progressively increasing the dead-rise ahead of the step at various linear rates. This allowed the effective fore-body angle of attack to be

HIGH-SPEED HYDRODYNAMIC DEVELOPMENT.

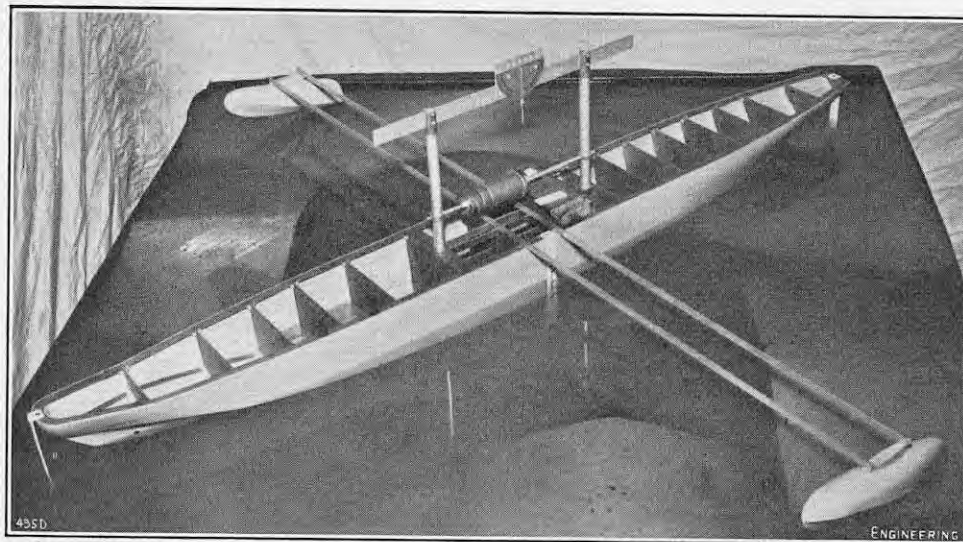


FIG. 4. TRIMMING BASIN AND DISPLACEMENT MODEL.

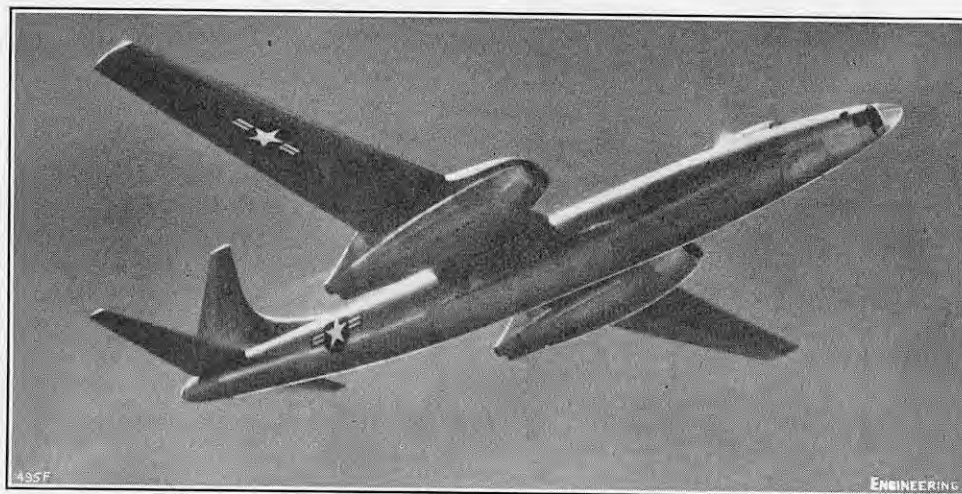


FIG. 9. CONVAIR XB-46 JET BOMBER.

adjusted to any value desired, still maintaining straight buttock elements. The family of lower trim limits shown in Fig. 3 illustrates the control acquired over lower-limit porpoising through fore-body warping.

It had long been desired to develop the seaworthiness and performance of seaplanes so that operations in relatively unprotected forward areas could be carried out. The survival probability of the aircraft in open water, away from base, depends upon the degree of flooding control provided. Conventional practice in seaplane design called for sufficiently watertight compartments to prevent the aircraft from capsizing in the event of two adjacent watertight compartments becoming flooded. This requirement was usually satisfied by providing five or six large full-depth bulkheads which divided the entire hull into six or seven watertight rooms. Normal access through the rooms was by means of small watertight personnel doors through these bulkheads. Such an arrangement precluded the use of the hull as an efficient cargo-carrier and implied complete inundation of equipment and cargo in the event of any damage afloat beyond the limited capacity of the bilge pumps. This condition was considered intolerable for a modern high-performance seaplane, and studies were initiated to incorporate into the high length-to-beam ratio hull an efficient and dependable multi-cellular watertight system.

Using a system of displacement models and a trimming basin, illustrated in Fig. 4, it was possible to make an elaborate study of hull compartments and flooding in a short time. For the high length-to-beam ratio hull, results indicated that 15 properly distributed cells would restrict the critical flood heights to levels below the floor of the cabin, thus completely freeing the inhabited portion of the hull of all obstructions, at the same time providing damage control which greatly enhanced the probability of survival. In many cases of minor damage it becomes feasible to take-off again, even with a compartment flooded, whereas a conventional seaplane must ride it out even though repairs to the equipment that caused the emergency

can be accomplished on the water. Structural studies of the multi-cellular principle of hull construction showed it to be a more efficient and lighter overall design.

A conventional V-bottom planing surface, such as is shown in Fig. 5, has been employed for years in classical research on planing phenomena, but it has never proved satisfactory for an actual seaplane hull because of the great height to which the spray would rise on leaving the chine. Therefore, rule-of-thumb criteria dictated some form of transverse curvature in the bottom of conventional seaplanes called chine flare, as illustrated in Fig. 6. During the second World War, when extreme overloading of all conventional seaplanes became a critical problem, extensive studies were initiated to determine the maximum influence on spray height that could be obtained through modification of transverse curvature. It was determined that a radius that is too small, or abrupt, would act only on the layer of water immediately adjacent to the hull, and the inertia of the unaffected mass would carry it by the local curvature with little change in direction. Similarly, if exaggerated reflex flare were employed, as in Fig. 7, the adjacent layer would actually rebound from the unaffected mass and rise higher than if no flare at all had been used. It was concluded that the most effective control, although vague, was obtained by a generous radius covering roughly one-third of the bottom and terminating with a horizontal or slightly downward direction at the chine.

During the course of isolating the effect of downward deflection of the chine, a simple expedient was employed which consisted of attaching a metal strip to a hull without flare and then progressively deflecting this strip and recording the spray height. As would be expected, there was no improvement beyond a few degrees of deflection below the horizontal, at which point the reflected spray became steadily worse, as in the condition of Fig. 7. When approaching a nearly vertical position, as shown in Fig. 8, marked reductions in spray height were noted. It was concluded that

Fig. 5. CONVENTIONAL HULL

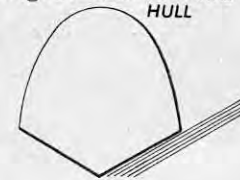


Fig. 6. PLUS CHINE FLARE

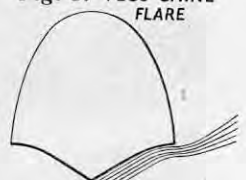


Fig. 7. PLUS REFLEX CHINE FLARE

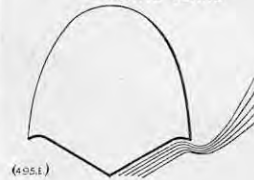


Fig. 8. PLUS SPRAY DAMS

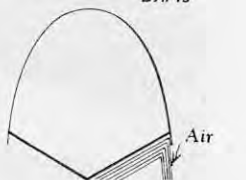


Fig. 10.

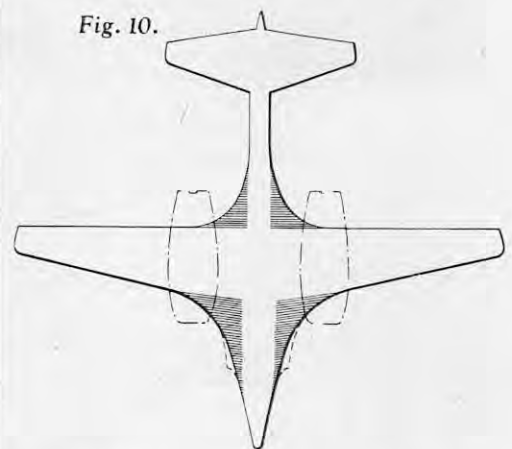


Fig. 11.



