ACCURACY IN A 72-IN. GEAR-HOBBING MACHINE.

For cutting turbine and similar high-quality gears, a modern gear-hobbing machine must work to close tolerances, usually of the order of 0·0002 in. to 0·0004 in., according to the dimension measured. It must produce gears in a wide range of sizes; the machine shown in Fig. 1, for example, has a maximum capacity of 72 in. diameter and a minimum of 6 in. For work that is so varied, a complex system of drives to the hob and work-table is necessary. Such features, considered separately, are not specially noteworthy, but a machine of this type is remarkable in that it combines all the features in one design. A high degree of accuracy is achieved in the finished gear in spite of the unavoidably complicated design of the hobbing machine. A considerable amount of work has been done on improving the accuracy of hobbing machines for high-class work, and in 1948 British Standard 1498, "Gear Hobbing Machines for Turbine and Similar Drives," was published. It established proper standards of accuracy for these machine tools, not only directly in respect of the feed screws, worms, wormwheels, intermediate gears, etc., but also for sample gears cut on the machine; and it distinguished between two grades of gears, A and B, the former suitable for heavily-loaded gears with high pitch-line velocities (as used in naval gearing, for example) and the latter for high-quality gears running under normal loading and pitch-line velocities.

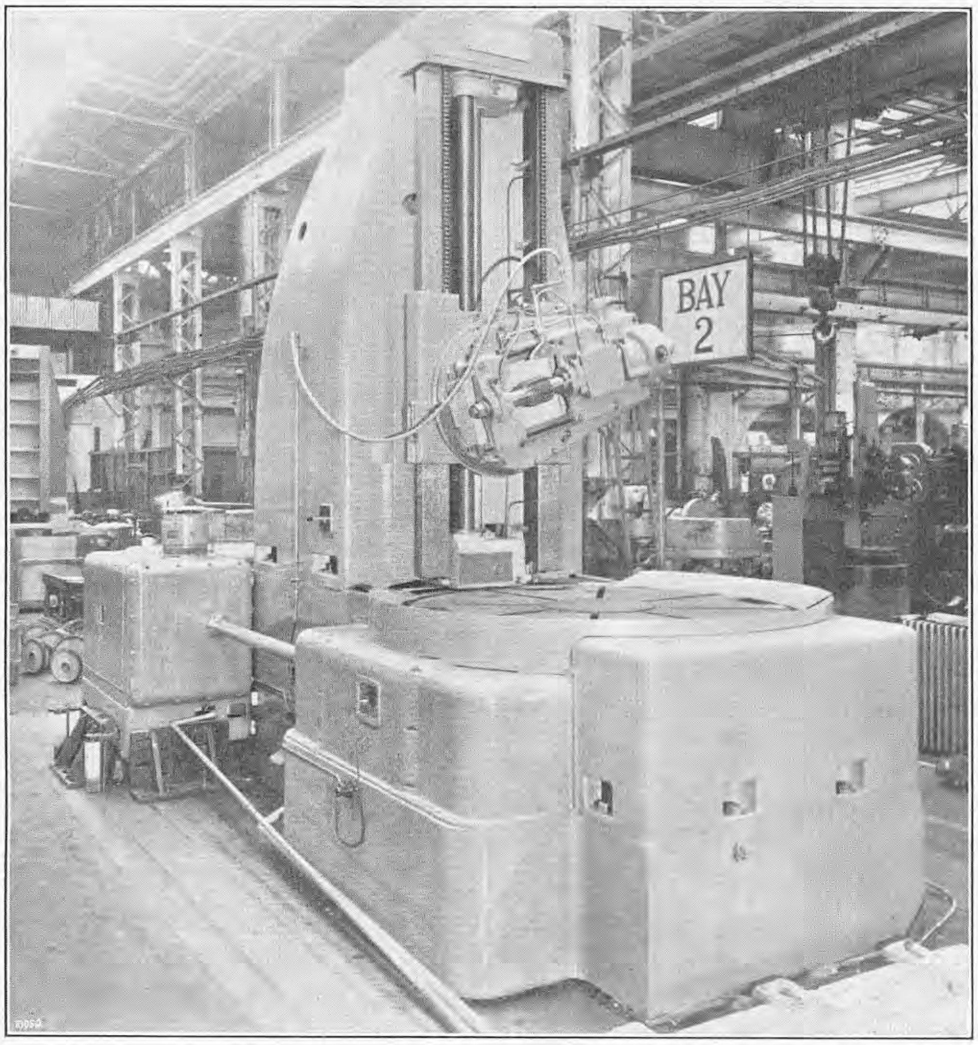
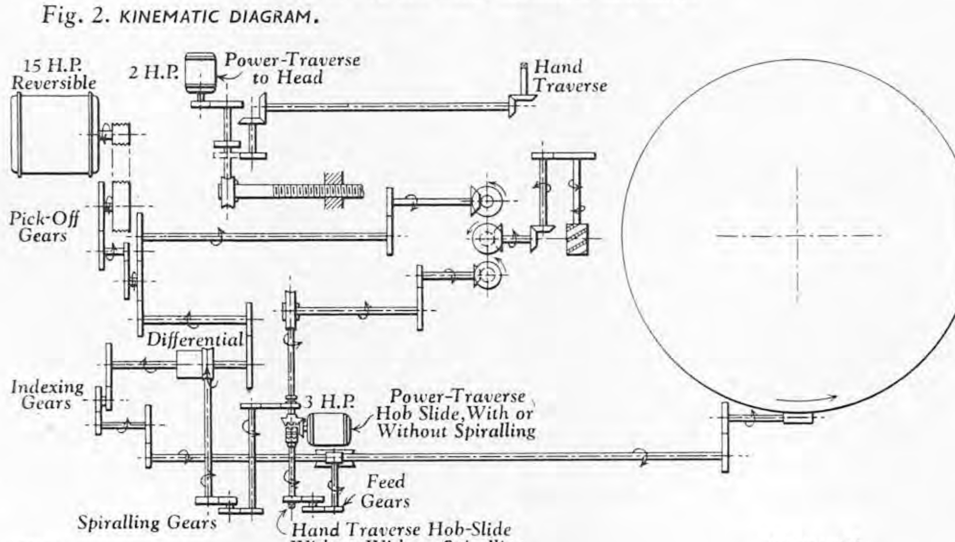


Fig. 1. 72-In. Gear-Hobbing Machine.

Fig. 2. KINEMATIC DIAGRAM.



The machine illustrated in Fig. 1 was built by David Brown Machine Tools, Limited, Manchester, for W. H. Allen, Sons and Company, Limited, Bedford. It conforms with the requirements of B.S. 1498, for grade A work, and has been examined and reported on by the National Physical Laboratory. With the permission of the Director of the Laboratory, and of the two firms concerned, it is now possible to compare the accuracy achieved by the builders of the machine with the standards laid down in B.S. 1498. The bed of the machine is in three sections, the largest forming the base, to which are bolted and dowelled the upright-support casting and the cradle casting. The upright moves on horizontal guides formed in the upright-support casting, to suit the diameter of the gear being cut, and the cradle casting houses the table, and dividing worm and wheel. The hob slide is traversed on vertical guides in the upright by a large-diameter lead screw, and is counterbalanced by a weight suspended in a space in the upright. It can be swivelled through 180 deg. about the horizontal centre-line. The bronze bearings which carry the hob spindle are fitted with spring-loaded pads to reduce radial clearance to a minimum, and the spindle is located axially by thrust washers which are ground and lapped to a high degree of flatness.

The machine table, 80 in. in diameter, is mounted on a radial-location bearing and a flat annular seating, and is attached to a fine-pitch dividing wormwheel, 68 in. in diameter, made of phosphor bronze. The 600 wormwheel teeth have a low pressure angle, which gives almost twice the normal depth of tooth and a greater number of teeth in contact with the dividing worm. The latter is of case-hardened steel, 7 in. maximum diameter and profile-ground to close limits. To eliminate the effect of running clearance in the radial-location bearing of the table, and to ensure that the table rotates truly about a fixed axis, lateral pressure is exerted by adjustable spring-loaded brake shoes on the rim of the table. The range of hob speeds is 20 to 80 r.p.m., and the range of feeds is 0·01 in. to 0·1 in. per revolution of the table. The maximum and minimum numbers of teeth that can be cut are 700 and 30, respectively.

Fig. 2 is a kinematic diagram of the machine, showing the arrangement of the several drives which are required for producing such a wide range of work. The drive from the main motor passes through pick-off gears and then divides, one shaft being coupled to the hob drive and another, through indexing gears, to the table worm and wormwheel. A differential gearbox in the latter drive can be used, in conjunction with the "spiralling" gears, to alter the relative speeds of the hob and the table so as to produce helical gears of the required angle. There are also drives for traversing the upright and the hob slide, both of which can be hand-operated or motor-driven. The N.P.L. tests were designed to check the errors in the principal motions, in so far as they affect the accuracy of gears generated on the machine and in accordance with B.S. 1498. They were in two parts: those on the machine itself and those on test gears cut on the machine.

N.P.L. Examination of Machine.

Table Motion.—The dividing gears of the machine were arranged so that the speeds of rotation of the hob and worm were in the ratio of 6 : 5, i.e., division for cutting 720 teeth, the wormwheel having 600 teeth. The variations in relative motion of the table to the worm shaft and hob shaft were recorded on smoked-glass plates using the N.P.L. design of piezo-recording equipment. Records were taken in four positions at 90 deg. on the table for both directions of rotation, but as the curves of results were similar it is sufficient to show—in Figs. 3 and 4, on page 194—specimen results for clockwise rotation of the table. Fig. 3 shows the errors at pitch-circle radius (P.C.R.) of the motion of the

ACCURACY IN A 72-IN. GEAR-HOBBING MACHINE.

Fig. 3. RELATIVE MOTION OF WORM TO TABLE, CLOCKWISE.

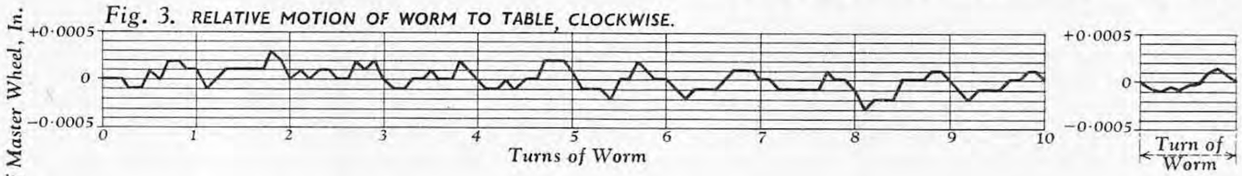


Fig. 4. RELATIVE MOTION OF HOB TO TABLE, CLOCKWISE.

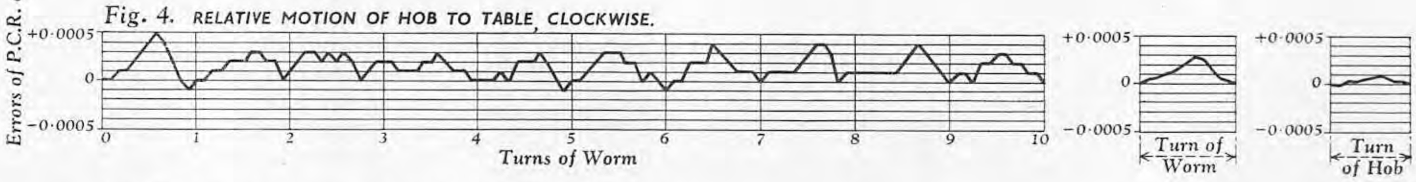
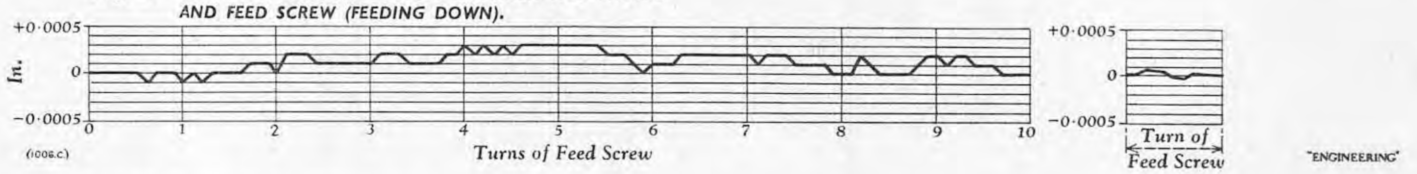


Fig. 5. ERRORS IN RELATIVE MOTION BETWEEN HOB SADDLE AND FEED SCREW (FEEDING DOWN).



worm relative to the table for ten turns of the worm. Fig. 4 shows the errors of the motion of the hob relative to the table. The cyclic error in the table motion per revolution of the worm shaft is defined by B.S. 1498 as the arithmetic sum of the maximum positive and maximum negative deviations (i.e., the total range of deviation) from uniformity in the movement of the table relative to its mean movement during one revolution of the worm shaft. For grade A work, B.S. 1498 allows a total range of average error of not more than 0·0004 in., for both worm-shaft frequency and hob-shaft frequency. Table I below shows that the errors of the machine were within this total range. A cyclic error amounting to 0·0003 in. total range was recorded on each set of flanks of the main indexing worm.

TABLE I.—*Cyclic Errors at P.C.R. of Machine Master Wheel. (Total Range.)*
Unit: 0·0001 in.

Relative Motion Between:	Plate No.	Worm-Shaft Frequency.		Hob-Shaft Frequency.	
		Clock-wise Motion.	Anti-Clock-wise Motion.	Clock-wise Motion.	Anti-Clock-wise Motion.
Worm and Table	1 (0 deg.)	3	2	—	—
	2 (90 deg.)	2·5	2	—	—
	3 (180 deg.)	2·5	2	—	—
	4 (270 deg.)	2·5	1·5	—	—
Hob and Table	1 (0 deg.)	2·5	2	0·5	1
	2 (90 deg.)	3	2·5	1	0·5
	3 (180 deg.)	3	2·5	1	0·5
	4 (270 deg.)	3	3	1	1

NOTE.—A cyclic error amounting to 0·0003 in. total range was recorded on each set of flanks of the main indexing worm.