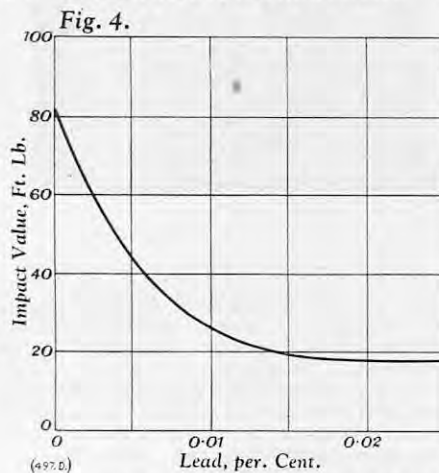
the increased effectiveness was due to the sharp intersection of the strip with the bottom, which in effect acts as a dam. This powerful effect was lost where the lowered chine was faired by using reflex flare, or a fillet of any nature. Because of obvious structural limitations, however, this highly effective vertical spray strip was not considered feasible for application to conventional hulls.

Convair had just completed one of the first jet-propelled land-based bombers to be built in the United States, the XB-46, shown in Fig. 9, and it appeared logical to attempt to "water-base" it with a minimum of revision. Deviating completely from established naval-architecture practice, a generous wing-hull fillet was added to the original XB-46, as shown in Figs. 10 and 11; and, to keep the thickness ratio of this addition within reason from the aerodynamic viewpoint, the plan form was faired generously into the bow and stern of the fuselage. As the frontal area had been increased, this was offset by eliminating the XB-46 engine nacelles and placing the engines within the fillets.

To investigate whether adequate spray control could be achieved by incorporating spray dams on this smooth fillet, a simple bridge-towed dynamically similar model was constructed to get a preliminary check on the hydrodynamic characteristics. From preliminary towing tests, it was concluded that spray could be controlled adequately at the design gross weight and that hydrodynamic stability was satisfactory. It was determined that the spray dam obtained its effectiveness by agitating violently the main spray blister and mixing it thoroughly with air. This aerated mass is deflected downwards with great force in a high-velocity jet and, because of the high content of entrained air, the water mass penetrates the free water surface with little or no rebound or reflection. The high-velocity curtain thus generated effectively retains the mass of water not directly contacted by the dam, which for these studies had a full-scale depth of only 6 in. Additional tests in moderately rough water and cross winds showed that some form of wing-tip float was required to assist the low righting moment inherent in the basic design.

(To be continued.)

WELDING WITH ALUMINIUM BRONZES.

FIG. 1. SINGLE-PHASE ALUMINIUM BRONZE. $\times 100$.FIG. 2. COMPLEX ALLOY. $\times 1500$.

WELDING WITH ALUMINIUM BRONZES.*

By E. C. MANTLE, M.Sc., A.I.M.

THE aluminium bronzes are a potentially useful group of filler-rod materials for making high-strength welds in copper-base alloys. Their mechanical strength is among the highest obtainable from copper-base alloys and they have excellent resistance to corrosion under a wide range of conditions. The presence of a strong oxide film on the surface of the metal makes gas welding with these alloys difficult, but work carried out by the British Non-Ferrous Metals Research Association has shown that, if certain metallurgical factors are taken into consideration, the alloys are quite suitable for arc welding. One important consideration is the need for welding electrodes conforming to a high standard of purity if multi-pass welds are to be made free from cracks, but there is no difficulty in the commercial production of suitably pure rods.

For the purpose of this report, the aluminium bronzes may be considered as three types, though rigid boundaries between one type and another do not exist, and materials of intermediate compositions are also produced. The three types are: simple alloys of low aluminium content, containing usually 5 to 7 per cent. of aluminium, with relatively small additions of iron, nickel or manganese; duplex aluminium bronzes of higher aluminium content, containing usually from 9 to 11 per cent. aluminium (these may also have small additions of iron, nickel or manganese); and complex aluminium bronzes based on the composition 10 per cent. aluminium, 5 per cent. nickel and 5 per cent. iron.

The simple alloys used for this work contained 7 per cent. of aluminium. This material is obtainable as plate, tube, rod or wire, but it is not used for castings.

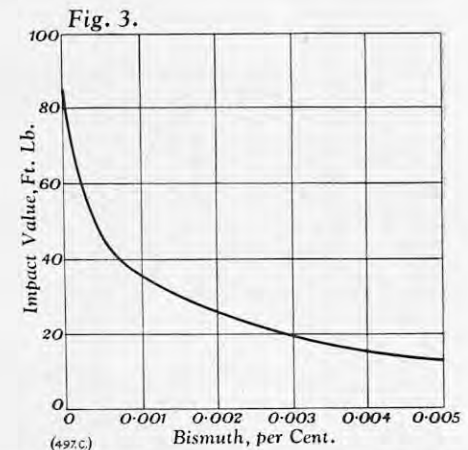
* B.N.F.M.R.A. Report D.54P. (communication from the British Non-Ferrous Metals Research Association). The work described was made available to members of the Association in a confidential development report issued in February, 1951.

The duplex alloys are mostly used for sand or die casting, though they may also be obtained in the wrought form. There is some danger of these duplex alloys becoming embrittled by structural changes which could occur through reheating of the deposited weld metal during later welding runs, and it is unlikely that they would be suitable electrode materials for multi-pass welds.

The complex alloy has the best mechanical properties and has proved to be the more suitable material for arc-welding electrodes. It may be obtained in wrought form as heavy-gauge sheet, extruded or hot-rolled bar and rod, as forgings and stampings, and as sand or die castings. The danger of embrittlement of the complex alloy by reheating is much less than with the duplex alloy, but, as mentioned later, it is undesirable for the aluminium content of this alloy to rise much above 10 per cent. The typical structures of the 7-per cent. aluminium bronze and the complex alloy are illustrated in Figs. 1 and 2, respectively.

Sand-cast plates up to $\frac{1}{2}$ in. thick in a complex aluminium bronze could readily be welded by the metallic-arc process with electrodes of the same composition, the welds being stronger than the basis sand-cast material. Some porosity was encountered in these welds at first, and was traced to moisture in the electrode coating. This was overcome by baking the electrodes for a short time at 110 deg. C. immediately before use. Baking at a higher temperature is not recommended because of the danger of cracks forming in the electrode coating, resulting in the tendency for pieces of the coating to break off and become entrapped in the weld. Sound welds were also obtained in rolled plates up to $\frac{1}{2}$ in. thick in an aluminium bronze containing 7 per cent. of aluminium, welded with electrodes of similar composition.

The butt welds referred to above were made with not more than two passes; but when thicker plates were welded, involving a larger number of passes, difficulty was experienced from cracking of the weld deposit. Reports from industry confirmed that this was the general experience with multi-pass welds in the aluminium bronzes. In such welds, the metal deposited during the later passes will be constrained



during cooling by the weld beads previously laid down. Stresses set up in this way could cause cracking, either if there is a tendency for the weld metal to tear during freezing, or if the weld metal is brittle when hot.

Tests in which pure alloys with varying aluminium contents up to 10 per cent. were allowed to solidify in a chill mould, shaped in such a way that constraint was imposed on the casting, showed that tearing did not occur during freezing. Hence it seemed evident that the weld deposits which had cracked were for some reason hot-short (i.e., the metal lacked ductility at high temperatures) and a metallurgical investigation was carried out to examine the mechanical properties of the aluminium bronzes at high temperatures.

The tendency of the aluminium bronzes to become embrittled at high temperatures was explored, using a notched-bar impact test which was carried out over a range of temperatures. It was found in these tests that, though alloys made from pure materials are ductile at all temperatures, both the 7-per cent. aluminium bronze and the complex alloy are embrittled at high temperatures if they contain small quantities of bismuth. This embrittlement was found to be most pronounced at 650 deg. C., and Fig. 3, herewith, shows how the impact value at this temperature for a 7-per cent. aluminium bronze falls as the bismuth content of the alloy increases. Though the ductility at normal temperatures is unimpaired by the presence of bismuth, only 0.0006 per cent. of bismuth caused a considerable reduction in the impact value at 650 deg. C. The complex aluminium bronze was found to be slightly less susceptible to embrittlement by bismuth, but 0.0015 per cent. was sufficient to cause a marked fall in impact value at 650 deg. C.

Analysis of the electrodes used in the welding trials where cracking occurred indicated that bismuth was present in amounts sufficient to make the alloys brittle at high temperatures, and probably the cracking of the weld metal could be attributed to this. The presence of a small amount of lead was also found to be harmful. As little as 0.005 per cent. caused a serious fall in the impact value at 650 deg. C., both with the 7-per cent. aluminium bronze and with the complex bronze, as may be seen from Figs. 4 and 5, respectively, and it is likely that amounts of lead in excess of this would be harmful in welding electrodes.