Hob-Saddle Motion.—The cyclic errors in relative motion of hob saddle and feed screw were measured at two positions for both directions of feed. The average cyclic error, total range, was found to be within 0·0001 in. for downward traverse and within 0·0002 in. for upward traverse of the hob saddle. B.S. 1498 allows 0·0004 in. for grade A work. A typical curve of results is shown in Fig. 5 for the hob saddle feeding down. Tests were also made to determine the extent of any tilt of the hob-saddle in the longitudinal and transverse vertical planes, by means of a sensitive level mounted on the hob saddle. The extent of this tilt, over most of the available traverse of the hob saddle, expressed in terms of relative motion of the hob with respect to the feed-screw nut, did not exceed 0·0003 in. in the longitudinal plane and is within 0·0002 in. in the transverse plane.

Parallelism of Hob-Saddle Motion to Table Axis.—The parallelism of hob-saddle motion with respect

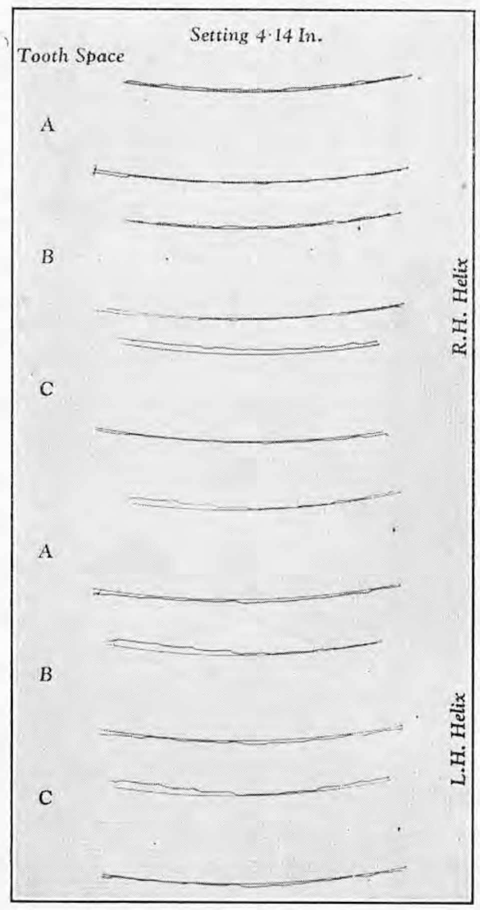


FIG. 6.

to the axis of rotation of the machine table was measured by means of a test pillar supplied by David Brown Machine Tools, Limited. Measurements were made in both the transverse and longitudinal planes at 6-in. intervals. The results are given in Table II, opposite. In the transverse plane, the maximum permissible errors quoted in B.S. 1498, for grade A machines, are 0·0002 in. and 0·0007 in., when measured over lengths of 6 in. and 36 in., respectively.

Eccentricity of Rotation of Hob Spindle.—The total indicator variations at three positions along the hob spindle were found to be as shown in Table III.

Axial Float of Hob Spindle.—The axial float of the hob spindle was found to be 0·0001 in. for both directions of rotation of the spindle, and therefore in accordance with B.S.1498, which allows 0·0002 in.

Eccentricity of Rotation of Table.—The total indicator variations at four positions approximately

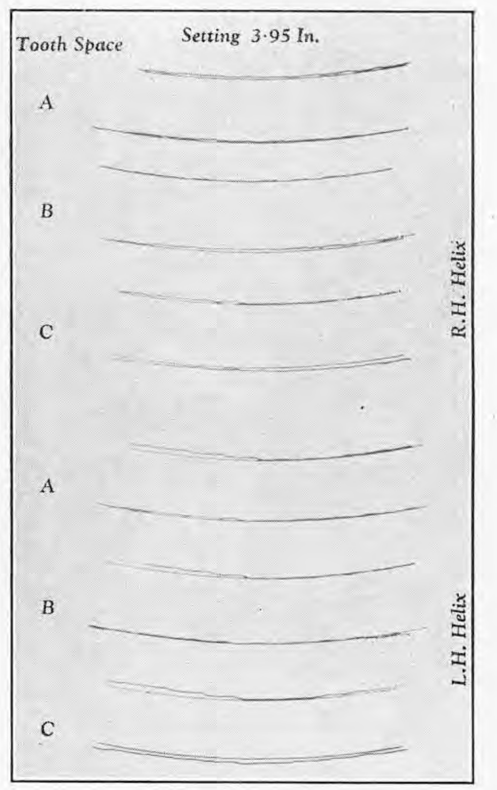


FIG. 7.

at 90 deg., on a ground reference band on the table periphery, were within the 0·0010 in., for both directions of rotation, allowed by B.S.1498. During the course of this test, the appropriate radial pressure loading was applied for each direction of rotation.

EXAMINATION OF TEST GEARS.

Tests were made on a double-helical gear, cut on this machine, in respect of tooth-flank undulations and axial pitch. Each helix was cut using the same portion of the feed screw. The following are the details of this gear: number of teeth, 172; circular pitch, 0·58896 in.; helix angle, 31 deg. 56·87 min.; axial pitch, $\frac{17}{18}$ in.; face width, $8\frac{1}{2}$ in.; machine feed during finish cutting, 0·04 in.; hob speed during finish cutting, 20 r.p.m.

The calculated wavelengths of typical undulations which may arise from periodic errors in the main machine elements are given in Table IV. In order to establish the amplitude and wavelength of any undulations which may arise from errors in the machine elements given in Table IV, it is essential that the spacing of the two fixed balls of the undula-

ACCURACY IN A 72-IN. GEAR-HOBBING MACHINE.

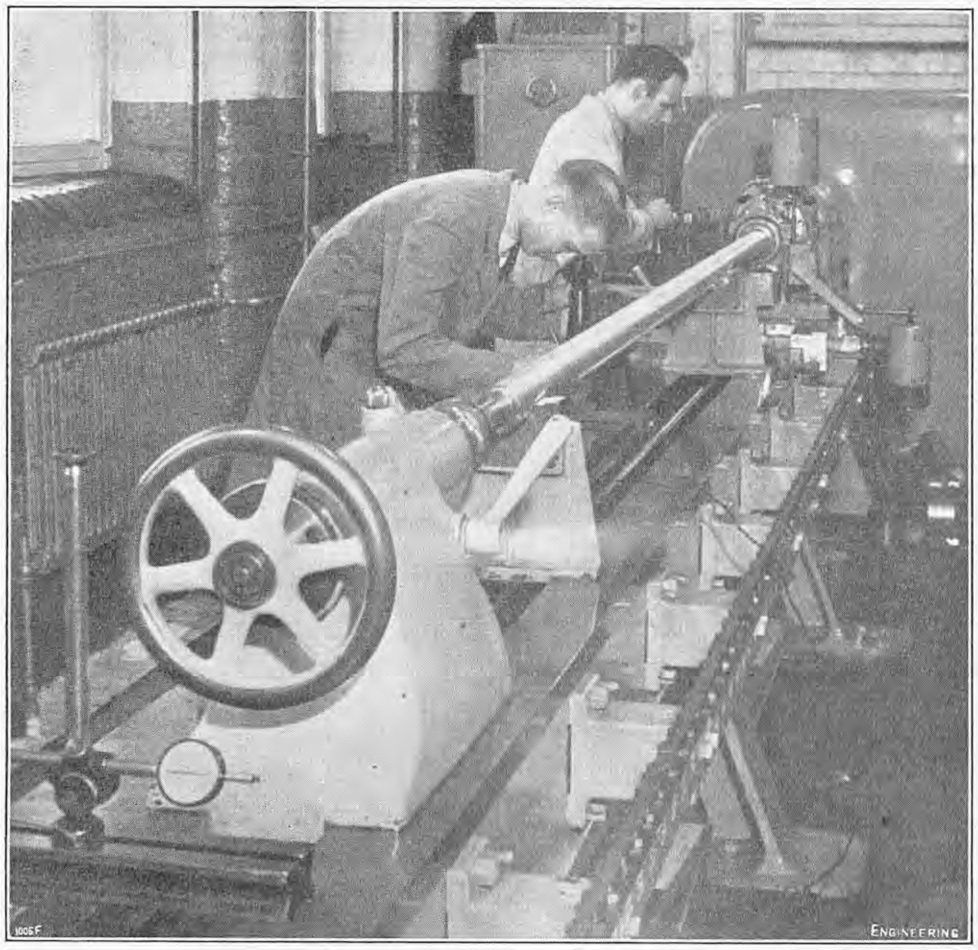


FIG. 8. MASTER SCREW-CUTTING LATHE.

tion recorded should correspond to an odd number of wavelengths. Table V shows the instrument settings together with the length of instrument traverse in each case.

TABLE II.—*Parallelism of Hob-Saddle Motion to Table Axis.*

Distance of Hob-Saddle Traverse, in.	Errors in Alignment (Unit 0·0001 in.).	
	Transverse Plane.	Longitudinal Plane.
0	0	0
6	0	−1
12	+0·5	−1
18	+0·5	0
24	0	+1
30	0	+1
36	−1·5	+2
42	−3	+3
47	−1·5	+4

NOTE.—In the transverse plane a + sign means that the hob saddle travels towards the right of table axis when facing the machine column. In the longitudinal plane a + sign means that the hob saddle travels towards the table axis.

Records were taken on both helices at three positions, spaced at approximately 120-deg. intervals, round the periphery of the gear. With the exception of the diurnal waveform, the photographic enlargements in Figs. 6 and 7 represent an overall magnification of 200, i.e., 20 × 2 (mechanical) × 5 (optical). The records show little evidence of any pronounced undulation and the amplitude of the wave-form only amounts to 0·0001 in.

Axial Pitch.—The axial pitch of the test gear was measured over a length of 6 pitches of nominal value 5·6667 in. The measured values were found to be: right-hand helix, 5·6662 in.; left-hand helix, 5,6660 in. These errors, of 0·0005 in. and 0·0007 in., respectively, do not exceed the 0·0007 in. allowed by B.S.1498 over an approximate length of 6 in.

Further measurements of axial pitch were carried out on a double-helical gear, available at Messrs. Allen's works, of which the main dimensions were: circular pitch, 0·45878 in.; normal pitch, 0·39984 in.; number of teeth, 256; helix angle, 29 deg. 21·89 min.; axial pitch, $\frac{53}{65}$ in. The axial pitch was measured over a length of 7 pitches of nominal value 5·7077 in., and the measured values were found to be 5·7072 in. for the right-hand helix and 5·7073 in. for the left-hand helix. The errors here, of 0·0005 in. and 0·0004 in., respectively, were also less than the B.S.1498 figure of 0·0007 in.

These results of the N.P.L. tests show how success-

TABLE III.—*Eccentricity of Rotation of Hob Spindle* (Unit: 0·0001 in.)

Position.		On Reversing Direction of Rotation.	Maximum Permissible Error, B.S. 1498.	
			Grade A.	Grade B.
At Drive End	3	3·5	2	3
At Centre	3·5	4		
At Other End	3	3		

ful David Brown Machine Tools, Limited, have been in complying with the standard requirements. The accuracy of the table drive has been achieved by a process of evolution, each master dividing wheel reducing some of the inaccuracies of its predecessor. The dividing wormwheel in the master machine at the makers' works is, in effect, the "great-grandfather" of the dividing wormwheels used in a considerable number of the turbine-gear hobbing machines in existence. However, the accuracy achieved in dividing would not have been of any appreciable value without parallel developments in the precision of lead screws. These important components are finished at the Manchester works on a master screw lathe, which is equipped with a corrector bar, as shown in Fig. 8, herewith.

The third component in which the utmost precision is vital is the dividing worm. These are produced for the makers by the David Brown Tool Company, at Huddersfield, who are also equipped for the accurate production of hobs to the standards laid down by the Admiralty. In addition, the large and rigid castings of the machine are stress-relieved before machining. The condition of the castings after treatment is observed by Brinell testing to ensure homogeneity of the materials on the vital portions such as slideways, etc.

Another important method of maintaining the required accuracy has been adopted by David Brown Machine Tools, Limited, on recent machines. These have two independent table motions, one o which has a coarse-pitch wormwheel, which is used for roughing operations, and another a fine-pitch wormwheel for making the finishing cut only.

TABLE IV.—*Gear-Tooth Undulations.*

Machine Element.	Number of Revolutions per Revolution of the Machine Table.	Calculated Wavelength Along Tooth Helix (in.).
(*a*) Periodic error of worm-shaft frequency	600 (number of teeth in master wheel)	0·319
(*b*) Periodic error of feed-screw frequency	Lead of feed screw (0·5 in.)	0·589
(*c*) Periodic error of 57-tooth gear-shaft frequency	600 × $\frac{49}{57}$ = 515·7895	0·564
(*d*) Diurnal change in surrounding air temperature	24-hour cycle	7·893

TABLE V.—*Instrument Settings for Gear-Tooth Undulations.*

Undulation.	Instrument Settings (in.).	Instrument Traverse (in.).
a } Fig. 6	4·14	5
b } Fig. 6	4·14	5
c } Fig. 7	3·95	5
**d* } Fig. 7	3·95	5

* This setting is half the diurnal wavelength, and consequently the magnification of the diurnal undulation records is only 100.

The first machine made by the Company to achieve grade "A" standards of accuracy was one supplied to Cammell Laird and Company, Limited, Birkenhead, in 1948. This machine had the unique feature of a tandem drive to ensure uninterrupted cutting by the use of one of two alternative sources of power supply, thus providing an automatic change-over in the case of power failure. Another machine to attain similar limits of accuracy was a 24-in. pinion machine, which is now installed at the works of the parent company, David Brown and Sons (Huddersfield), Limited. This machine has certain unusual features, the most notable being the combined structure of the head and the work steady, designed to ensure the utmost rigidity.

TINPLATE EXPORTS.—It was stated by Mr. Peter Thorneycroft, the President of the Board of Trade, on August 1, that 28,000 tons of tinplate were exported to Continental Europe during the twelve months ended June 30, 1952.

THE P. & O. LINER "CHUSAN."—Before commencing this season's cruising programme, the P. & O. liner Chusan was fitted with a new top to the funnel, which was also heightened, to prevent the drift of smoke and the deposit of smuts on the superstructure. The new funnel top was designed by J. I. Thornycroft & Co., Ltd., and was constructed by R. & H. Green & Silley Weir, Ltd., at the Royal Albert Dock works, London. During the first cruise, of 13 days, the modification proved very effective, no smoke touching any part of the ship's structure. There was a complete absence of fumes on the after decks.

LITERATURE.

Annual Report (Technical), 1948, Central Board of Irrigation, India. Parts I and II.

Offices of the Board, Curzon-road Barracks, New Delhi, India. Parts I and II. [No price indicated.]