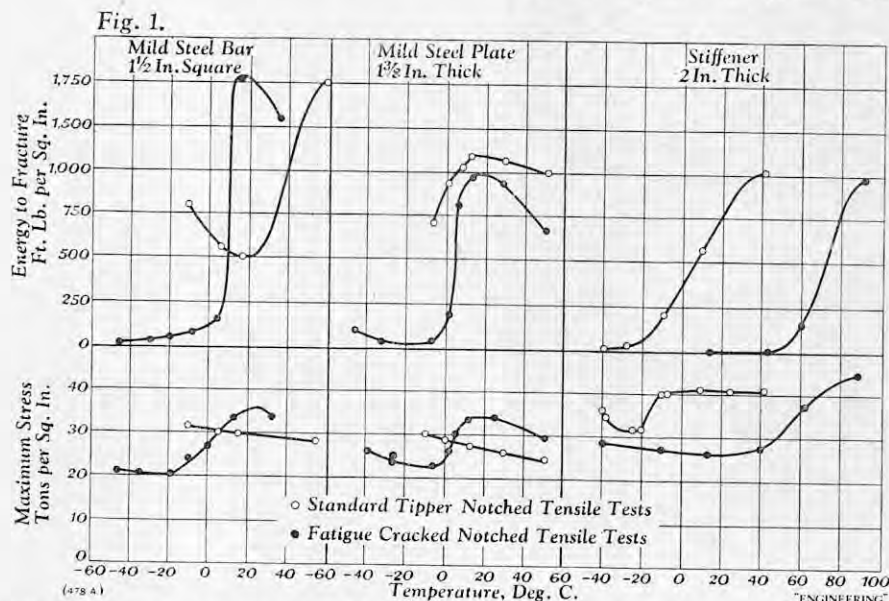
TABLE I.—Welding Details.

Alloy.	Plate Thickness, In.	Electrode Diameter, In.	Current, Amp.	No. of Passes Made.
Complex	2	1/8	300	20
"	2	1/8	350-370	10
"	1	1/8	300	10
"	1	1/8	300-330	8
Single-phase (7 per cent. Al)	1	1/8	180-200	12

Later work has confirmed that, if materials with very low bismuth and lead contents are used, it is possible to make multi-pass welds free from cracking. For instance, welds free from cracks have been made in 1 in. and 2 in. thick cast plates of complex aluminium bronze with lead and bismuth contents of the order of 0.001 per cent. and 0.00015 per cent., respectively, using electrodes of the same composition and purity. The outstanding feature of these welds was that the strength was always at least equal to that of the basis sand-cast plates, even when these had an ultimate tensile strength exceeding 40 tons per square inch, and in tensile tests fracture always occurred in the basis material. This is attributable to the finer structure of the chilled weld metal in comparison with that of the sand-cast plates.

BRITTLE FRACTURE OF MILD STEEL.

(For Description, see Opposite Page.)



Details of the welding technique employed for these tests are given in Table I, herewith. The complex aluminium-bronze electrodes had good running characteristics and gave a stable arc. The welding pool was large and fluid, forming smooth ripples from which the slag could easily be removed between passes, and neat welds were obtained with no visible defects.

Tests were also made with high-purity 7 per cent. aluminium-bronze electrodes. In this case, the electrodes were used to make butt-welds in 1 in. thick hot-rolled plates of the same alloy. Though the strengths of these welds were not so high as that of the parent plate—the “weld efficiency” derived from the expression

U.T.S. of weld after removal of surplus metal $\times 100$
U.T.S. of annealed plate
averaged 76 per cent.—this was mainly because of poor penetration at the root of the weld.

Welding with the 7 per cent. aluminium-bronze electrodes was much more difficult than with the complex aluminium-bronze electrodes. The metal flowed sluggishly in heavy globules from the electrode to the work, the weld pool looked viscous, and freezing was rapid. Owing to this, prominent ripples remained after each pass and it was difficult to remove the slag from these crevices. Many of the welds were found to contain slag inclusions of a sharp angular form, which would be expected to detract from the strength of the welds. Probably some of these difficulties would be overcome with greater experience. The aluminium-bronze electrodes used were coated with a proprietary welding flux and the welds were all made by industrial operators. A direct-current arc was used, with the electrode positive.

To check whether it is necessary for both the parent metal and the electrodes to be of high purity, or if it is sufficient for the electrodes alone to be pure, the welding trials with the 7-per cent. aluminium bronze were repeated with impure parent metal, butt welds being made in 1 in. hot-rolled plates containing 0.002 per cent. of bismuth, as compared with about 0.0006 per cent. of bismuth in the previous trial. The electrodes were the high-purity ones used before. It is improbable that as much as 0.002 per cent. bismuth would be found in aluminium-bronze plates in practice, since the presence of more than 0.001 per cent. bismuth introduces difficulties in hot-rolling this alloy.

Again the strengths of the welds were impaired because of poor penetration of the weld metal; but there was no more evidence of cracks in the welds made in the plates containing large amounts of bismuth than there was in the pure plates, suggesting that contamination of the weld deposit by pick-up of bismuth from the parent metal does not occur. Subsequent analysis of the weld metal has confirmed this.

It is evident that satisfactory multi-pass welds can be made, even when the parent metal is not of high purity, provided that the electrodes used are made from pure material. This has since been demonstrated in a case where cracking was being encountered in the fillet-welding of a flange to a pipe, using 7-per cent. aluminium-bronze electrodes. Analysis of these electrodes revealed that they contained enough bismuth to cause embrittlement at high temperatures, and a change to high-purity electrodes completely overcame the cracking of the weld deposit.

Because of the high strength of the aluminium

bronzes and their good corrosion resistance, they should be useful filler-rod materials for making high-strength welds in other copper-base alloys. One example of a possible application is in the repair of high-tensile brass marine propellers, and, in the course of this work, some welds made with aluminium bronze in cast high-tensile brass have been examined. In one case, some $\frac{3}{4}$ in. cast plates were welded by the metallic-arc process, using 7-per cent. aluminium-bronze electrodes, and in another case carbon-arc welds were made, using complex aluminium-bronze filler rods. Though some of the welds were marred by slag inclusions and gas holes, the welds obtained were virtually free from cracks when high-purity welding rods were used.

The specifications for the complex aluminium bronze of the 10 per cent. aluminium, 5 per cent. nickel, 5 per cent. iron type allow a considerable latitude in the aluminium content, and it was thought desirable to see what effect changes in the aluminium content would have on the mechanical properties of the welds. A few experiments were made in which $\frac{1}{2}$ in. thick complex aluminium-bronze cast plates, each containing 5 per cent. of nickel and 5 per cent. of iron, but with different aluminium contents, were welded with rods of the same composition. Butt welds between a pair of plates were made by a single pass on each face with $\frac{1}{4}$ in. diameter welding rods. With this size of rod, a single pass was sufficient to fill the weld completely, but penetration along the root face was rather imperfect.

Hardness explorations were made on cross-sections through the welds and tensile tests were carried out on test-pieces taken across the welds and also on small pieces cut from the weld beads themselves. It is apparent from the results of these tensile tests given in Table II, herewith, that increase of the aluminium

TABLE II.—Tensile Tests on Welds in Complex Aluminium Bronzes.

Aluminium Content, Per Cent.	Position of Test-Piece.	U.T.S., tons per sq. in.	Elongation, Per Cent.	Comments.
10	Transverse	60	8.0	
	Longitudinal from weld bead itself	49	3.3	
10.6	Transverse	47	1.5	Cavity at fracture.
	Longitudinal from weld bead itself	53.5	4.5	
11.2	Transverse	62.5	3.0	
	Longitudinal from weld bead itself	55.5	3.0	

content of the complex aluminium bronze above 10 per cent. may result in brittleness if it is used for welding. Examination of sections from these welds showed that some modification to the basis metal in zones adjacent to the weld had occurred in all cases, causing some increase in hardness. The weld beads themselves were generally similar in hardness to the altered zone of basis metal. In the case of a complex alloy containing 10 per cent. of aluminium, this change

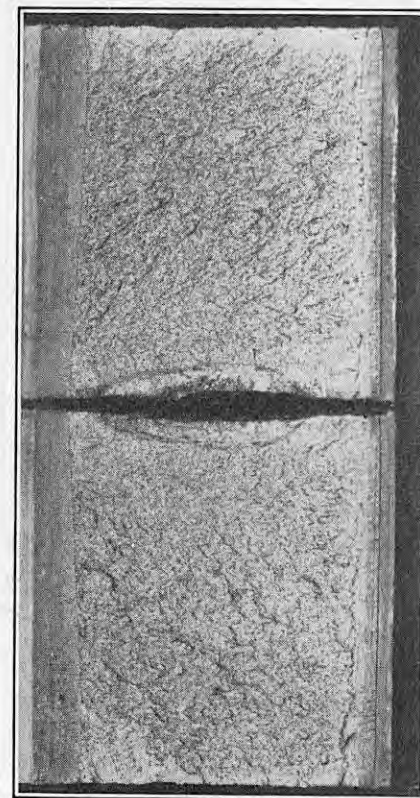


FIG. 2. FATIGUE NOTCHED TENSILE FRACTURE.

in hardness was from about 240 to 290 Vickers Pyramid Number. Alloys with higher aluminium contents tended to show greater increases in hardness over that of the unaffected basis metal.