THIS ponderous document (Publication No. 47) follows the usual lines adopted for its predecessors, but has been considerably expanded by the inclusion of sections dealing with water power. The meeting of the Board took place in December, 1948, and the Prime Minister (Pandit Nehru) and Mr. A. N. Khosla, President of the Board, inaugurated the proceedings. Details are given of the previous meetings in 1948 by the various committees, and these are followed by the summarised annual reports of the eight research stations. The remainder of the first volume includes the technical proceedings under the headings of "Hydrology," "Theory of Flow and Design of Channels," "Water Power Works," "Soil Science," "Water Utilisation Projects" and "General"; the section entitled "Hydraulic Works" fills the entire second volume. This sub-title is rather misleading, since the vast majority of the works described are only projects or models. The same could be said of much that appears in the report as a whole.

An item of considerable interest is the subject of translation of technical terms into the "national language." It is not by any means clear what this expression means, for there is no language except English which is really general in India. Bengali, Hindi and Urdu are mentioned, and the general consensus of opinion was that, at this stage, English terms should not be discarded and that all technical terms translated into Hindi should be adopted into other Indian languages. There is an obvious danger that the Nationalist influences will work against the preservation of English, and already it is being suggested that articles in Hindi should be encouraged in the *Journal* of the Central Board of Irrigation. This is a perfectly natural development, but none the less an unwelcome one to English-speaking engineers, who must deplore anything which tends to raise a barrier between peoples. In Japan, similarly, there has been a great effort to abolish European language influences and, though this has been set back by the outcome of the war, it will probably recur. In China, a similar state now occurs, and threatens to interrupt all neighbourly relations.

An interesting suggestion by Dr. N. K. Bose, that mustard seed is suitable material for the study by models of silt exclusion, was discussed. Dr. Bose stated that mustard seed grains did not float, but settled down and rolled along the bed. If this is true of English mustard, the idea may be valuable. An extensive discussion of artificial rainfall is reported, including the effects of the atom bomb, but no very useful suggestions were made. On page 701 of the report there are two items relating to tidal models, one on the Hooghly at Titaghar jute mill and the other at Cochin Harbour. These should be of interest to harbour engineers, especially the second. The subject of fish passes for dams was also considered, but no really serviceable comments were made except about the importance of studying the particular fish concerned. Indian fish differ in their habits from those of other countries. While the use of river models is to be welcomed, there seems to be in India a regrettable tendency to rely too exclusively upon their indications. This is presumably due in part to inability, in the present, economic situation, to raise the necessary funds for major works, but there is a grave danger that the fascination of model experiments may lead to misdirection of effort.

In these two volumes, there does not seem to be much work reported on actual rivers, though there must be many streams in India which have not been sufficiently studied. In China, one river alone, the Whangpoo, was the subject of intensive study for many years, and unless similar methods are applied in India it is to be feared that, when the time is ripe for major works to be undertaken, there may not have been adequate preparation. Perhaps we are doing an injustice to Indian engineers in making this suggestion, but certainly the impression given in this report is that not nearly enough attention is being given to practical matters and river records. The photographic illustrations which occur are so badly obscured in printing that they serve no useful purpose and might well have been omitted. The line illustrations, however, are well done, and praise must be given to the proof-reading, the number of errors being very small.

Red Metal: The Calumet and Hecla Story.

BY DR. C. HARRY BENEDICT. University of Michigan Press, Ann Arbor, Michigan, U.S.A. [Price 4 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 32s. net.]

THIS is an unusual book in several respects. In that it is a history of some of the most famous copper mines in the world, of course, it is unique; but there must be very few industrial enterprises which have been so fortunate in their "biographers," for Dr. Benedict is a metallurgist of high distinction, a historian (it would seem) by instinct, and has been associated for more than half a century with the undertakings of which he writes, knowing personally Alexander Agassiz, James MacNaughton and others of the men who built up what is now the Calumet and Hecla Consolidated Copper Company.

The mining properties with which the book is concerned are located in the Keweenaw peninsula, in the State of Michigan, and on the shore of Lake Superior. That there was copper in the region was well known, and mines had been worked profitably in the peninsula, before the Civil War; many more, however, had proved unprofitable to work, and more still had never progressed beyond the schemes of speculators, and not a few swindlers. The existence of the Calumet Conglomerate lode, however, was unsuspected (at least, by white prospectors) until Edwin J. Hulbert, in 1858, while surveying the route for a proposed road, discovered fragments of copper-bearing rock which, he concluded, had worked up to the surface; its condition showed that it had not been transported from elsewhere by stream or glacial action. He buried the pieces of rock until he was in a position to acquire the land, which he did in 1864. The ore proved difficult to work, however, by the primitive methods available, added to which it appeared that Hulbert was not the most successful of mine managers. Eventually, he was dismissed by resolution of the board of the Calumet and Hecla Mining Companies (then separate) and Quincy A. Shaw, who was President of both, and his brother-in-law, Alexander Agassiz, took control. Their troubles continued until they replaced the previous drop stamps with Ball steam stamps, after which they made rapid progress, until, "by the end of the year 1867 the Hecla mine was already the premier producer of the district" with an output of almost 3,000,000 lb. of ingot copper, though the mine was only nine months old. The Calumet mine made less spectacular progress, producing only 1,600,000 lb. of copper in 1867; but it developed rapidly enough when its "teething troubles" were overcome until, in 1899, the two mines together produced over 89 million pounds of copper, sold at an average price of 17·6 cents a pound, and were able to distribute 10,000,000 dollars in dividends.

To trace the subsequent fortunes of the Consolidated Company (as it became in 1871) would take up much space, and would be unfair to the author of the book, whose story deserves to be read as he has told it; but it may be said that the technology of copper recovery, both from the ore and from the masses of tailings, dating from the early days and subsequently worked over again by new techniques, especially the flotation process, owes much to the skill and pertinacity of those who conducted the company's operations. A great deal of the credit for these later developments belongs personally to the author of this book, and students of American mining history and economics may count themselves fortunate that he is as able a recorder as he is a metallurgist.

Strain Gauges: Theory and Application.

BY PROFESSOR IR. J. J. KOCH, IR. R. G. BOITEN, IR. A. L. BIERMASZ, G. P. ROSZBACH AND G. W. VAN SANTEN. Cleaver Hume Press, Limited, 42A, South Audley-street, London, W.1. [Price 15s.]

THE authors state in the preface of this book (one of Philips' Technical Library) that they wrote "with the intention of providing for the benefit of future users, a concise but comprehensive description of the technique of measuring with strain gauges and everything appertaining thereto." The electric resistance strain gauge, however, has been so thoroughly investigated and discussed in the past ten years that a comprehensive and comprehensible account of it can hardly be expected within a mere 93 pages. The most successful sections, Chapters 3 and 4, written by Ir. R. G. Boiten for the beginner, provide a detailed description of the method of cementing a strain gauge to a metal surface by means of a nitrocellulose cement, the wiring of the gauge, and an account of the inaccuracies, chiefly electrical in origin, which may occur in this method of measuring strain. The clear instructions in Chapter 3 on bonding and wiring are particularly valuable, for many beginners are misled by the over-simplified instructions issued by the gauge manufacturers, and this important aspect of the art receives scant attention in the literature on the subject. It is a pity that the methods of bonding with thermosetting resins are not included in the book. They are far superior as adhesives and insulators at temperatures over 40 deg. C., and where the gauges are used in measuring instruments.

The remainder of the book is mainly a repetition of information which has already been given in text-books on the subject. In Chapter 1, the construction of a gauge is rather perfunctorily described and a new derivation given of the gauge factor. In a book where measuring errors amounting to 10^{-5} and 10^{-6} in strain are discussed, it is odd to find that brief reference only is made of the variation in gauge factor among a batch of gauges, and of possible non-linearities in the relationship between resistance change and strain in the wire, both of which are the cause of relatively large experimental errors. Chapters 2 and 5 are hardly in keeping with the rest of the book. The beginner, expecting to find in Chapter 2 a simple description of the resistance networks which are used principally for static strain measurements, may easily be left with the impression that the strain gauge is merely a convenient input impedance for a great deal of electronic circuitry. Professor Koch, in Chapter 5, which is entitled "Stresses and the Theories of Failure," attempts a course of stress analysis, a subject which has been dealt with more clearly and simply in text-books on elasticity and plasticity. These 20 pages might have been used more profitably to describe a method for measuring principal strains by a rosette-type gauge. To sum up, the experimenter who has already handled these gauges successfully will find little new information in this book, but the beginner could profitably add Chapters 3 and 4 to his reading on the subject.

WHALE FACTORY SHIP "JUAN PERON."

HARLAND AND WOLFF, LIMITED, BELFAST.

FIG. 1. VESSEL UNDER WAY.

THE ARGENTINE WHALE-FACTORY SHIP "JUAN PERON."

ALTHOUGH it has been known for a long time that whales are a prolific source of valuable commodities other than blubber, until comparatively recent years large quantities of valuable by-products of the whale fisheries have had to be wasted because of deficient techniques and the lack of processing machinery suitable for use in factory ships. The continued shortage of oils and fats, however, has given an added impetus to developments in this direction and outstanding advances have been made in the processing of whales to obtain, for example, liver oils, of high vitamin content, and meals rich in protein, in addition to the usual blubber oils. To accommodate the extra plant required for these processes and, at the same time, to provide storage space for the additional end products, factory ships have tended to increase in size. One of the latest vessels to be put into service, namely, the Juan Peron, is understood to be the largest vessel of this type yet built, and her processing machinery the most elaborate to be installed in a factory ship. This vessel was built at the Belfast yard of Harland and Wolff, Limited, for the Compañia Argentina de Pesca, Buenos Aires, and has been designed so that, in the off season, she can be employed on normal tanker duties.

An impression as to the general appearance of the Juan Peron can be gained from Fig. 1, on this page, and Fig. 2, on page 198, which shows the vessel leaving for her trials; and from the profile drawing given in Fig. 4, on Plate VIII. Figs. 5 to 12, on the same Plate, give the deck plans, and a general view of the flensing deck is shown in Fig. 3, on page 198. As will be seen from these illustrations, the design follows the usual practice for a vessel of this class, the navigating bridge being set well forward to give a long flensing deck and a slipway provided in the stern to permit the whales to be hauled inboard. The principal dimensions are: length between perpendiculars, 635 ft.; breadth, moulded, 80 ft.; breadth at flensing deck, 80 ft.; depth to tank deck, 36 ft.; depth to flensing, deck, 61 ft., and oils of mean summer draught, 34 ft. 6 in. The deadweight tonnage is approximately 27,000, the gross tonnage 22,300, and the net tonnage 14,570. To enable the vessel to operate as a tanker, she has been built under Lloyd's special survey for ships carrying oil in bulk with a flash point below 150 deg. F. This means that certain safety precautions have had to be incorporated in the design; the factory spaces, for example, are arranged so that there is adequate ventilation when oils of low flash point are being carried, and the electrical system is so designed that all equipment not required when working as a tanker can be isolated. The remaining electrical equipment, of course, is of flame-proof construction.

There are two decks, namely, the flensing deck, on which the whales are cut up, and the factory deck, the former having a length of 323 ft. and the latter a length of 358 ft. The factory is capable of handling up to 2,500 tons of raw materials a day, including 320 tons of lean meat, 200 tons of grax (that is, the solid residues and entrained liquors which come from the blubber and fat-meat treatment sections) and 15 tons of raw liver. There are ten main oil cargo tanks; these extend across the vessel and are divided fore and aft by three continuous longitudinal bulkheads, the capacity being sufficient to contain approximately 25,500 tons of oil at 39 cub. ft. per ton, with the necessary allowance for expansion. A double bottom is fitted under the machinery spaces and this is suitably divided for the carriage of fresh water, oil fuel and lubricating oil. The forward hold is insulated for the carriage of whale meat, and the refrigerating plant is installed at the forward end of the factory space. Deep tanks are fitted below this hold and these are used for the carriage of oil fuel, fresh water or water ballast, a centre line bulkhead being provided in each tank. Fresh water or water ballast is also carried in the forward and after peak tanks and in a tank under the slipway. Two cargo-pump rooms are provided, one between Nos. 3 and 4 tanks and the other between Nos. 6 and 7 tanks.

The accommodation for the owners, captain, deck officers, factory manager, etc., is arranged in the bridge structure and that for the engine-room officers in the after deck-house. The seamen and engine-room hands are berthed below the poop deck, the cooks, stewards and mess boys in the forecastle, and the factory workers and catcher crews aft on the flensing and factory decks, and on a stringer deck, known as the cabin deck, situated between these two. The total complement is 484, comprising the ship's crew of 92, a catcher crew of 136, and 256 factory workers. The galleys, pantries, butcher's shop, bakery, etc., and the mess rooms for the petty officers, ratings, factory workers, stewards, etc., are situated under the forecastle deck. The facilities provided for the crew include a recreation room; two laundries with electrically-driven machinery, one forward and one aft; a hospital, with consulting rooms and a dispensary, and a complete X-ray installation. The accommodation complies with the latest requirements of the Argentinian authorities and the British Ministry of Transport.

The vessel is propelled by twin screws, each driven by a Harland and Wolff—B. and W. six-cylinder single-acting four-stroke Diesel engine, constructed by the builders of the ship and designed with under-piston pressure induction. The bore and stroke are 740 mm. and 1,500 mm., respectively, and the service speed is 110 r.p.m. Fresh-water cooling is employed for the cylinder liners and covers, but the pistons are cooled with oil from the forced-lubrication system in accordance with the builders' usual practice. With the exception of the oil purifiers, all auxiliary machinery in the engine room is steam-driven, steam for this purpose, and for process work in the factory, being provided by six single-ended cylindrical boilers, burning oil fuel under a system of forced draught. The boilers are installed on a flat at the forward end of the engine room, an athwartship bulkhead separating the flat from the rest of the engine room. In addition to the usual auxiliaries, there are three evaporating and distilling plants, each capable of producing 250 tons of fresh water a day and arranged so that each plant can work in single, double or triple effect.

The factory machinery, deck auxiliaries, refrigerating plant, galley and pantry equipment, etc., are electrically operated, the total number of electric motors on board being 301 and the total connected load approximately 2,107 kW. Direct current for these various services is supplied at 220 volts by five 425-kW generating sets, each driven by a Harland and Wolff six-cylinder Diesel engine having a bore and stroke of 580 mm. and 570 mm., respectively, and one 120-kW Diesel-engine set. There is also a 120-kW motor-driven generator which supplies direct current at 110 volts for lighting purposes. The generating plant, together with the associated auxiliaries, is situated forward of the main engines below the boiler flat.