Practical Recommendations.—Welds of high strength may be made by the metallic-arc process, using aluminium-bronze electrodes, or by the carbon-arc process with aluminium-bronze filler rods. Good results are more readily obtained with the complex aluminium bronze of the 10 per cent. aluminium, 5 per cent. iron and 5 per cent. nickel type than with the 7 per cent. aluminium-bronze alloy, the former having better running characteristics and giving a more fluid weld pool than the latter, which tends to flow sluggishly and gives a weld pool which freezes rapidly. Difficulty is then encountered in removing the slag between passes. In either case, the electrodes should conform to a high standard of purity and should preferably contain not more than 0.0005 per cent. of bismuth and not more than 0.001 per cent. of lead. Purity of the parent metal is relatively unimportant.

With the complex aluminium bronze, the aluminium content should preferably be limited to 10 per cent. to avoid danger of brittleness after welding. Just before use, coated electrodes should be baked at about 110 deg. C. to remove moisture. Too high a baking temperature may cause the coating to flake during welding. Carbon-arc welding may be preferable with the 7 per cent. aluminium bronze, because the work can be preheated more easily and flux residues melted and incorporated in the flux cover so that they do not become entrapped in the weld metal during succeeding passes.

COLD-CATHODE X-RAY ILLUMINATOR.—A cold-cathode X-ray illuminator has been designed by Messrs. Watson and Sons (Electro-Medical), Limited, Parkers-street, London, W.C.2, in conjunction with the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, to facilitate and improve the viewing of radiographs. Cold-cathode tubes have been chosen for this purpose, since they readily attain full intensity, do not generate heat, have no alternating-current “flicker,” can be dimmed without elaborate apparatus and have a high luminous efficiency throughout a long life. The tubes used in the illuminator are coated with one of the new halophosphate powders and are about 10 ft. long. They are bent into the shape of a grid and are placed in front of a reflector, so that uniform distribution of illumination is obtained. Three degrees of intensity are available and the colour is approximately that of daylight. Radiographs of any size up to 14 in. by 17 in. can be viewed. The electrical consumption is about 100 watts at 230 volts.

BRITTLE FRACTURE OF MILD STEEL.

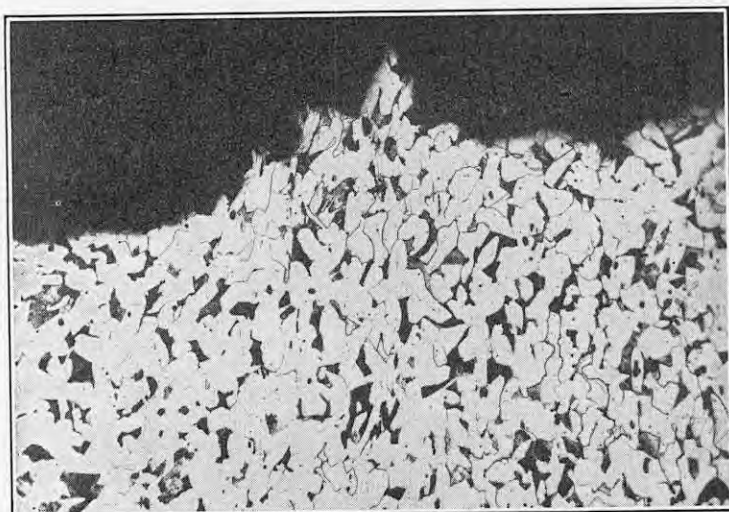
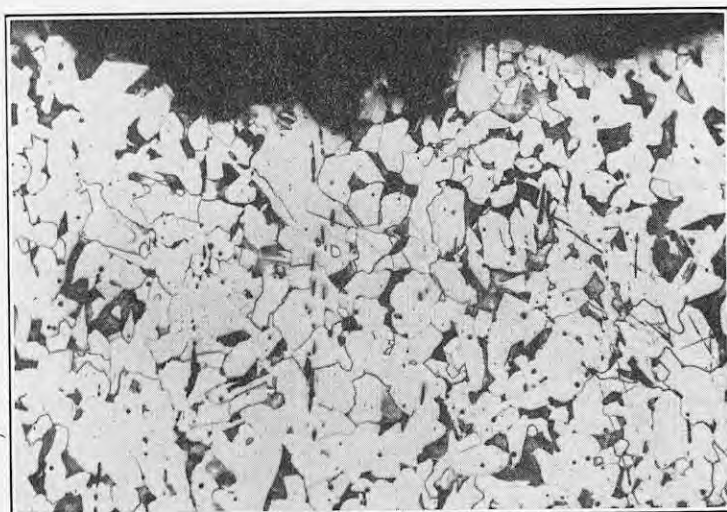
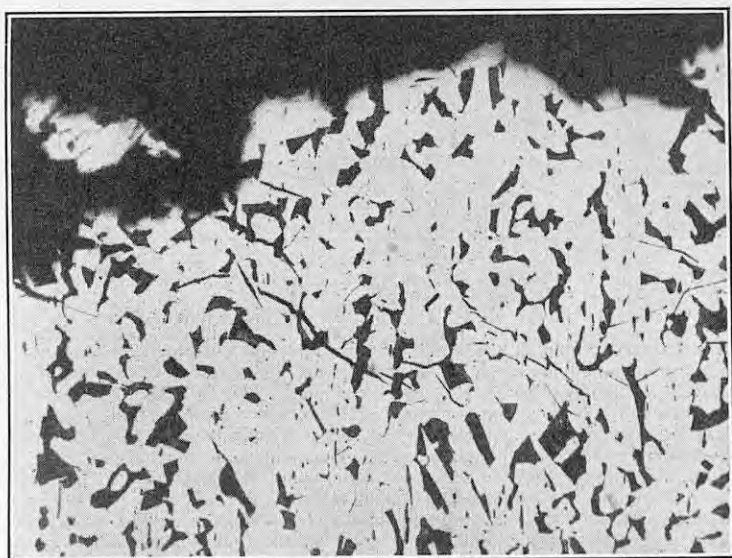
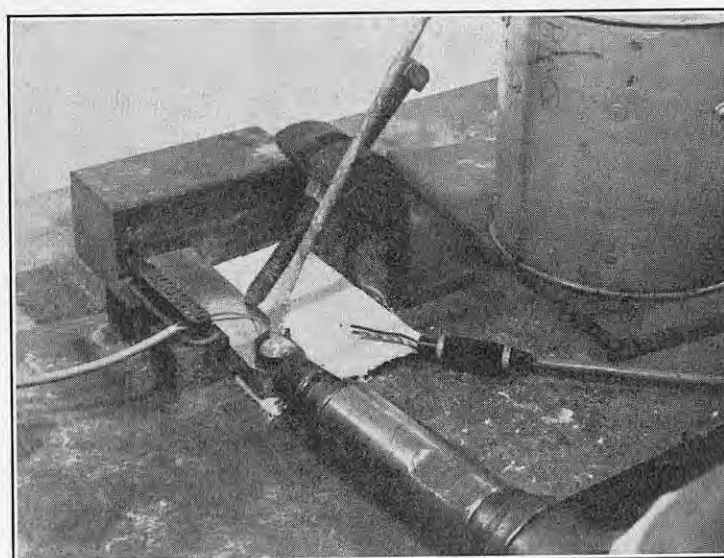
FIG. 3. YIELD AT ROOT OF FATIGUE CRACK. TESTED AT -10 DEG. C. $\times 100$.FIG. 4. BRITTLE FRACTURE IN FATIGUE-CRACKED BAR. TESTED AT -10 DEG. C. $\times 100$.FIG. 5. BRITTLE FRACTURE IN FATIGUE-CRACKED BAR. TESTED AT -20 DEG. C. $\times 100$.

FIG. 6. CRACK-PROPAGATION TEST WITHOUT TRANSVERSE STRESS.

BRITTLE FRACTURE OF MILD STEEL.*

By T. S. ROBERTSON, M.Sc. (Eng.).

SINCE the end of last century, the subject of brittle fracture in steels has increasingly occupied the attention of research workers. It is only recently, however, that brittle fracture of mild steel has come into prominence. First, collapse of a bridge in Belgium, then later, catastrophic brittle failure in some ships, has set in motion one of the largest collective researches of our time, on the Continent, in the United States and in this country. Till comparatively recently, tests have been of a simple character, Charpy or Izod test-pieces being accepted as standard. The early assessment of notch brittleness in terms of the energy required to fracture was probably dictated by its ease of measurement in the two forms of test named, but criteria of assessment remain a very lively source of controversy even to-day. Early researches by Stanton and Batson† established that by increasing the velocity of an impactive blow, transition from tough to brittle type fracture could be produced in mild steel. Later Docherty‡, by increasing the speed in slow-speed notch bend tests, produced a transition from tough to brittle type fracture in cold-drawn mild steel. Stanton and Batson§ demonstrated that geometrically similar test-pieces showed a size effect under impactive loading. Docherty|| produced this effect in geometrically-similar slow-bend notched test-pieces

and attributed it to transition from tough to brittle fracture. Lea* by overstrain in tension followed by low-temperature heat treatment, produced a transition from tough to brittle fracture in mild steel by varying the amount of overstrain.

In the recent speed-up in research into brittle fracture, changes in test procedure have been introduced. Many investigators now prefer a test on full plate thickness and some insist that a symmetrically-notched tensile test-piece is essential to simulate practical conditions of stressing in plates. Generally, however, tests for brittleness follow one main pattern; a notched test-piece is pulled or bent until, after some degree of straining, a crack propagates from the notch. The nature of the crack can be changed from tough to brittle by controlled variation of chemical composition, heat treatment, size of test-piece, speed of testing, the temperature at which the test is carried out, etc. Thus the change from tough to brittle fracture is determined by a number of features, many of which are conditioned by the analysis and mill history of the steel before testing and others by the mode of carrying out the test. Temperature change produces a transition from tough to brittle in mild steel and, being easily controlled, has been adopted as a standard means for investigation. Much controversy centres round the criterion for assessment of results. Three main criteria are used, namely, energy to fracture, appearance of fracture and local contraction of the section at fracture. These three criteria do not always give the same temperature transition ranges, neither do different types of test give the same ranges on one steel when the same criterion is used, but it is generally agreed that transition temperature tests put the materials tested in the same order of merit. The temperature

ranges established bear no relation to those in which the material will break brittle in practice. Thus the designer is given an order of merit for the materials he has available, but has no information whatever as to what design stress he should adopt to safeguard the structure from catastrophic brittle failure or at what temperature he may expect trouble from brittle fracture.

A study of accounts of catastrophic failures indicates that there are two stages in such fractures. First, somehow or other, a crack must be started; then, second, this crack must propagate with extreme speed through the structure. Although high local stress may be associated with the first part, there is evidence that continued propagation may take place at low nominal stress of value about 5 tons per square inch. This continued propagation at low nominal stress is the most important feature of catastrophic failure. In a research into the effect of sharp notches on the temperature-transition ranges for three mild steels, carried out at Naval Construction Research Establishment, Tipper, notched tensile tests were made. The steels were an ordinary commercial mild-steel bar $1\frac{1}{2}$ in. square, a shipbuilding steel plate $1\frac{3}{8}$ in. thick, and a heavy stiffener 2 in. thick that had broken in brittle manner under test at atmospheric temperature. The bar had a temperature transition range on energy assessment covering $+20$ deg. to $+60$ deg. C., the plate -40 deg. to $+20$ deg. C., and the stiffener -20 deg. to $+40$ deg. C. (see Fig. 1, opposite). To produce a really sharp crack, a second series of Tipper pieces cut from the three steels had shallow notches cut in them and were then each subjected to about 250,000 cycles of bending fatigue stressing until the fatigue cracks, started in the notches, had reached normal notch depth (see Fig. 2). On testing these pieces as in the normal Tipper test, the bar gave a transition range, on energy assessment, covering -5 deg. to $+15$ deg. C., the plate

* Paper read at a joint session of Section B (Chemistry) and Section G (Engineering) of the British Association, at Edinburgh, on Tuesday, August 14, 1951.

† *Min. Proc. Inst. C.E.*, vol. 211, page 81.

‡ *ENGINEERING*, vol. 131, page 347 (1931).

§ *Min. Proc. Inst. C.E.*, vol. 211, page 75.

|| *ENGINEERING*, vol. 139, page 211 (1935).

* *Proc. Inst. Mech.E.*, vol. 131, page 539, 1935.

BRITTLE FRACTURE OF MILD STEEL.

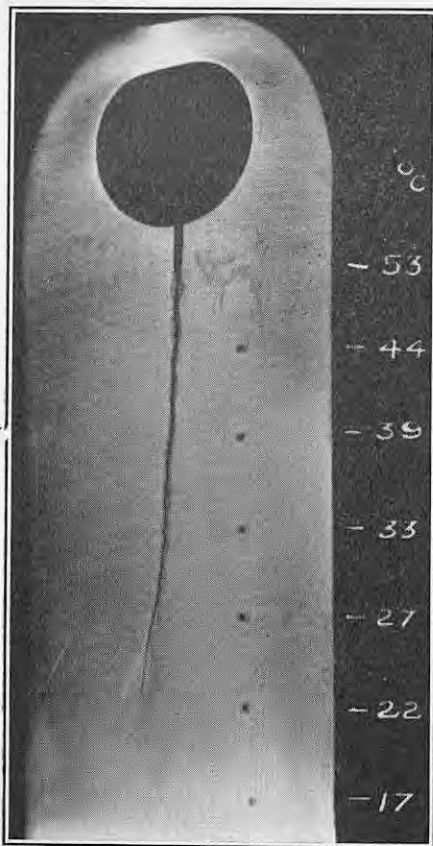


FIG. 7. CRACK ARREST WITH YIELD AT ROOT OF CRACK.

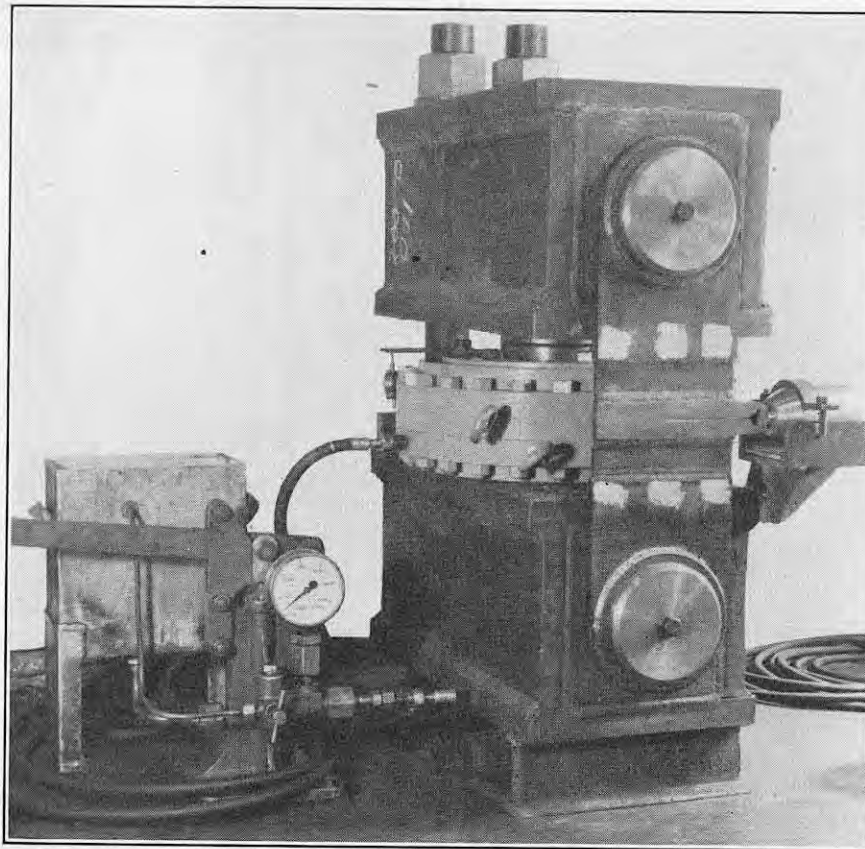


FIG. 8. CRACK-PROPAGATION TEST WITH TRANSVERSE STRESS.

—5 deg. to +15 deg. C., and the stiffener +40 deg. to +95 deg. C. That the transition temperature range was lowered in the bar, little changed in the plate and raised in the stiffener provides evidence that, under this treatment, at least, certainly the order of merit was changed.

In the tests on the three mild steels, plots of maximum stress reached before fracture, shown in Fig. 1, provide a startling contrast. The fatigue cracked test-pieces each showed a loss of strength over the transition range of the order of 40 per cent., whereas, with standard notches, the strength increased continuously with fall of temperature in the bar and in the plate. In the stiffener, however, there is a fall of about 20 per cent. in strength near the bottom of the energy transition zone. It would appear, therefore, that the stiffener is brittle enough to exhibit a loss of strength at low temperature with a standard notch and that the temperature at which this loss of strength occurs is raised by the sharp fatigue crack.

To investigate whether the loss of strength found could be caused by the general action of fatigue stressing on the material a further test-piece was cut from the stiffener. This was fatigue stressed in direct pull and push, the whole section being subjected to 90 per cent. of the fatigue life that would cause fracture. Standard notches were then cut and a test at +40 deg. C. showed the same maximum stress as for the ordinary Tipper test. If a sharp crack results in loss of strength, then the very sharp crack present during the propagation of brittle fracture will possess the very properties necessary to explain why ships have broken in two at nominal stresses of quite low value.

Microscopic examination of the broken fatigue cracked notched tensile test-pieces shows that there was considerable yield in the material at the root of the fatigue crack, but very much less yield, if any, in the material through which the brittle crack propagated at temperatures below the transition range. Fig. 3, page 445, refers to the piece tested at —10 deg. C., and shows the fatigue crack terminating about one quarter of the way across the illustration, from the left, at a zone of yielded material, followed by the brittle crack which propagated through the remaining section. Fig. 4 shows the brittle crack, farther from the notch, in the same test-piece. Note that a few subsidiary cracks have propagated in nearby crystals. Fig. 5 shows the brittle crack at the critical temperature —20 deg. C. at which the material exhibited minimum strength. The multitude of subsidiary cracks is significant. Thus tests using machined and even fatigue notches introduce a large degree of artificiality that may mask those properties that lead to catastrophic failure.