The deck machinery includes two steam-operated fishing winches and two 40-ton steam winches for hauling whales up the slipway on to the flensing deck. Two steam capstans are fitted at the after end of the poop deck for handling the grab hooks which are fastened to the carcase of the whale before hauling commences. There are also ten steam capstans, twelve 10-ton derricks, two 15-ton derricks and a 15-ton steam winch for handling the carcases on the flensing deck. The 10-ton and 15-ton derricks are operated by sixteen 5-ton steam winches. Extensive workshop facilities are provided on the 'midship deckhouse on the flensing deck for use by the personnel concerned with the maintenance of the factory machinery and the whaling equipment on the catchers. There is also the usual workshop adjacent to the machinery space for dealing with repairs to the propelling machinery.

The factory machinery, as previously indicated, is capable of handling up to 2,500 tons of raw material a day. A considerable part of the plant is devoted to the recovery of oil from the blubber, fat meat and the bones by processes which, in general, follow traditional lines. The more interesting parts of the processing machinery are, undoubtedly, the lean-meat meal plant, the liver plant and the grax plant; these were designed and constructed by Messrs. Rose, Downs and Thompson, Limited, Old Foundry, Hull. The treatment of the meat is divided into three stages, namely, the preliminary reduction and oil separation, sterilisation and drying, and cooling, grinding and packing. The meat is cut into cubes of approximately 12 in. on the flensing deck and is delivered into hoggers. These employ rotating knives which just clear anvil cutters and reduce the meat, together with any bone, to a pulp. The construction of the hoggers will be seen from Fig. 17, on page 199, which shows one of the units with the covers folded back for inspection. On leaving the hoggers the pulped meat is first passed over magnetic belts to remove any harpoon fragments, etc., and is then fed into steam-jacketed treatment tubes, where it is cooked, hot water being added to free the oil and blood liquors; one of the treatment tubes is illustrated in Fig. 13, on Plate IX. As it leaves the treatment tubes, the meal falls on to vibrating screens which separate the liquors from the solids, the former passing to receiver tanks and the latter into low-pressure liquor expellers.

The expellers are designed to remove the bulk of the liquor remaining in the cooked pulp. One of these machines is illustrated in Fig. 18, on page 199, where it is shown in the shops of Messrs. Rose, Downs and Thompson. The method of operation is to express the pulp continuously by double screws in two successive cages, the pressure set up by the volume reduction forcing most of the liquor through perforations in the cage walls. As in the case of the vibrating screens, the liquors removed by the expellers drain into the receiver tanks, from which they are pumped through a screen, for the removal of fine solids, to a further receiver tank, ready for processing in the centrifugal sludge separators and the oil purifiers. The solids from the expeller are conveyed to an elevator which feeds them into the sterilising and drying units. One of these is illustrated in Fig. 14, on Plate IX, where it is shown in course of erection at the maker's works. This illustration, it whould be explained, only shows the three drying tubes in position, but the sterilising tube is mounted directly above the drying tubes on the same structure.

The meal, as the material has now become, is carried through the steriliser tube by a continuous worm, the heat for sterilisation being applied through a steam jacket. The tube is scavenged by heated air, the vapours released from the meal being condensed and removed from the air stream before it reaches the exhaust fan, so as to protect the fan from erosion and overloading. The driers operate under a fairly high vacuum, to increase their efficiency, and, as a consequence, the meal has to be fed into the top tube of each drier through a vacuum valve. It is moved along each tube in turn by helical paddles, the shafts of which, as will be seen from Fig. 14, are driven from a geared motor through a single chain. The vapours are removed by a wet-type vacuum pump, the evaporated water being condensed before it reaches the pump. These vapours leave the driers at a considerable velocity and carry quite large pieces of meal towards the vacuum pumps; traps are inserted, therefore, in each vapour line to prevent the meal from leaving the driers by this means. The dried meal is discharged from the bottom of the drier through a further vacuum discharge valve and is then conveyed to vibratory screens which remove the rubbery sinews.

The screened meal passes directly to the coolers, one cooler and its associated screen serving two banks of driers. One of the meal coolers is illustrated in Fig. 19, on page 199. The meal is moved along each tube by paddles and cold air is blown through the tube, the paddles being designed so that they tend to lift the meal and cause it to fall through the air stream, any fine dust collected by the air being separated out in a cyclone. Air locks are fitted to the inlet and outlet, the latter being fitted with a variable-speed gear to regulate the discharge rate of the meal, and, therefore, the length of time spent in the cooler. On leaving the cooler, the meal passes over a further magnetic belt for removal of any iron which may have passed through the plant and is then delivered to a combined grinder and cyclone unit, finally passing to an automatic weighing and bagging machine.

The liver plant on board the Juan Peron may be divided into four main sections, namely, the initial preparation of the raw material, the extraction of the oil by a solvent, treatment, and packing. The complete plant occupies a space about 17 ft. wide by 72 ft. long between the tank and flensing decks, and is capable of processing up to 15 tons of liver in 24 hours. The pre-treatment processes are designed to reduce and regulate the moisture content of the raw liver and to produce a meal which can be penetrated by the solvent. After being stripped from the offals on the flensing deck, the liver is delivered to a motor-driven mincing machine, which reduces it to a size that can be handled conveniently in the coagulating chamber. The coagulating machine, illustrated in Fig. 15, on Plate IX, reduces the minced liver to a flaky form, a certain amount of the excess water being evaporated and removed by a current of hot air blown across the chamber. The minced and coagulated meal is then dried and cooled, drying being carried out under vacuum and at a low temperature to prevent oxidisation of the vitamin A in the oil and the ribo-flavin content of the meal. The pre-drying and cooling unit is illustrated in Fig. 16, on Plate IX; it is of the same basic construction as the meat-meal drier, consisting of four tubes, three for drying and one for cooling, mounted in a common structure.

After drying, the meal passes through a water-jacketed cooling tube and is conveyed to the extractor feed bin, ready for delivery to the solvent extraction plant. This plant is a self-contained unit designed for batch operation; it has a capacity of about 25 cwt. and employs trichlorethylene as a solvent. It consists of a vertical steam-jacketed vessel equipped with slow-speed stirrers, so designed that they assist in discharging the meal after

WHALE FACTORY SHIP "JUAN PERON."

HARLAND AND WOLFF, LIMITED, BELFAST.

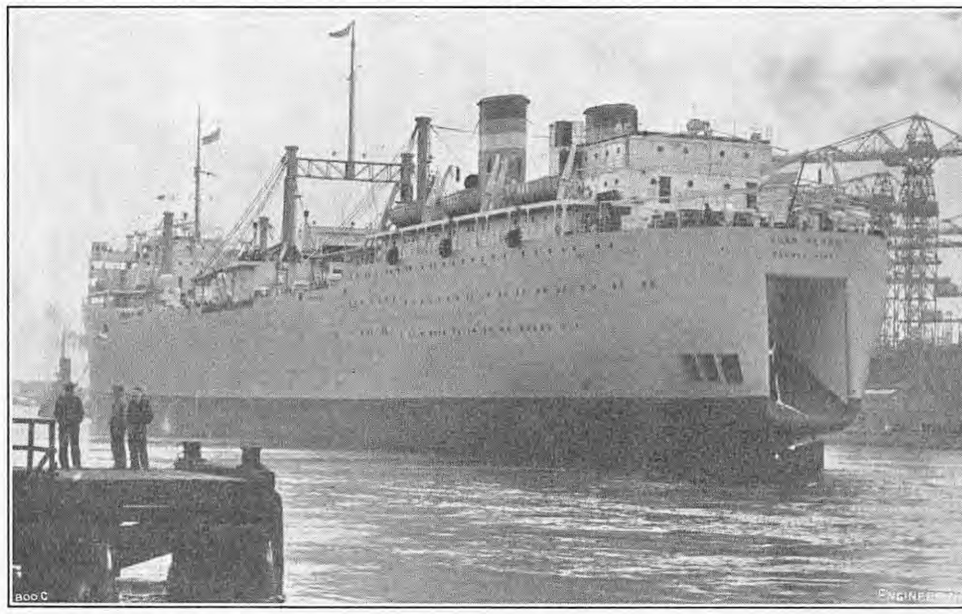


FIG. 2. STERN OF VESSEL, SHOWING SLIPWAY.

FIG. 3. FLENSING DECK.

ARGENTINE WHALE FACTORY SHIP "JUAN PERON."

HARLAND AND WOLFF, LIMITED, BELFAST.

(For Description, see Page 197.)

Fig. 4.

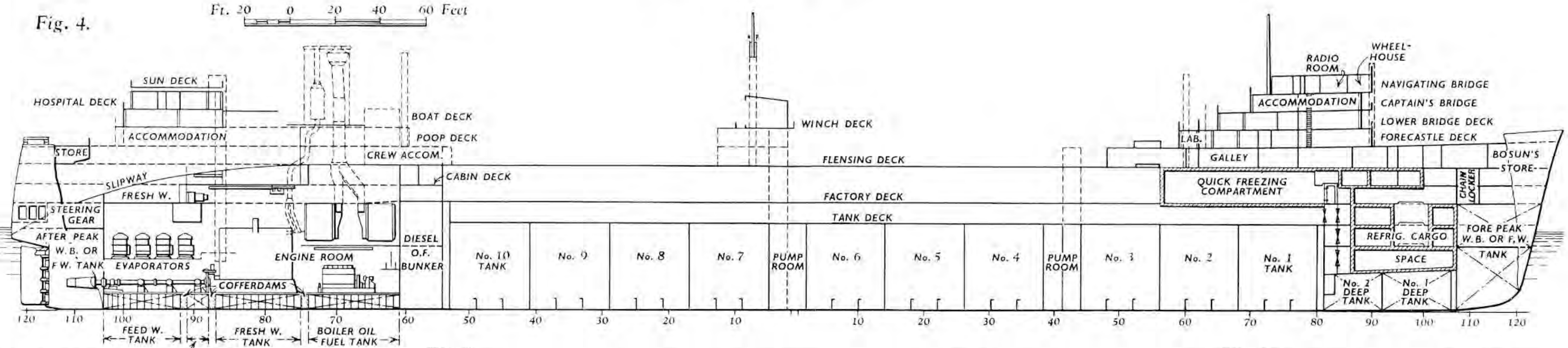


Fig. 5. BOAT DECK.

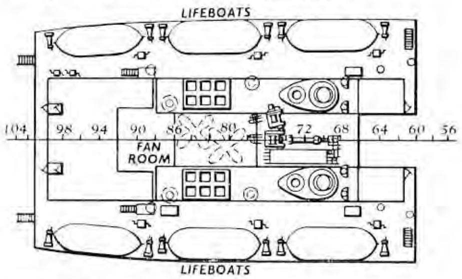


Fig. 6. WINCH DECK.

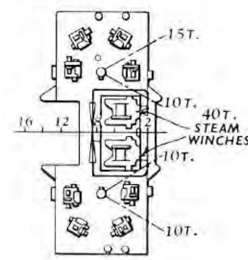


Fig. 7. LOWER BRIDGE.

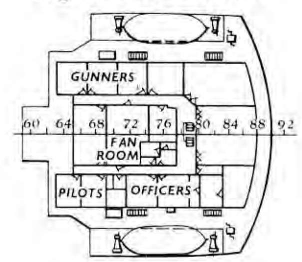


Fig. 8. CAPTAIN'S DECK.

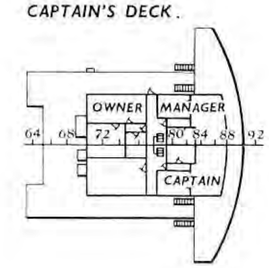


Fig. 9. NAVIGATING BRIDGE.

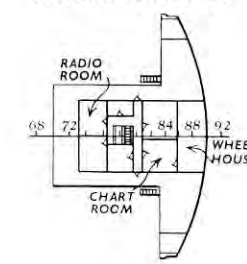


Fig. 10. TOP OF WHEELHOUSE.

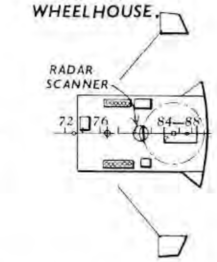


Fig. 11. CABIN DECK.

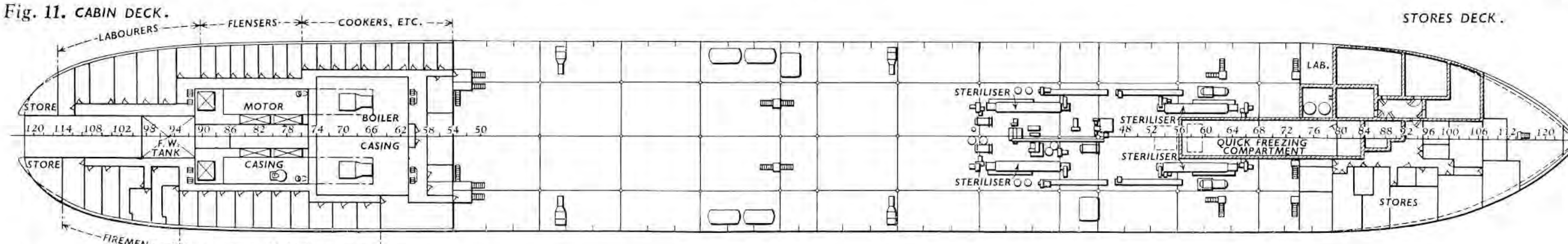
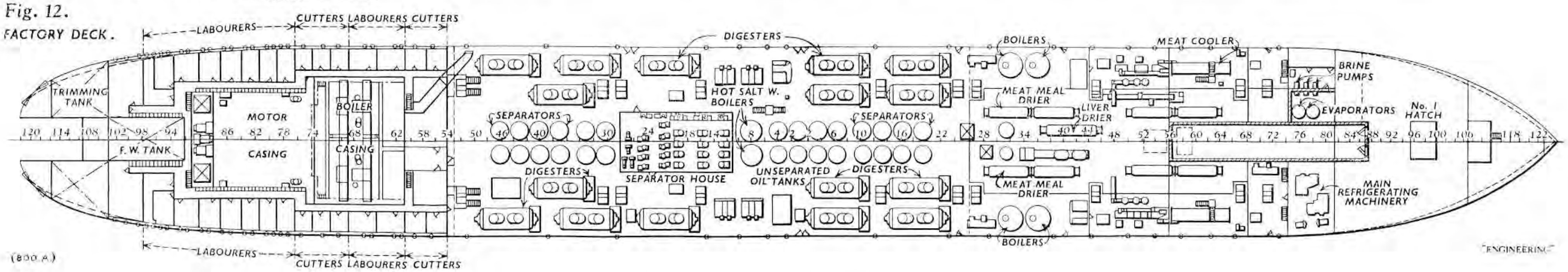


Fig. 12. FACTORY DECK.