The idea was conceived that, if a propagating crack could be started at very low temperature in a test-piece of varying brittleness, the capacity of the material to resist crack propagation could be studied.

A test-piece was devised which met this requirement. It was in the form of a full thickness strip, flame cut from a plate. It was 8 in. long and 2 in. wide, with one end cut semi-circular. Near this rounded end a 1-in. diameter hole was drilled centrally in the width so as to leave $\frac{1}{8}$ in. thickness of metal under the radius. A jeweller's saw cut $\frac{3}{16}$ in. deep was made centrally in the width on the side of the hole remote from the radiused end. The specimen was clamped flat on a thick piece of asbestos with its end hard against a heavy stop. It was cooled by pouring liquid nitrogen at a controlled rate into the hole. By this means a temperature gradient was established along the length of the specimen to achieve a variation in brittleness. The temperature was measured by a thin flat thermocouple held in contact with the specimen at successive $\frac{1}{2}$ -in. marks. When the temperature had reached a steady value, the crack was started at the notch and propagated into the material by a rapid series of blows on the rounded end from a heavy pneumatic riveting hammer, the arrangement being as shown in Fig. 6, page 445. It was found that for mild steels a temperature of at least —70 deg. C. at the sawcut was necessary to start a crack there which would propagate without surface yield. This crack propagated rapidly into the test-piece, advancing with each blow till eventually it stopped, when continued blows resulted in the yield of the material round its root, as shown in Fig. 7. This yielding was easily recognised on the polished surface of the test-piece and was found to be reproducible at the same temperature for different temperature gradients arranged by warming up the remote end with a gas flame. In general, this temperature was found to be low compared with that at which some of the material tested had given trouble in practice.

It was realised that each blow, by driving a wedge of yielded material into the rounded end of the test-piece, would propagate the crack only so far as the stress at the root of the crack was high enough to continue propagation. Therefore this test showed arrest of the crack at a low temperature that represented conditions for propagation at an unknown minimum value of transverse stress. The next development then was to arrange that a known value of transverse stress should be maintained during the test and to dispense with the series of blows, replacing them by a single blow necessary to start propagation.

The transverse stress is easily applied by welding

the test-piece into two heavy lugs that carry holes for pins for attachment to shackles in a very simple testing machine which uses a hydraulic capsule to apply the load. A photograph of the machine is reproduced in Fig. 8. Intermediately between the lugs and the edges of the test-piece, two strips of thinner material are interposed. On assembly in the testing machine a load sufficient to yield the strips is applied. This ensures that stored stresses in the welds will be relieved and that the plastic deformation will produce a uniform stress distribution along the test-piece. The length of the test-piece has been increased to 12 in. to give an operative length of 10 in. and the width to 3 in. to allow preparation for welding. After the mechanical stress relieving process, four Huggenberger extensometers are attached, two on each side of the test-piece at quarter length points. Load is applied and the stress and its uniform distribution are verified. The extensometers are removed and brass caps are attached to each side of the now horizontal hole in the test-piece by a through bolt. Liquid nitrogen is poured at a regulated rate into one cap, passes through the hole as it evaporates and escapes to atmosphere by a vent in the other cap. A small flat-flame gas burner is used to heat the other end of the specimen. After about 20 minutes the temperature gradient along the test-piece has reached a steady value and it is measured and checked measured by thermocouple, the value —70 deg. C. at notch and +60 deg. C. at the remote end, being usual values for a normal mild steel. The gradient is about 10 deg. C. per inch at mid-length. The appropriate transverse load is now applied and a bolt gun is inserted into a guide carrying a trapped plunger that contacts the rounded end of the specimen. The movement of this plunger is limited to $\frac{1}{4}$ in. A heavy mass is brought into contact with the heated end of the test-piece.

The gun is fired, and a crack, started at the notch by the impact, immediately propagates along the length of the specimen into zones of gradually increasing temperature till it stops. The speed of this crack is such that for the usual travel of about 6 in., high-speed photography at 4,000 frames per second is too slow to record it. The crack appears full length in the space of one frame. This means that the speed of propagation of the crack exceeds 2,000 ft. per second and is probably much higher, since no film so far has shown a crack in process of development in the frame adjacent to the one with an arrested crack. At such a high speed of propagation there is not time for the relaxation of stress initiated by the crack to have reached the uncracked part as increased tension before the crack has stopped. The nominal stress in the material into

BRITTLE FRACTURE OF MILD STEEL.

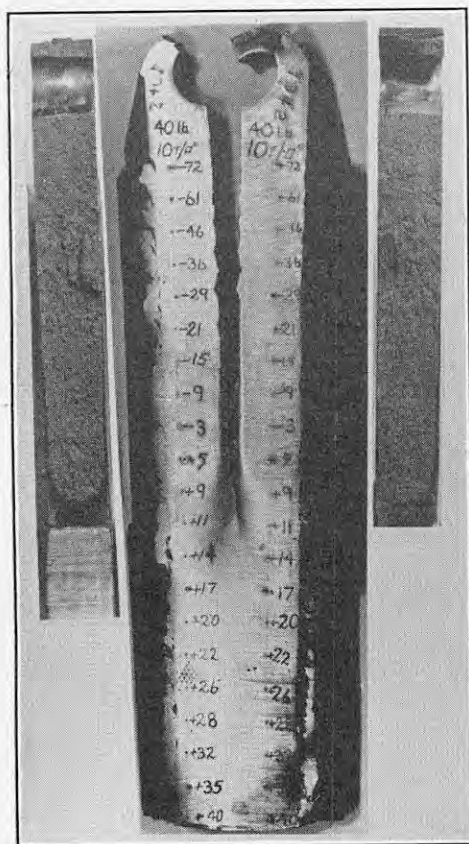


FIG. 9. CRACK ARREST SHOWING THUMB-NAIL MARKING.

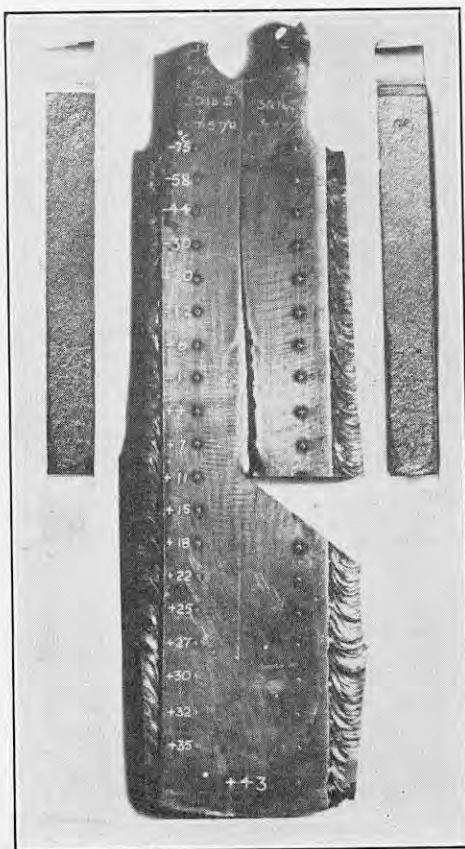


FIG. 10. CRACK ARREST WITH SECOND BRITTLE FRACTURE THROUGH YIELDED MATERIAL.

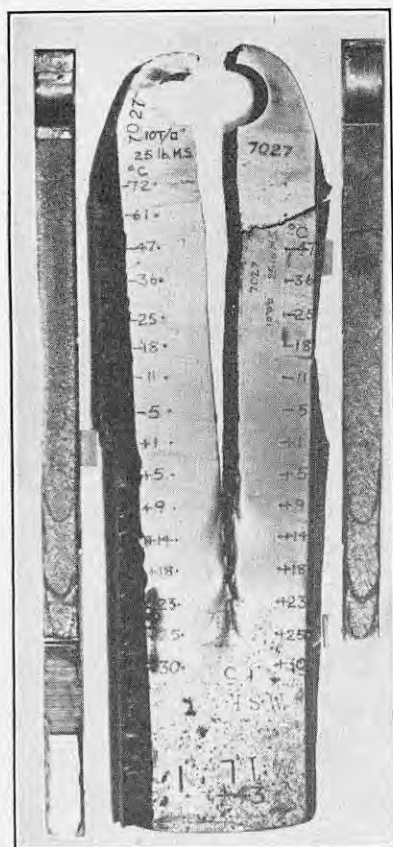


FIG. 11. SUCCESSIVE BRITTLE FRACTURES THROUGH YIELDED MATERIAL.

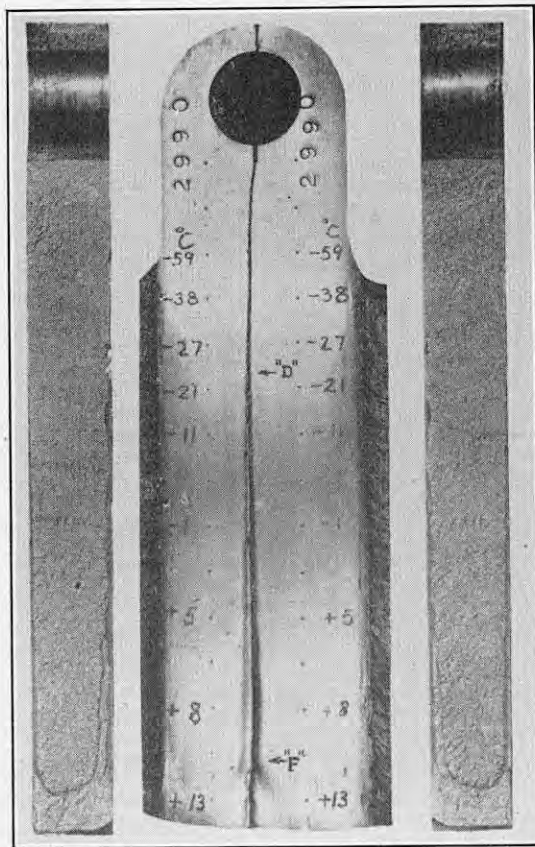


FIG. 12. LOCAL SURFACE YIELD DURING CRACK PROPAGATION.

which the crack propagates must therefore remain substantially unaltered. Soon after the crack has stopped the increase of stress follows and extensive yield of the material round the root of the crack takes place. The temperature at which yield took place is best determined after cutting open the specimen to reveal the fractured surfaces. The result is illustrated in Fig. 9. The two halves show a characteristic thumb-nail marking where the brittle fracture stopped. The focus of this marking is used to identify the tempera-

ture at which arrest took place and yields consistent results for the same material tested at the same stress with different temperature gradients. Characteristic results are given in Table I.

An examination of the results in Table I shows that, as the transverse stress is reduced, there is a sudden drop in the temperature at which the propagating crack is arrested. This is, in fact, a strength transition which, in most of the materials tested, occurs at a low stress value of the order of 5 tons per square inch. The

temperature at which the crack is arrested varies little with increase of stress above the transition. Steel B is outstanding, especially in the strength transition. The stress of 12 tons per square inch is high enough for most applications for a mild steel, and, even above this stress the critical temperature of -5°C . is low in comparison with values obtained from other samples excepting, of course, the thin plate. It is evident that the test substantiates the lower transition temperature generally agreed for thin plates, but there is, no doubt, a strength transition also for thin plates. Below the strength transition, the temperature for arrest of the crack falls to a low level seldom met with in practice. This suggests that the designer can now be given a safe stress below which there is no chance of brittle fracture at ordinary working temperatures.

An examination of many fractures produced by the new method shows that very often a second brittle fracture occurs in the yielded material after the first arrest, which can just be distinguished, in the original photograph, in the left-hand fracture in Fig. 10. It has been established by others that the transition temperature of mild steels is considerably raised by yielding, the rise being more marked if the yielded material is aged for a few days before testing. That there is evidence sometimes of one, even two or three successive brittle cracks through the yielded material, each with an arrest and subsequent yield, indicates that yield *per se* must raise the brittle temperature considerably (see Fig. 11). In this lies an

TABLE I.—Crack Propagation Tests of Mild Steel.

Letter.	Material.	Transverse Stress, Tons per Sq. In.	Crack Arrest Temperature, Deg. C.
A	1 in. plate	15	12
	0.20 per cent. C.	13	10
	1.44 per cent. Mn.	10	10
		7½	10
		5	-36
B	1 in. plate	15	-5
	0.13 per cent. C.	13½	-5
	0.97 per cent. Mn.	12	-42
C	1 in. plate	10	20
	0.31 per cent. C.	7½	20
	1.32 per cent. Mn.	5	-45
D	¾ in. plate	10	8
	0.23 per cent. C.	7½	7
	1.02 per cent. Mn.	5	-35
E	¾ in. plate	16	-10
	0.23 per cent. C.	15	-20
	0.87 per cent. Mn.	10	-22

explanation of the width of transition temperature bands resulting from other forms of brittleness test. The criteria of lateral contraction and of energy involve yield prior to fracture at a series of increasing temperatures. Those test-pieces with higher contraction or energy than the minimum yield more, and eventually yield enough to fracture in brittle fashion at the temperature of test. Extension of the transition range of lower temperatures is due to the use of a notch of sharpness less than that of the natural notch provided by a propagating crack. Fissures that open at the root of a machined notch during the progress of a test complicate matters, and, allied with the phenomenon of yield embrittlement, can account for the stepped transition curves that have recently occupied much space in the literature on brittle fracture in America.

Fig. 12 shows a fracture with clearly marked surface yield at temperatures below that of the first arrest. This surface yield band gains in breadth and in depth as the temperature of the test-piece rises. In appearance it is akin to the 45 deg. part of the cup and cone fracture in an ordinary tensile test-piece. A hypothesis of triple tensile stress—in which shear yield is prevented—is consistent with the presence of this band of yield. The surface of the test-piece must be at zero normal stress, so that a crack, propagating under conditions of triple tensile stress, will not be able to maintain these conditions right up to the surface. Yield will therefore take place on the surface under the high two-dimensional tension there. It follows from this hypothesis that thick plates should exhibit greater brittleness than thin ones. The depth of the zone affected by the surface will be more or less constant for a material in a given condition whatever the thickness. Thus, even for a propagating crack of uniform sharpness, the thick material will have a greater proportion of its thickness subject to the action of triple tensile stress.

A deposited weld bead produces a heat-affected zone which will start a sharp crack at the root of a notch after a small amount of yield. Tests that employ this means for starting fracture naturally show a rise in transition temperatures over unwelded plates, but it is still evident from an examination of fractures that considerable tearing of a ductile nature may take place

in the material adjacent to the heat-affected zone during the higher temperature tests, before yield has progressed far enough to cause brittle fracture in the remainder of the material. In such tests the adoption of a criterion of 2 per cent. lateral contraction before fracture insists that the crack shall pass through yielded material. To infer from tests on yielded material how to avoid catastrophic failures by brittle fracture through unyielded plates at low nominal stress levels is open to criticism, but the new test simulates the practical conditions of actual fracture and it is confidently hoped will contribute to the solution of the problem of brittle failure in mild steel.

This account is published with the approval of the Lords Commissioners of the Admiralty, but the responsibility for any statements of fact or opinions expressed rests solely with the author, who is indebted to the Superintendent, Naval Construction Research Establishment, where this work was carried out, for encouragement and advice during the development of the test. Thanks are also due to Mr. G. A. Keay, B.Sc., chief metallurgist at the above Establishment, for help in discussion of the metallurgical aspects of the test.

TRADE PUBLICATIONS.

Fork Trucks.—Conveyancer Fork Trucks, Ltd., Liverpool-road, Warrington, have issued an illustrated pamphlet describing the advantages of the fork-lift truck for handling materials.

Ladders.—Lyte Ladders, Ltd., Rogerstone, Newport, Monmouthshire, have published a price list of their aluminium-alloy ladders, which are available in several designs for general and special purposes.

Flameproof Lighting Fitting.—Details of a flameproof lighting fitting which is intended for use in the petroleum, coke, gas and shipbuilding industries are given in a leaflet published by Victor Products (Wallsend), Ltd., Wallsend-on-Tyne.

Aircraft Accessories.—We have received from Vickers-Armstrongs Ltd., Weybridge, Surrey, an illustrated catalogue giving details of their aircraft accessories, which include chairs, sanitary fittings, fuel cocks and valves, and universal pulleys and guards.

Rock Drills.—Holman Brothers, Ltd., Camborne, have issued an illustrated catalogue giving particulars of their drifter drills for wet or dry drilling, which range from a 92-lb. drill with a bore of 2½ in. and a stroke of 2½ in. for light operations to a 198-lb. drill with a bore of 4 in. and a stroke of 3½ in. for very heavy duty.

Dust Collectors.—Keith Blackman, Ltd., Mill Mead-road, London, N.17, have prepared a brochure on their W1100 wet-type dust collectors, which are recommended for dusts injurious to health or liable to cause fire or explosion hazards; the collectors are made as units which are semi-portable. The dust is collected and deposited in the form of sludge which is readily disposed of.

"Rails and Rail Accessories."—Thos. W. Ward, Ltd., Albion Works, Sheffield, have produced a booklet with this title that should be useful as a reference to the forms and nomenclature of rails, chairs, crossings and turnouts, fishplates, keys, lever boxes, lever rods, rail fastenings, re-railing ramps, switch slips, buffer stops, wheel stops, etc. Well-prepared line drawings are used to illustrate the parts which the firm make for private railway sidings.