(800 A)

"ENGINEERING"

ARGENTINE WHALE FACTORY SHIP "JUAN PERON."

HARLAND AND WOLFF, LIMITED, BELFAST.

(*For Description, see Page* 197.)

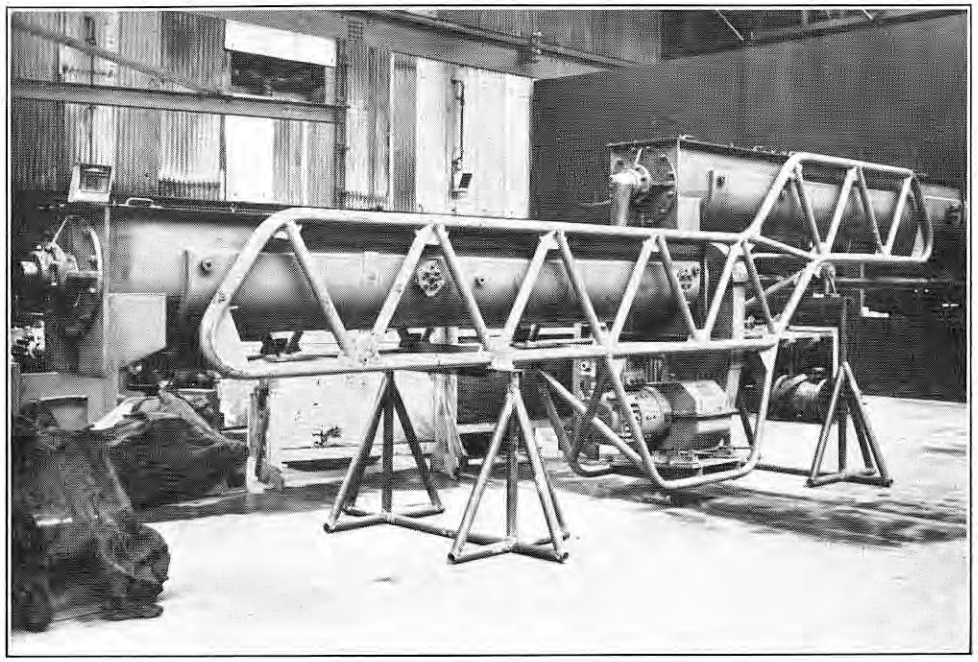


FIG. 13. WHALEMEAT TREATMENT TUBE.

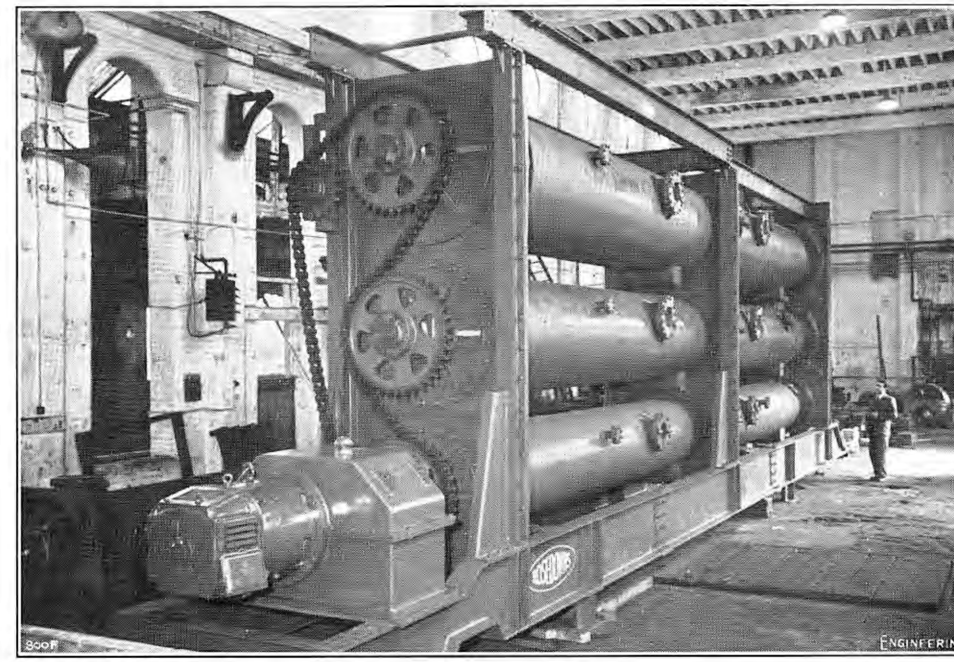


FIG. 14. MEAT-MEAL DRYER.

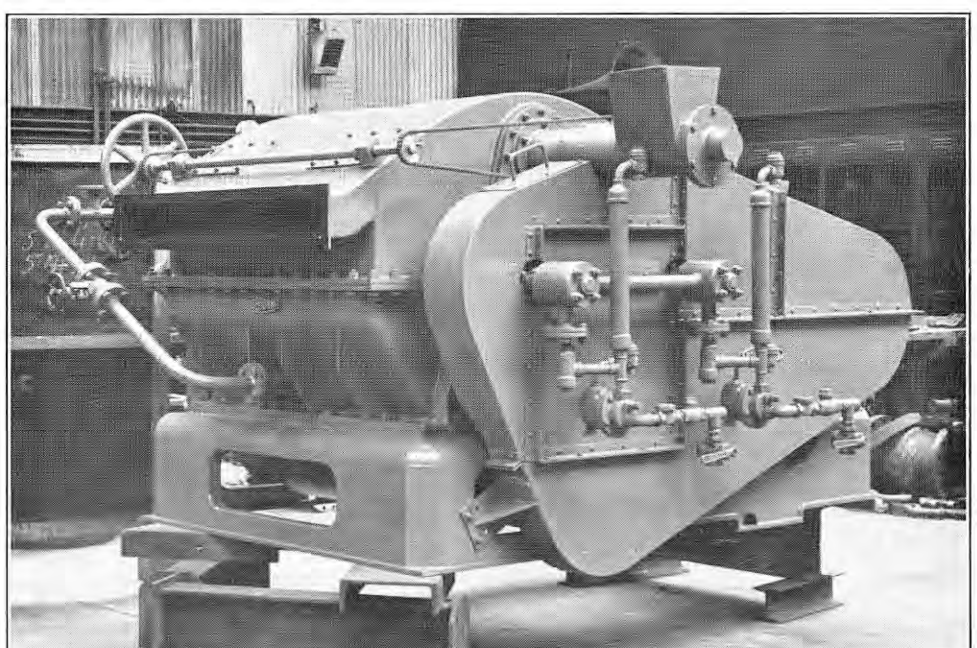


FIG. 15. COAGULATING CHAMBER.

FIG. 16. LIVER-MEAL DRYER.

(To face page 190.)

WHALE FACTORY SHIP "JUAN PERON."

HARLAND AND WOLFF, LIMITED, BELFAST.

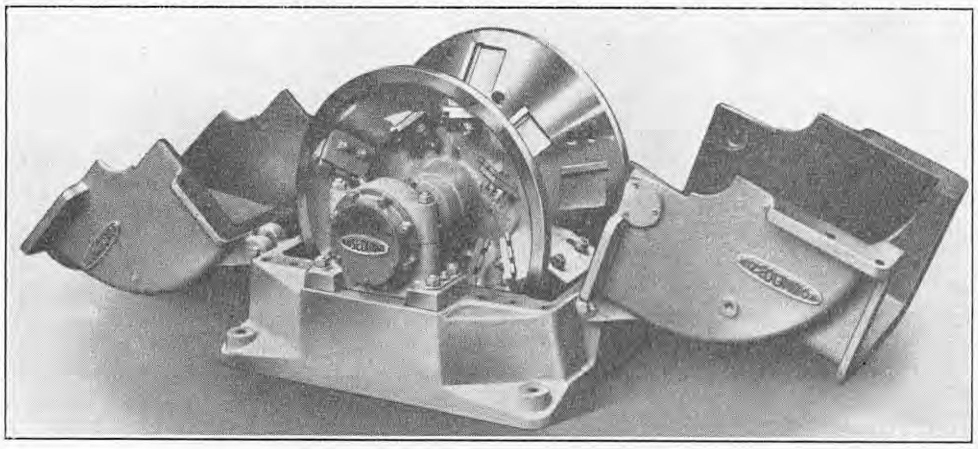


FIG. 17. WHALEMEAT HOGGER WITH COVERS OPENED.

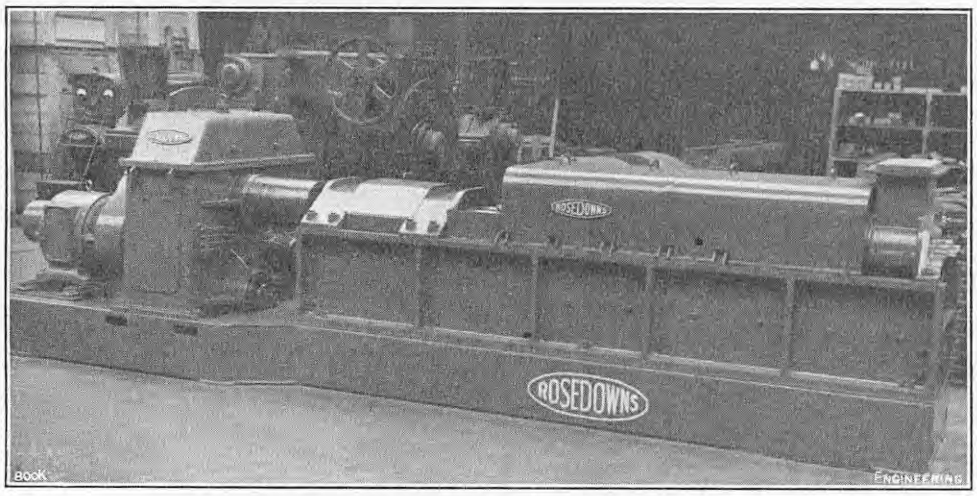


FIG. 18. LIQUID EXPELLER.

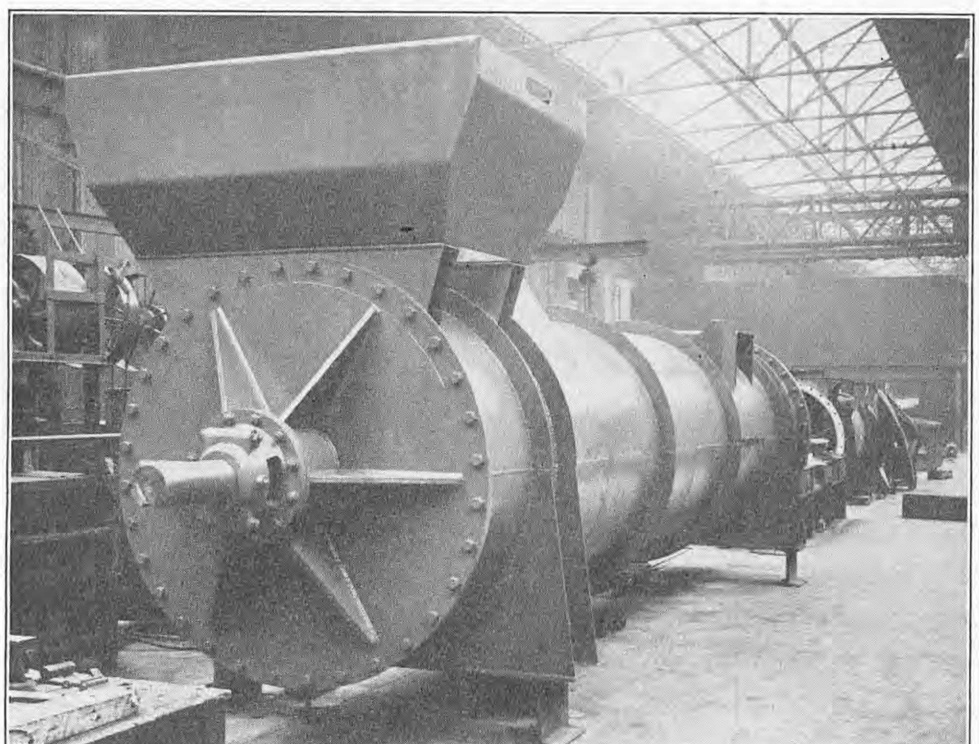


FIG. 19. MEAT-MEAL COOLING TUBE.

processing. Each batch of meal is admitted through a charging door at the top of the vessel and is given a series of washes with heated solvent, the process being repeated until only 0·5 per cent. of oil is left in the residual meal. The mixture of oil and solvent, known as miscella, is drained from the vessel through a filter of coir matting. Initial washes yield a strong mixture known as full-miscella, but later washes yield only a weak mixture, known as half-miscella. Clean solvent is used for the final wash and the weak mixture obtained is filtered, pumped to the mixed-solvent tanks, and used again for the first wash of a new charge of oily meal; but the stronger mixture of oil and solvent from the first wash is pumped through a filter to the mixed-solvent tanks in readiness for distillation. When the final wash has been completed, the solvent is purged from the saturated meal by admitting de-aerated steam. After all the solvent has been removed, the wet meal is discharged from the extractor pot and passes to the finishing section.

The full-miscella collected in the mixed-solvent tank is transferred to a still, where the solvent is vaporised under a fairly high vacuum. Normally, the still is heated by hot water, but steam can be employed when a rapid evaporation is required. The oil collects in the base of the still and final traces of solvent are driven off by admitting de-aerated steam, an oil-sampling device being fitted to the still so that laboratory tests can be made without disturbing the distillation process. The solvent vapour is drawn into a condenser by a wet vacuum pump which delivers through a solvent separator to an independent separator in which the solvent rises to the surface and overflows into the clean-solvent tank. The solvent-free oil is pumped to a filter press to remove the fine solids and brighten the oil, which gravitates thence through a cooler to the receiving tank. It is then stored in drums ready for further processing on shore.

The meal removed from the extractor is fed first to a "balancing" bin and then to a drying tube, in which it is subjected to a current of hot air. The spent air leaves the tube through a dust filter which leads to a condenser and separator; as a result, fine solids are prevented from leaving the drier and the vapours entrained in the air are removed before reaching the extraction fan. The dried meal is then elevated to a cooling tube, the plant being designed so that some of the heat abstracted during the cooling process can be used for drying. The meal produced in the liver plant does not require grinding and it is conveyed, therefore, directly to the automatic weighing and bagging machine.

The solid residues and entrained liquors which come from the blubber and fat-meat treatment sections are known as grax. This material contains an appreciable quantity of valuable oil and the grax plant installed in the Juan Peron has been designed to recover this oil. The plant comprises a number of gyratory screens and low-pressure expellers of the type used in the meat-meal section. After it has left the blubber boilers, the raw material is passed to the gyratory screens which separate out most of the free liquor. The solids, which still contain a considerable quantity of oil, are then passed through the expellers which express a high percentage of the remaining oil, but, unavoidably, permit a small quantity of fine solids to come away with the oil. To get rid of these fines, therefore, the liquor removed from the grax by the expellers is recirculated through the gyratory screens. After passing through the screens, the liquor is pumped to the central separation and purification plant, the solids, at present, being discharged overboard.

LYONS INTERNATIONAL FAIR.—The 35th International Fair at Lyons will be held from Saturday, April 11, to Monday, April 20, 1953, inclusive. Over 5,000 exhibitors, covering 58 trade groups, took part in this year's Fair. Robert Brandon and Partners, Ltd., 47, Albemarle-street, London, W.1, are the Fair's representatives in Great Britain.

DELIVERIES OF AMERICAN STEEL.—According to a statement made by Mr. Duncan Sandys, the Minister of Supply, on August 1, deliveries at steel mills in the United States of iron and steel destined for the United Kingdom amounted to 400,526 tons up to June 30, 1952. This total comprised 342,332 tons of steel, 20,000 tons of pig iron and 38,194 tons of scrap. All the pig iron and scrap, and 309,077 tons of the steel had already arrived in this country. The balance of the 600,000 tons involved in the agreement with the United States was due to be made available to the British Government by the end of December next.

THE EDUCATION OF ENGINEERS IN SOME EUROPEAN COUNTRIES.*

By PROFESSOR S. J. DAVIES, D.Sc.(ENG.).

(*Concluded from page* 166.)

ENGINEERING EDUCATION IN SWITZERLAND.

I HAVE left Switzerland to the last for two reasons: firstly, it has both the Federal Technical High School at Zürich, which is independent, and the Ecole Polytechnique at Lausanne, a faculty of the university; secondly, it is the most prominent example of a country which, though it possesses small natural resources, succeeds, by the skill and energy of its technical men, in winning a high standard of living for its people. Some conception of the range of the subjects treated at Zürich, and of the strength in the individual branches, may be gained from Table VII, herewith, in which are set out both the diplomas and the doctorates awarded in 1951. While there are, of course, individual points of difference, the courses for the diploma follow lines roughly parallel to those in Germany: they require, in the first part, a minimum of four semesters of study, leading to the preliminary examination, called the *Vorexam*, and, in the second part, four semesters leading to the diploma examination. A special individual piece of work must similarly be presented by each candidate for the diploma. The subjects studied in the first part include a great deal of applied science in addition to mathematics, physics, and chemistry; in the second part, and especially in the last year, there is a considerable narrowing of the work, within the branch of the candidate, towards his speciality.

TABLE VII.—*Awards by the Federal Technical High School, Zürich, in* 1951.

Branches.	Diplomas.	Doctorates.
Architecture	59	1
Civil Engineering	87	—
Mechanical Engineering	112	5
Electrical Engineering	82	6
Chemical Engineering	108	67
Forestry Engineering	3	4
Agricultural Engineering	69	10
Pharmacy	3	4
Mathematics	12	} 14
Physics	16	
Natural Sciences	20	12
Totals	571	123

It is seen that a relatively large total number of doctorates was awarded for research work, but over half of these were in the Chemical Engineering Department; the remainder, however, reflect a strong overall background of research activity. The total number of students in the school was 3,251, of whom no fewer than 634 were foreigners, a proportion of nearly 20 per cent.

Among its other activities, the school publishes the results of researches carried out by its members. A second important activity is that of the central library of the school, which renders a general service as well as the normal one: it contains, for example, copies of well over a million patent specifications; books may be borrowed for reading, either personally or by post; it has an important information service on scientific and technical matters, and in 1950-51 answered nearly 3,000 inquiries. It also organises exhibitions of fine art. The school is thus necessarily a large organisation, with many ramifications.

The Ecole Polytechnique at Lausanne, on the other hand, has an organisation of a type well familiar in Great Britain. Its actual courses are similar to those at Zürich, and have the necessary measure of interchangeability with them to enable students to pass from one school to the other. The branches and their individual sizes may be judged from Table VIII, herewith.

The language of instruction is exclusively French, while at Zürich, though certain courses are given in French, the majority are in German. The general tenor of the courses at Lausanne follows that more common in France than in Germany, namely, after a sound grounding in pure sciences, to give a broad education in the applied sciences. There is less specialisation in the final years than at Zürich; though, if such specialisation were desired, it would be difficult to bring about in a small school.

TABLE VIII.—*Number of Diplomas Granted by the Ecole Polytechnique, Lausanne, in* 1951.

Branch.	Swiss.	Foreigners.	Totals.
Civil	11	9	20
Mechanical	4	9	13
Electrical	19	10	29
Physicist	2	1	3
Chemical	4	3	7
Surveyor	5	3	8
Architect	5	0	5
	50	35	85

The figures in Table VIII reveal the astonishing fact that 35 out of 85 diplomas, or 41 per cent., were awarded to foreigners. That the language of instruction is French attracts many foreigners, from the Middle East and elsewhere, who have French as a second language. If each foreigner takes five years for his diploma, that would assume 165 foreign students at the school. This number, added to the 634 at Zürich, gives a total of 800 foreign students of technological branches in Switzerland. Though Switzerland has no official colonies, it has many unofficial ones, and undoubtedly benefits greatly from the goodwill carried home by its numerous foreign students.

Lastly, the excellent Swiss technical schools, not of university standing, must be mentioned, since they produce engineers of good standing who may, however, not carry the adjective *diplômé*, denoting immediate professional status.

SUMMARY AND CONCLUSIONS.

And now comes the question: Of what interest to us is all this information? In order to give opportunity of making comparisons, I have prepared Table IX, herewith, which sets out for the countries mentioned, excepting France, and for Great Britain, the populations, degrees and diplomas in the several branches, and lastly, as an index, the numbers of first degrees or diplomas awarded per 100,000 of the population. The data for Great Britain in the upper line are derived from the annual report of the University Grants Committee for 1949-50; they do not, therefore, include those who take London internal degrees at the London Polytechnics, nor those who take London external degrees. The numbers when these are added are given in the lower line, in which the final index figure then becomes 5·75. While some of those gaining degrees in this way may study under good conditions and against a reasonable background, it must be affirmed that the majority study under conditions that are markedly inferior to those under which the diploma students in the other countries carry on their work. For a conservative comparison of this country with the others, the upper line should thus be taken, for which the index in the last column is 4·03.

It is sometimes urged that the contributions of our technical schools supplement, in a satisfactory way, the relatively small number of university graduates. Good as these contributions are, there are two points to be made, one quantitative and the other qualitative. Firstly, we have seen that the other countries possess similar facilities to those of our technical schools, and that they produce many men who, though they may not be given direct professional status in their own countries, might well be accepted, on academic grounds, as corporate members of our engineering institutions. Secondly, it would be idle to suppose that the basic grounding in mathematics, physics, and chemistry of the men with Higher National Certificates and Diplomas is other than on a much lower level than that of the Continental professional engineers with diplomas. We are thus not justified, in this comparison, in counting men with Higher National awards as additional to those from our universities, since competing countries have similar supplementation of their technical strengths.

Concerning those other countries, it is common knowledge that their engineering and similar industries represent a much smaller proportion of their labour forces than that of Great Britain; the relationships in Switzerland and in Germany probably come nearest to our own. These two countries, and especially Germany on account of its size, are our principal European competitors. It is seen that the index for Switzerland is by far the highest. But the index for Germany, which does not include chemical engineering, etc., is already higher than that for Great Britain; and it must be remembered that the technical high schools, severely damaged during the war, have not yet been fully reinstated.

TABLE IX.—DIPLOMAS AWARDED ANNUALLY.

Country.	Population, millions.	Civil Eng'g. and Surveying.	Mech. and Marine Eng'g., Naval Arch., Aeronautics.	Elect. Eng'g.	Chem. Eng'g. and Ind. Chem.	Mining and Metallurgy.	Total.	Number per 100,000.
Belgium	$8\frac{1}{2}$	64	54 – 71 – 57 (M - E)		19	97	362	4·26
Germany (Federal) ..	$47\frac{3}{4}$	830	700	530	?	350	2,410	5·05
Sweden	7	110	136	98	70	26	440	6·29
Denmark	$4\frac{1}{4}$	110	80	60	60	—	310	7·3
Norway	$3\frac{1}{4}$	58	42	16	30	13	159	4·9
Netherlands	$10\frac{1}{4}$	179	194	74	67	24	538	5·26
Switzerland	$4\frac{3}{4}$	114	125	111	109	—	459	9·66
Great Britain*	49	{450 – 154 – 578		344	194	252	1,972	4·03
		{450 – 960 – 578 (Gen.)		344	201	288	2,821	5·75

* For Great Britain, the category "(Gen.)" includes graduates whose degrees are unclassified within the branches of civil, mechanical and electrical engineering.

But to compare this country with Switzerland and Germany on the basis of these figures gives a very incomplete picture of our needs. While Switzerland and Germany, like Great Britain, export a high proportion of their manufactured products, neither has responsibilities as the centre of a world Commonwealth. It is true that the larger Commonwealth countries have large engineering schools of their own, but they continue to look to this country for engineers; British engineers are also in demand in South America. Since the war, many posts in India and in Pakistan, for which no suitable candidates from here could be found, have been given to engineers from Central Europe; the latter have also played an important part in engineering activity in South America. All this will, in the long run, have a bad influence on our export trade.

We have seen that about 20 per cent. of the students of the two principal engineering schools in Switzerland are non-Swiss. In Great Britain, in all branches of study in the universities, the percentage of full-time students from outside Great Britain in 1949-50 was 7·1, divided between 4 per cent. from the Commonwealth and 3·1 per cent. from other countries. The data for engineering students are not available, but the percentages are not likely to be appreciably higher. The provision of places for engineering students from overseas is a further important element in our present national need, since it is clearly to our ultimate advantage that these students should be trained here by British engineers and scientists, and on British instructional equipment.

These last two matters were not touched upon in the recently published *Fifth Annual Report** of

* Address delivered at the fourth annual meeting of the Regional Advisory Council for Higher Technological Education (London and Home Counties), held at Hastings on July 10, 1952.

* H.M. Stationery Office, Cmd. 8561.

the Advisory Council on Scientific Policy, but the relationship between productivity and scientific man-power was rightly stressed. The view was also expressed that there should be more men with a science training in top-level posts in industry and in the Civil Service; it was said that "this is not likely to happen without a change in the climate of opinion about the prestige of science." This brings me to a further important difference between the Continental countries and our own, namely, the high regard and prestige carried by engineers in those countries, and the way in which engineers and their work are taken for granted by the educated man in this country. The educated Frenchman, Swiss or German, for example, is vastly better informed on engineering matters than his British counterpart, and it is from the Press and from the schools that this desired "change in the climate of opinion" must come.

All comparisons with Continental countries and with the United States lead to one simple conclusion: that immediate action should be taken by the Government so that many more men can be trained to a high level as engineers, and, as a beginning, that the numbers of engineering graduates from the universities should be increased with all speed to at least 3,000 a year, giving a grand total of about 4,000 a year. For this, considerable special grants, and the necessary building priorities, should be made to those universities which have not appreciably increased their engineering faculties since the war, of which London, Wales, and Oxford are prominent examples. It is easier, cheaper, and, what is most important, quicker to enlarge existing organisations than to set up new ones. Relatively small increases in buildings, equipment, and staff would give the earliest return. Other plans must necessarily be of a long-term nature.

The responsibility for determining the qualifications of professional engineers is, by virtue of their Royal Charters, vested in the Institutions of Civil, Mechanical, and Electrical Engineers. A large proportion of the candidates for corporate membership obtain some measure of exemption from the institutions' examinations through their university degrees. The remainder, most of whom come with Higher National Diplomas and Certificates, are clearly inferior, as regards their basic education in mathematics, physics, and chemistry, to those trained as professional engineers in Continental countries. The Institutions, by giving serious attention to raising their standards in these subjects, could do much in the direction of improving the quality of their non-graduate corporate members. If higher qualifications in these basic subjects were called for, the engineering students could at once receive proper instruction, since most technical colleges have good departments of physics and chemistry.

Agreement is common among practising engineers in all branches that their problems, which tend to increase with every new development, can only be solved by the engineer with a sound understanding of the basic sciences. This tendency, if my own engineering experience is a guide, will become accentuated with time, and our young men must be adequately grounded to solve these problems.

I record my great indebtedness to the Rector of the Royal Institute of Technology, Stockholm; the Rector, and Professor G. Eichelberg, Federal Technical High School, Zürich; Professor A. Stucky, Lausanne; M. Langlois-Berthelot, Général Crochu and M. André Dauphin, Paris; Professor A. Coppens, Louvain; Professor J. J. Broeze, Delft; Professor L. J. Mansa, Copenhagen; Professor Orvig, Trondheim; the Direktor of the Verein deutscher Ingenieure, Düsseldorf, and Professor F. A. F. Schmidt, Aachen. All have kindly helped me with information; they, however, are not responsible for any deficiencies in my use of their information.

BAUXITE DEPOSITS IN INDIA.—According to data received from the Information Centre of the United Nations in London, new bauxite deposits, described as extensive, have been found in the hills about 15 to 20 miles north of the Korba coalfields, in Madhya Pradesh. The Tungra Hill in the Thana district of Bombay also has deposits estimated to contain a substantial tonnage of bauxite.

TRENDS IN ELECTRICITY CONSUMPTION.

THE British Electricity Authority have decided to distribute at monthly intervals tables showing the electricity sold by them to the Area Boards and the electricity sent out by the Boards to their consumers. Table I, which is reproduced herewith, is the first of this series, and shows the sales in each month from the beginning of April, 1951, to the end of June, 1952, inclusive. It also shows the sales in the twelve months ending March 31, 1949, 1950, 1951 and 1952, as well as the sales in the year ending each month from April 30, 1951, to June 30, 1952, inclusive. The remaining columns in the table indicate the actual percentage changes that have occurred in each month or twelve months in the period covered, as well as the percentage changes adjusted to normal weather and standard working days. The figures disclose that there has been an actual decrease in every month since February, 1952, compared with the corresponding month of the previous year. When, however, allowance is made for the difference in the number of working days and in the weather conditions, there has been a slight increase. For instance, the figures for June, 1952, show an increase of 1·4 per cent. over those of June, 1951, after these adjustments have been made. Nevertheless, the real trend of consumption is downwards, the rate of increase in 1952 being 3·6 per cent. in April, 1952, 2·9 per cent. in May, 1952, and only 1·4 per cent. in June, 1952, over the corresponding months of 1951.