Portable Conveyor.—A leaflet, obtainable from the International Heating and Ventilating Co., Ltd., 4, Denbigh-gardens, Richmond, Surrey, describes a portable conveyor, about 14 ft. long and driven by a petrol engine or an electric motor, which is a handy appliance for loading and unloading coal or other bulk materials. It can be used with lorries or railway trucks, or in other ways, and will discharge at the rate of 25 to 30 tons per hour.

Pneumatic and Electric Tools.—The Climax Rock Drill and Engineering Works, Ltd., Carn Brea, Redruth, Cornwall, have issued an illustrated catalogue giving specifications and describing the applications of their pneumatic and electric tools and equipment for contractors, shipbuilders, foundries, etc. The equipment includes paving breakers, coal picks, clay diggers, trench pumps, vibrators, electric drills, chipping hammers, riveters, grinders, etc.

Welding Electrodes.—Technical Circular T.C. 846, from the Quasi-Arc Co., Ltd., Bilston, Staffordshire, gives the mechanical properties, chemical composition, etc., of that firm's Radian (new type) mild-steel electrodes, which are made in ten sizes from 16 s.w.g. to ½ in. in diameter. These electrodes are fully extruded, and under the B.S. 1719-1951 classification they have the code No. E217. They are intended for general structural engineering and shipbuilding work; the smaller sizes are suitable for welding joints in sheet metal down to 20 s.w.g.

NOTES ON NEW BOOKS.

American (3rd Angle) and British (1st Angle) Projection for Engineering Technical Colleges, Universities and Workshops.

By GUY L. MURRAY, M.I.Mech.E. Toledo Woodhead Springs, Limited, Clifton Works, Neepsend-lane, Sheffield, 3. [Price 10s. 6d. net.]

In our issue of May 12, 1950 (vol. 169, page 521), we described and illustrated an ingenious model designed by Mr. G. L. Murray to show at a glance the essential difference between the third-angle projection that is standard practice in North America and the first-angle method which is still largely used in British drawing offices. In this brochure, Mr. Murray has developed the theme. The model was made of thick sheets of clear Perspex, arranged with the ends and sides hinged so that the whole structure could be laid flat to show the relationship of the plan and elevators on a drawing. In the brochure, the outline of the same model is used, but the several parts are printed (in colour) on thin sheets of transparent material, so that they can be folded back or superimposed as desired. The method is clear and effective, though perhaps not quite so immediately impressive as the folding model. It will be gathered quickly from the accompanying text that Mr. Murray favours the American method; in this he is supported by Professor Sir Charles Inglis, F.R.S., who contributes a foreword.

Compressed Air in Mining and Industry.

Compiled and edited by SYDNEY H. NORTH. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 18s. net.]

It is rather surprising to find a former editor of a technical journal on compressed air attempting to cover the basic features of compressed-air installations, the applications of compressed-air power in mines, quarries, constructional works and industry, and the diversity of tools and appliances operated by this power, in a mere 170 pages. Although realising the difficulties of the task, Mr. North has proceeded to compile a series of chapters which certainly succeed in indicating the very wide range of application of compressed-air power. The information on basic principles, however, is too sketchy to serve any useful purpose and, in fact, engineers may raise their eyebrows at some of the statements, as, for example, that "the air compressor is one of the most reliable prime movers in use." While occasional attempts are made to discuss the suitability of different types of plant for specific purposes, the book consists essentially of a rather disjointed collection of descriptive material on various applications of compressed-air power, ranging from coal mining to laundries, from milk to beer, and from power hammers to paint sprayers.

Reference Tables for Thermocouples.

By HENRY SHENKER, JOHN I. LAURITZEN, JUN., and ROBERT J. CORRUCINI. National Bureau of Standards Circular 508. The Superintendent of Documents, United States Government Printing Office, Washington 25, D.C., U.S.A. [Price 35 cents.]

THESE tables, incorporating recent changes in electrical units and temperature scale, cover all the common commercial thermocouples. They are based on data previously published by the Bureau of Standards and have been expanded to meet current requirements. Electromotive forces are expressed in absolute units, which became effective on January 1, 1948, and temperatures are expressed on the International Temperature Scale of 1948. Following a short introduction, the tables themselves are divided into two parts in which temperatures are measured in the Celsius (Centigrade) scale and in the Fahrenheit scale, respectively. The thermocouples listed are platinum-10 per cent. rhodium, platinum-13 per cent. rhodium, chromel-alumel, copper-constantan, and chromel-constantan. For each individual couple, except the last, the tables are grouped in pairs. In the first member of a pair, the argument is the electromotive force in absolute millivolts and the tabular entries are in degrees Celsius or Fahrenheit. In the second member, the argument is the temperature of the hot junction in degrees Celsius or Fahrenheit, and the tabular entries are in absolute millivolts. In the single table for the chromel-constantan thermocouple, the argument is the temperature. In all cases, the temperature of the reference junctions are 0 deg. C. or 32 deg. F. The interval of the argument for electromotive force is 0.01 millivolt and the corresponding temperatures are given to the nearest 0.1 deg. C. or F. The interval of the argument for temperature is 1 deg. C or F., and the corresponding electromotive forces are given to the nearest 0.001 millivolt. Minor discrepancies resulting from rounding off have been allowed to stand. Tables for iron-constantan thermo-

couples are under revision, and are scheduled to appear in a separate publication. This comprehensive and well-arranged set of tables should prove valuable to all users of thermocouples.

Foundations of Aerodynamics.

By PROFESSORS A. M. KUETHE and J. D. SCHETZER. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5.75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 46s. net.]

THE authors, who are respectively professor and associate-professor in aeronautical engineering at the University of Michigan have endeavoured, in this book, to present "in a form suitable for classroom use, the foundations on which aerodynamics rests." It is intended to form a basis for a one-year post-graduate course for engineering, mathematics, or physics graduates who have no previous knowledge of aerodynamics. It should be made clear, however, that the standard of mathematics assumed is higher than that usually achieved by the average engineering graduate in this country. For those students who are equipped with the necessary mathematical knowledge, it should prove to be a valuable text-book. It is well written, and the conclusions of the mathematical arguments are admirably summarised. The authors are particularly concerned with fostering an understanding of the limitations of the assumptions on which the theories are based. In the first six chapters, the flow of a perfect fluid and its application to predicting the lift of aeroplane wings is considered. The following five chapters are concerned with the flow of a compressible inviscid fluid through channels and about wings. Four chapters are devoted to the viscous incompressible homogeneous fluid and the flow in boundary layers and tubes. A few brief analyses of the flow of a viscous compressible homogeneous fluid are included to serve as an introduction to the subject. In the last chapter, some practical problems of wing design are discussed in relation to the principles developed. Bibliographical references are given in footnotes. Problems for the student to solve are provided at the end of the book.

Stages and Discharges, Mississippi River and Its Outlets and Tributaries, 1949.

United States Army Corps of Engineers. The President, Mississippi River Commission, Vicksburg, Mississippi, U.S.A. [Price 1.00 dol.]

THIS is a tabular statement for the year 1949 which will be of great interest to river engineers. A table of maximum, minimum and mean discharges and, similarly, the highest, lowest and 1949 high and low stages are given in an 18-page prologue. Reservoir particulars are also stated. At Arkansas City, in 1927, the discharge is reckoned to have been 2,472,000 cusecs if the river had been confined between levees. This compares with an observed value in 1949 at the same place, 559 miles from the mouth, of 1,523,000 cusecs. The minimum at the same place was 88,000 cusecs in 1939 and 206,000 cusecs in 1949. The mean for 1949 is given as 650,000 cusecs. The drainage area at Arkansas is stated at 1,130,700 square miles as compared with 1,243,700 at the head of "passes" in Louisiana. These figures show an extraordinary similarity to those for the Yangtze.

BOOKS RECEIVED.

Resistance Strain Gauges. By J. YARNELL. Electronic Engineering, 28, Essex-street, Strand, London, W.C.2. [Price 12s. 6d.]

Definitions and Formulae for Students. Practical Mathematics. By LOUIS TOFT. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2. [Price 1s. 6d.]

Directory of Railway Officials and Year Book, 1951-1952. Tothill Press Limited, 33, Tothill-street, London, S.W.1. [Price 40s.]

Production Engineering Administration and Management. By PROFESSOR J. V. CONNOLLY. Bunnell Publications, Limited, 12, Bloomsbury-square, London, W.C.1. [Price 5s.]

Fellowship of the Air. Jubilee Book of the Royal Aero Club, 1901-1951. By B. J. HURREN. Hiffe and Sons, Limited, Dorset House, Stamford-street, London, W.C.2. [Price 30s. net, postage 9d.]

Selected Government Research Reports. Volume 9. Powder Metallurgy. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 18s. net.]

Analysis of the Four-Bar Linkage. Its Application to the Synthesis of Mechanisms. By PROFESSORS JOHN A. HRONES and GEORGE L. NELSON. The Technology Press of the Massachusetts Institute of Technology, Cambridge 39, Massachusetts, U.S.A. [Price 15 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 120s. net.]