It is both difficult and, perhaps unwise, to be too dogmatic as to the reasons for these changes. It would be equally unwise to prophesy that the downward tendency is permanent. With these reservations it may be said that the falling off is due to a decrease in trade activity, and consequently to a weakening of purchasing power. The weather, which was more favourable than the average during the period under review, may also have been an influence, and other factors may have been a greater use of private generating plant and a reduction in

TABLE I.—ELECTRICITY SOLD BY THE BRITISH ELECTRICITY AUTHORITY.

Date.	Sales in Month Ended.	Sales in 12 Months Ended.	Percentage Change in Electricity Sold Over Corresponding Period of Previous Year.				
			Actual.		Adjusted to Normal Weather and Standard Working Days.		
			Month.	Twelve Months.	Month.	Cumulative Since April 1, 1951.	Twelve Months.
	Million kWh.	Million kWh.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Year ended—							
March 31, 1949	—	43,151	—	+10·5	—	—	+ 8·3
March 31, 1950	—	45,766	—	+ 6·1	—	—	+ 8·6
March 31, 1951	—	51,848	—	+13·3	—	—	+11·1
March 31, 1952	—	55,340	—	+ 6·7	—	—	+ 6·5
Month ended—							
April 30, 1951	4,567	52,496	+16·5	+13·6	+11·0	+11·0	+11·1
May 31, 1951	4,340	52,978	+12·4	+13·7	+10·8	+10·9	+11·1
June 30, 1951	3,780	53,360	+11·1	+13·7	+ 8·7	+10·2	+11·0
July 31, 1951	3,669	53,662	+ 9·0	+13·3	+10·0	+10·1	+11·0
August 31, 1951	3,732	54,015	+10·4	+13·4	+ 8·9	+ 9·9	+10·9
September 30, 1951	4,062	54,215	+ 5·0	+12·5	+ 8·5	+ 9·6	+10·6
October 31, 1951	4,828	54,648	+ 9·9	+12·1	+ 8·8	+ 9·5	+10·4
November 30, 1951	5,001	54,756	+ 2·1	+11·2	+ 5·8	+ 8·9	+ 9·8
December 31, 1951	5,247	54,607	− 2·7	+ 9·1	+ 2·8	+ 8·0	+ 8·9
January 31, 1952	5,796	54,965	+ 6·7	+ 8·5	+ 3·8	+ 7·5	+ 8·1
February 29, 1952	5,269	55,352	+ 8·1	+ 8·1	+ 3·8	+ 7·1	+ 7·4
March 31, 1952	5,039	55,340	− 0·5	+ 6·7	+ 1·1	+ 6·5	+ 6·5
April 30, 1952	4,372	55,145	− 4·3	+ 5·0	+ 3·6	+ 3·6	+ 5·9
May 31, 1952 (*p*)	4,185	54,990	− 3·6	+ 3·8	+ 2·9	+ 3·3	+ 5·4
June 30, 1952 (*p*)	3,769	54,979	− 0·3	+ 3·0	+ 1·4	+ 2·7	+ 4·8

(*p*) Provisional.

TABLE II.—ELECTRICITY SENT OUT BY AREA BOARDS.

Area Board.	Totals for June.			Cumulative Totals for First Three Months of Year.			Twelve Months Totals Ended June 30.		
	1951.	1952.	Increase or Decrease.	1951.	1952.	Increase or Decrease.	1951.	1952.	Increase or Decrease.
	Million kWh.	Million kWh.	Per cent.	Million kWh.	Million kWh.	Per cent.	Million kWh.	Million kWh.	Per cent.
(*b*) London	323	325	+0·6	1,187	1,098	−7·5	5,241	5,210	−0·6
(*b*) South Eastern	187	191	+2·1	671	645	−3·9	2,885	2,991	+3·7
(*b*) Southern	217	236	+8·8	759	768	+1·2	3,261	3,458	+6·0
(*b*) South Western	109	113	+3·7	386	374	−3·1	1,657	1,676	+1·1
(*b*) Eastern	316	329	+4·1	1,118	1,085	−3·0	4,734	4,864	+2·7
(*a*) East Midlands	297	291	−2·0	986	946	−4·1	4,107	4,200	+2·3
(*a*) Midlands	401	400	−0·2	1,340	1,315	−1·8	5,587	5,751	+2·9
(*a*) South Wales	241	254	+5·4	738	789	+6·9	2,912	3,190	+9·5
(*a*) Merseyside & N. Wales	247	236	−4·5	811	762	−6·0	3,436	3,420	−0·5
(*a*) Yorkshire	400	393	−1·7	1,292	1,277	−1·2	5,373	5,531	+2·9
(*a*) North Eastern	257	244	−5·1	830	791	−4·7	3,410	3,503	+2·7
(*a*) North Western	456	422	−7·5	1,477	1,399	−5·3	6,069	6,402	+5·5
(*b*) South East Scotland	79	82	+3·8	265	266	+0·5	1,147	1,191	+3·8
(*b*) South West Scotland	194	198	+2·1	658	640	−2·7	2,836	2,880	+1·6
Total all Area Boards	3,724	3,714	−0·3	12,518	12,155	−2·9	52,655	54,267	+3·1
Direct sales by Central Authority	56	55	−1·8	169	171	+1·2	705	712	+1·0
Grand total	3,780	3,769	−0·3	12,687	12,326	−2·8	53,360	54,979	+3·0
Mainly industrial Areas marked (*a*)	2,299	2,240	−2·6	7,474	7,279	−2·6	30,894	31,997	+3·6
Mainly non-industrial Areas marked (*b*)	1,425	1,474	+3·4	5,044	4,876	−3·3	21,761	22,270	+2·3
Total number of working days	27·45	26·94	—	81·81	82·11	—	—	—	—

domestic consumption. Load shedding is not regarded as having been an important influence.

Table II, which shows the electricity sent out by the Area Boards during June, 1951, and June, 1952, as well as the cumulative totals for the first three months of both years and for the full twelve months, is worthy of study. It not only indicates the differences in the amount of electricity actually sent out by the several boards, but the relative trend of sales in the industrial and non-industrial Areas. As will be seen, those Areas with a high proportion of industrial sales, taken as a group, showed a decrease of 2·6 per cent. in June, 1952, over the corresponding month in 1951, while the remaining (non-industrial) Areas showed an increase of 3·4 per cent. On the other hand, during the twelve months ended June 30, 1952, the industrial Areas showed an increase of 3·6 per cent., whereas the increase in the non-industrial Areas was only 2·3 per cent. In the South Wales industrial Area, it is thought that the June increase of 5·4 per cent. may be due to increased demand of the Steel Company of Wales, while the greater increase of 8·8 per cent. in the non-industrial Southern Area is ascribed, not to greater domestic demand, but to the inauguration of the Fawley oil refinery. The falling off of 7·5 per cent. in the industrial North-Western Area is probably due to conditions in the textile industry.

It may be added that an industrial Area is defined as one in which 50 per cent. or more of the consumption is used for industrial purposes. Actually the average figure is about 65 per cent.

MULTIPLY-LOADED AND CONTINUOUSLY-LOADED STRUTS.

By Professor W. J. DUNCAN, D.Sc., F.R.S.*

(Concluded from page 182.)

EXAMPLE I.—*Singly and Multiply Loaded Cantilever Struts.*—The true fundamental neutral mode of a uniform cantilever strut rigidly built in at the root and loaded only at the tip is

$$y = a\left(1 - \cos\frac{\pi x}{2l}\right)$$

where a is an arbitrary constant. Hence, by (22), the axial displacement is

$$u(x) = \tfrac{1}{2}\int_0^x \left(\frac{\pi a}{2l}\right)^2 \sin^2\frac{\pi x}{2l}\,dx$$

$$= \frac{\pi^2 a^2}{16l^2}\left(x - \frac{l}{\pi}\sin\frac{\pi x}{l}\right). \quad . \quad (28)$$

The elastic energy is

$$V = \tfrac{1}{2}\int_0^l EI\left(\frac{d^2y}{dx^2}\right)^2 dx = \frac{\pi^4 a^2 EI}{64l^3}. \quad . \quad (29)$$

When the only load is P applied at the tip we get

$$P\,u(l) = V$$

or

$$\frac{P\,\pi^2 a^2}{16l} = \frac{\pi^4 a^2 EI}{64l^3}$$

and

$$P = \frac{\pi^2 EI}{4l^2} = 2{\cdot}467\left(\frac{EI}{l^2}\right),$$

which is the usual result. If we repeat the calculation with the constrained mode

$$y = a\,x^2$$

we obtain, similarly,

$$P = 3\left(\frac{EI}{l^2}\right).$$

This mode is a very crude approximation to the true one and the error of excess in the critical load is considerable. Evidently the bending moment at the tip vanishes and the simplest polynomial satisfying the true boundary conditions at root and tip is

$$y = a\left(x^2 - \frac{x^3}{3l}\right).$$

This constrained mode yields

$$P = 2{\cdot}5\left(\frac{EI}{l^2}\right)$$

and the error of excess is now only 1·3 per cent. In accordance with the general theory, the constrained modes yield values of the critical load which are too high.

Next, take the case where equal loads P are applied at the tip and at the mid-point and take as the constrained mode the true mode for a single load at the tip. Then $u(x)$ is given by (28) and we find for the critical condition

$$\frac{P\,\pi^2 a^2}{16l}\left(1 + \frac{\pi - 2}{2\pi}\right) = \frac{\pi^4 a^2 EI}{64l^3}$$

and this reduces to

$$P = 2{\cdot}088\left(\frac{EI}{l^2}\right).$$

We have already seen that the value of the coefficient yielded by the "exact" method is 2·0167, so the error of excess is 1 per cent. In a similar manner and using the same constrained mode we obtain for the case of three equal loads P applied at the tip and at distances of one-third and two-thirds of the length from the root

$$P = 1{\cdot}703\left(\frac{EI}{l^2}\right).$$

It has already been shown that the true value of the coefficient is 1·672 and the error of excess is accordingly 1·9 per cent. This error is greater than in the last case because the true neutral mode is more different from that assumed, as would be expected.

EXAMPLE 2.—*Uniform Pin-Jointed Strut with Single and Double Loads.*—When there is a single load at the end the true fundamental mode of neutral displacement is

$$y = a\sin\frac{\pi x}{l}. \quad . \quad . \quad . \quad (30)$$

Hence we find that

$$u(x) = \frac{\pi^2 a^2}{4l^2}\left(x + \frac{l}{2\pi}\sin\frac{2\pi x}{l}\right). \quad . \quad (31)$$

while

$$V = \frac{\pi^4 a^2 EI}{4l^3}. \quad . \quad . \quad (32)$$

For a single load P at the tip the critical condition is

$$P\,u(l) = V$$

so

$$P = \frac{\pi^2 EI}{l^2}$$

and this is the correct result. For a single load applied at the middle of the strut we obtain with the above mode of displacement

$$P\,u\left(\frac{l}{2}\right) = V$$

and

$$P = \frac{2\pi^2 EI}{l^2} = 19{\cdot}74\left(\frac{EI}{l^2}\right).$$

We have already seen that the correct value of the coefficient is 18·66 and the error of excess is accordingly 5·8 per cent.

We shall now recalculate the last problem and shall minimise the critical load obtained from a mode containing one variable parameter. Assume

$$y = a\left(\sin\frac{\pi x}{l} + q\sin\frac{2\pi x}{l}\right). \quad . \quad (33)$$

We then obtain

$$u(x) = \frac{\pi^2 a^2}{4l^2}\left[\begin{aligned}&(1 + 4q^2)\,x + \frac{4ql}{\pi}\sin\frac{\pi x}{l}\\ &+ \frac{l}{2\pi}\sin\frac{2\pi x}{l} + \frac{4ql}{3\pi}\sin\frac{3\pi x}{l}\\ &+ \frac{q^2 l}{\pi}\sin\frac{4\pi x}{l}\end{aligned}\right] \quad (34)$$

and

$$V = \frac{\pi^4 a^2 EI\,(1 + 16q^2)}{4\,l^3}. \quad . \quad (35)$$

Hence for a single load at $x = \frac{l}{2}$, the critical condition is

$$P = \frac{2\pi^2 EI}{l^2}\left[\frac{1 + 16q^2}{1 + \frac{16q}{3\pi} + 4q^2}\right]. \quad (36)$$

When the fraction within the bracket is stationary, q satisfies the quadratic equation

$$32q^2 + 9\,\pi\,q \quad 2 = 0,$$

and the numerically small root is

$$q = \frac{\sqrt{(81\,\pi^2 + 256)} - 9\pi}{64} = 0{\cdot}0658.$$

When this value of q is substituted in the formula (36), we get

$$P = 18{\cdot}69\left(\frac{EI}{l^2}\right).$$

The error of excess in the coefficient is now only 0·03, or about one-sixth of 1 per cent.

Suppose next that equal loads P are applied at the tip and at the middle of the strut. We shall first obtain the solution from the "exact" equation already established. Put $P_1 = P_2 = P$, $\mu_1 = \mu$, $\mu_2 = \mu\sqrt{2}$, and $\frac{\mu l}{2} = \alpha$. The equation (18) can then be reduced to

$$\frac{1}{\sqrt{2}}\cot\alpha\sqrt{2} + \cot\alpha = \frac{1}{6\alpha}$$

and the smallest root of this is found to be $\alpha =$ 1·2783 radians. Accordingly,

$$P = 4\alpha^2\left(\frac{EI}{l^2}\right) = 6{\cdot}536\left(\frac{EI}{l^2}\right).$$

If we use a constrained mode identical with the true mode for an isolated tip load, we get from the equation of energy

$$P\left[u\left(\frac{l}{2}\right) + u(l)\right] = \frac{\pi^4 a^2 EI}{4l^3}$$

or

$$P = 6{\cdot}580\left(\frac{EI}{l^2}\right).$$

The error of excess in the coefficient is 0·044 or 0·7 per cent. It will be noted that the error is much less than for the case of isolated load at the mid-point with the same constrained mode in use, as would be expected, since the constrained mode is the true mode for the tip load alone.

SAFE APPROXIMATE RULE BASED ON THE THEORY OF CONSTRAINTS.

As we have stated and illustrated by examples, the energy method necessarily gives an optimistic estimate of a critical load system unless the assumed mode of displacement agrees with the true one. We shall now prove that a certain simple rule, which will be explained, necessarily errs, if at all, on the side of pessimism. It may thus be possible to set upper and lower bounds to the critical loading when the exact solution is unknown.

Consider a multiply loaded strut and let P_n be the load at the nth load point when the strut is in a critical condition. Also let u_n be the axial displacement at the nth load point for the true critical mode of displacement and V the corresponding amount of elastic potential energy in the whole strut.

Then

$$\Sigma\,P_n\,u_n = V$$

or

$$\Sigma\,P_n\left(\frac{u_n}{V}\right) = 1, \quad . \quad . \quad (37)$$

where the summation covers all the applied loads. Further, let P_{cn} be the true critical load when a single load is applied at the nth load point and P'_{cn} the value of the critical load at the same point when the displacement is constrained to agree with that characteristic of the complete critical load system. Then, by the general theorem on the influence of constraints,

$$P'_{cn} \geqslant P_{cn}. \quad . \quad . \quad . \quad (38)$$

Also

$$P'_{cn}\,u_n = V$$

by the principle of energy, or

$$\frac{u_n}{V} = \frac{1}{P'_{cn}}$$

and equation (37) becomes

$$\sum\frac{P_n}{P'_{cn}} = 1. \quad . \quad . \quad . \quad (39)$$

By the inequality (38) this implies that

$$\sum\frac{P_n}{P_{cn}} \geqslant 1. \quad . \quad . \quad . \quad (40)$$

Provided that all the loads P_n are compressive, we shall therefore err, if at all, on the safe side by calculating the critical loading from the equation

$$\sum\frac{P_n}{P_{cn}} = 1. \quad . \quad . \quad . \quad (41)$$

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This is a very useful rule when the loads P_{cn} are easily calculable. Alternatively, the loads P_{cn} for evenly spaced load points may be calculated and tabulated once for all. Attention is drawn to the fact that this rule applies to struts tapered in any manner.

Example 1. *Uniform Cantilever Strut.*—This is a very simple case for

$$P_c = \frac{\pi^2 EI}{4 h^2},$$

where P_c is the critical load for a load point distant h from the root. Accordingly, we have

$$\sum P_n h^2{}_n \geqslant \frac{\pi^2 EI}{4}, \quad . \quad . \quad . \quad (42)$$

where P_n is applied at overhang h_n. For a distributed compressive load of intensity $p(x)$ per unit run we obtain similarly

$$\int_0^l p(x)\, x^2\, dx \geqslant \frac{\pi^2 EI}{4}, \quad . \quad . \quad . \quad (43)$$

where l is the length of the strut.

Suppose now that we have equal loads P applied at the tip and at half the overhang. Then

$$P\,(l^2 + \tfrac{1}{4} l^2) \geqslant \frac{\pi^2 EI}{4},$$

or

$$P \geqslant \frac{\pi^2}{5}\left(\frac{EI}{l^2}\right) = 1\cdot974\left(\frac{EI}{l^2}\right).$$

We have seen that the correct value of the coefficient is $2\cdot067$ and $1\cdot974$ is $4\cdot5$ per cent. low. For three equal loads P at distances from the root of l, $\frac{2}{3}l$ and $\frac{1}{3}l$, we get

$$Pl^2\left(1 + \frac{4}{9} + \frac{1}{9}\right) \geqslant \frac{\pi^2 EI}{4},$$

or

$$P \geqslant \frac{9\,\pi^2}{56}\left(\frac{EI}{l^2}\right) = 1\cdot586\left(\frac{EI}{l^2}\right).$$

The correct value of the coefficient has been shown to be $1\cdot672$, and the error of deficiency in $1\cdot586$ is $5\cdot1$ per cent.

Example 2. *Pin-Jointed Uniform Strut.*—For a single load at the tip

$$P_c = 9\cdot87\left(\frac{EI}{l^2}\right),$$

while for a single load at the mid-point

$$P_c = 18\cdot66\left(\frac{EI}{l^2}\right).$$

Suppose, then, that equal loads P are applied at the tip and at the middle.

We get

$$P\left(\frac{1}{9\cdot87} + \frac{1}{18\cdot66}\right) \geqslant \left(\frac{EI}{l^2}\right)$$

or

$$P \geqslant 6\cdot455\left(\frac{EI}{l^2}\right).$$

We have shown that the true value of the coefficient is $6\cdot536$, so the error of deficiency in $6\cdot455$ is $1\cdot3$ per cent.

THE COMPARISON METHOD.

The method now to be described is called the comparison method by Temple and Bickley,* and, although of limited applicability, it is worthy of brief mention. Suppose that an exact solution can be found for a critical loading system L_c on a certain strut S. Let S′ be derived from S by thickening (or, more generally, stiffening) over the whole or part of its length. Then, by the general theorem on constraints, the system L_c will certainly be a sub-critical or "safe" loading for S. Conversely, if S″ be derived from S by thinning (or increase of flexibility in any manner) the load system L_c will be supercritical for S″. Temple and Bickley give an example where a lower bound to the critical load on a strut is obtained by this method while an upper bound is provided by the energy method.

Small Corrections.—The energy method enables us to calculate the influence of any small change of the conditions on the critical loading of a strut or structure. When the exact critical mode for the unmodified strut is known, this should also be used for the modified strut, for then, by Rayleigh's Principle, the error in the critical loading will be of the second order.

As a simple example let us find the reduction in the critical load of a uniform vertical cantilever strut caused by the weight of the strut itself. Let w be the (constant) weight of unit length of the strut and take the mode of deflection to agree with that of a weightless strut, so $u(x)$ is given by equation (28). We find that

$$\int_0^l w\, u\,(x)\, dx = \frac{(\pi^2 - 4)\, a^2\, w}{32}$$

and the equation of energy yields

$$P + \frac{\pi^2 - 4}{2\pi^2}\, lw = \frac{\pi^2 EI}{4l^2}\ . \quad . \quad . \quad (44)$$

Hence the reduction in the critical load is

$$\frac{\pi^2 - 4}{2\pi^2}\, lw = 0\cdot3 \times \text{(weight of strut)}$$

with close approximation. For a uniform pin-jointed vertical strut we find similarly that the deduction from the critical load is just one half of the weight of the strut.

As another simple example take a uniform pin-jointed strut with an elastic support of small stiffness at the mid point. Let the support be of stiffness c (force per unit of linear displacement in the lateral direction). Since by equation (30) the displacement at mid-span is a, the energy stored in the support is $\frac{1}{2}\, ca^2$ and the equation of energy becomes

$$\frac{\pi^2 a^2 P}{4l} = \frac{\pi^4 a^2 EI}{4l^3} + \tfrac{1}{2}\, ca^2,$$

or

$$P = \frac{\pi^2 EI}{l^2} + \frac{2\, cl}{\pi^2}.$$

This correction is valid only when $\dfrac{2\, cl^3}{\pi^4 EI}$ is small.

Continuously-Loaded Struts.—As a very simple example of a continuously-loaded strut we take the problem of finding the length of the tallest self-supporting column. We shall apply various approximate methods and compare the results with the known "exact" solution which is*

$$l = 1\cdot996\sqrt[3]{\frac{EI}{w}} \quad . \quad . \quad . \quad (45)$$

where w is the weight of unit length of the column and the numerical coefficient is equal to $\sqrt[3]{\dfrac{9\alpha^2}{4}}$ where α is the smallest root of the Bessel function $J_{-\frac{1}{3}}\,(x)$, namely $1\cdot88$. While this example is entirely academic, it provides a good test of the methods.

First, the "safe" rule for cantilever struts yields

$$\int_0^l w\, x^2\, dx = \frac{\pi^2 EI}{4}$$

or

$$l^3 = \frac{3\,\pi^2}{4}\left(\frac{EI}{w}\right) = 7\cdot402\left(\frac{EI}{w}\right).$$

Hence

$$l = 1\cdot949\sqrt[3]{\frac{EI}{w}},$$

and this is $2\cdot4$ per cent. low.

Next, let us use the energy method and first take a constrained mode identical with the true neutral mode of a uniform cantilever strut with tip load only. We have merely to put P zero in equation (44) and so derive

$$l^3 = \frac{\pi^4}{2(\pi^2 - 4)}\left(\frac{EI}{w}\right) = 8\cdot298\left(\frac{EI}{w}\right).$$

Hence

$$l = 2\cdot025\sqrt[3]{\frac{EI}{w}},$$

which is about $1\cdot5$ per cent too high.

The constrained mode

$$y = a\left(x^2 - \frac{x^3}{3l}\right),$$

which makes the curvature zero at the tip, yields exactly

$$l = 2\sqrt[3]{\frac{EI}{w}}$$

and this is only $0\cdot2$ per cent. high. Lastly, the constrained mode

$$y = a\left(x^2 - \frac{2x^3}{3l} + \frac{x^4}{6l^2}\right),$$

which makes both $\dfrac{d^2y}{dx^2}$ and $\dfrac{d^3y}{dx^3}$ vanish at the tip, yields exactly the same result as that last obtained.

Another possible method is to regard the column as divided into a number of segments and to suppose that the distributed load on each segment is replaced by a concentrated load at its mid-point equal to the total load on the segment. This method has been applied to the present problem by supposing the column divided into three equal parts the mid-points of which are accordingly at distances of $\frac{1}{6}\, l$, $\frac{1}{2}\, l$ and $\frac{5}{6}\, l$ from the root. We then treat the column as a cantilever of length

$$l' = \frac{5}{6}\, l$$

with equal loads amounting to $\frac{wl}{3}$ applied at the tip and at the fractions $\frac{1}{5}$ and $\frac{3}{5}$ of the overhang. Equation (15) then becomes

$$\sqrt{3}\,[\sqrt{2} - \tan 2\alpha \tan 2\sqrt{2}\,\alpha]$$
$$= \sqrt{2}\tan\sqrt{3}\,\alpha\,[\sqrt{2}\tan 2\sqrt{2}\,\alpha + \tan 2\alpha],$$

where

$$\alpha = \frac{\mu_1 l'}{5} = \frac{l}{6}\sqrt{\frac{wl}{3EI}} = \sqrt{\frac{wl^3}{108EI}}.$$

It is found that the smallest root of the equation is $0\cdot2726$ radian. Hence

$$\frac{wl^3}{EI} = 108\alpha^2 = 8\cdot026$$

and

$$l = 2\cdot002\sqrt[3]{\frac{EI}{w}}.$$

This is about $0\cdot3$ per cent. too high.

Conclusions.—The critical loadings of multiply and continuously loaded struts can be found by the following methods.

(*a*) Exact solution of the differential equations of the problem. For multiply-loaded uniform struts the solution is somewhat laborious but not difficult. In general, the critical loading is derived from the solution of a transcendental equation. Continuously applied loads can be treated approximately by supposing the total loading on a segment of the strut to be replaced by its resultant acting at a single point coincident with the mean-point of the loads.

(*b*) Use of theorems based on the influence of constraints, together with knowledge of the critical loads for each individual load point in isolation. The critical loading obtained in this way errs, if at all, on the safe side.

(*c*) Bounds to the critical loadings can sometimes be found by comparison with cases where exact solutions are known. This method is of very limited utility.

(*d*) The energy method. Here the critical loadings err, if at all, on the side of optimism. Results of any required degree of accuracy can be obtained by minimising the loading obtained from a constrained mode of deflection containing one or more variable parameters. This is the method of the widest applicability and the best for general use. The influence of small modifications of the system can be found very easily by this method.

Even if exact methods are used, the various approximate methods are of great value in locating the roots of the equations for the critical loads.

* *Rayleigh's Principle and its Applications to Engineering*, Oxford, 1933.

* See Gray, Mathews and MacRobert, *A Treatise on Bessel Functions*, Macmillan, London. The solution is originally due to A. G. Greenhill, "On Height Consistent with Stability," *Proc. Camb. Phil. Soc.*, vol. 4, 1881.

HIGH-POWER TELEVISION TRANSMITTER IN SCOTLAND.

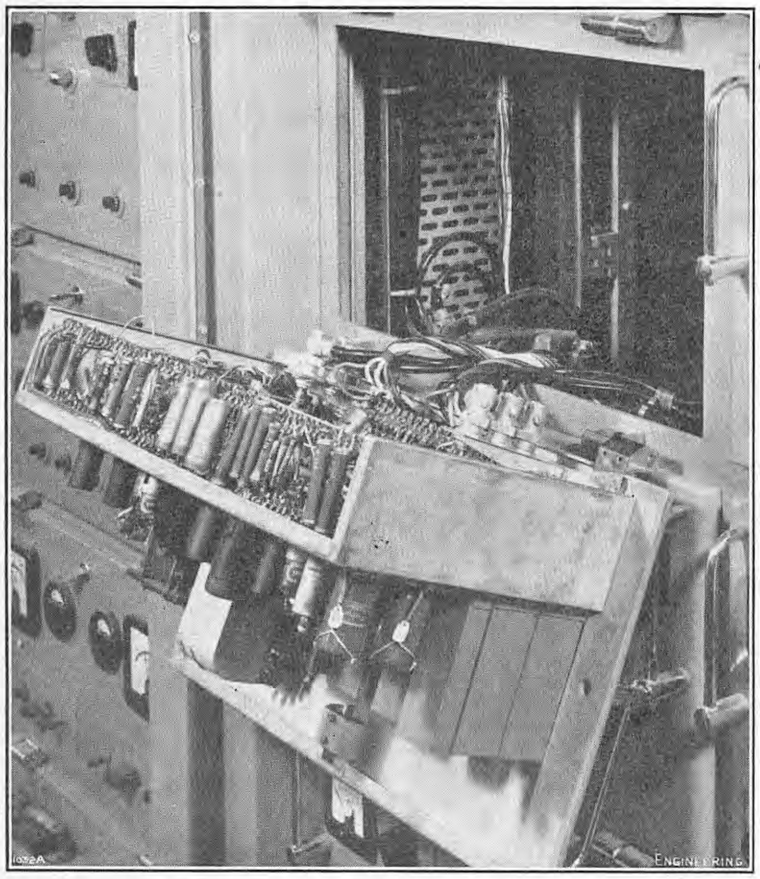

Fig. 1. Amplifier Unit Open For Inspection.

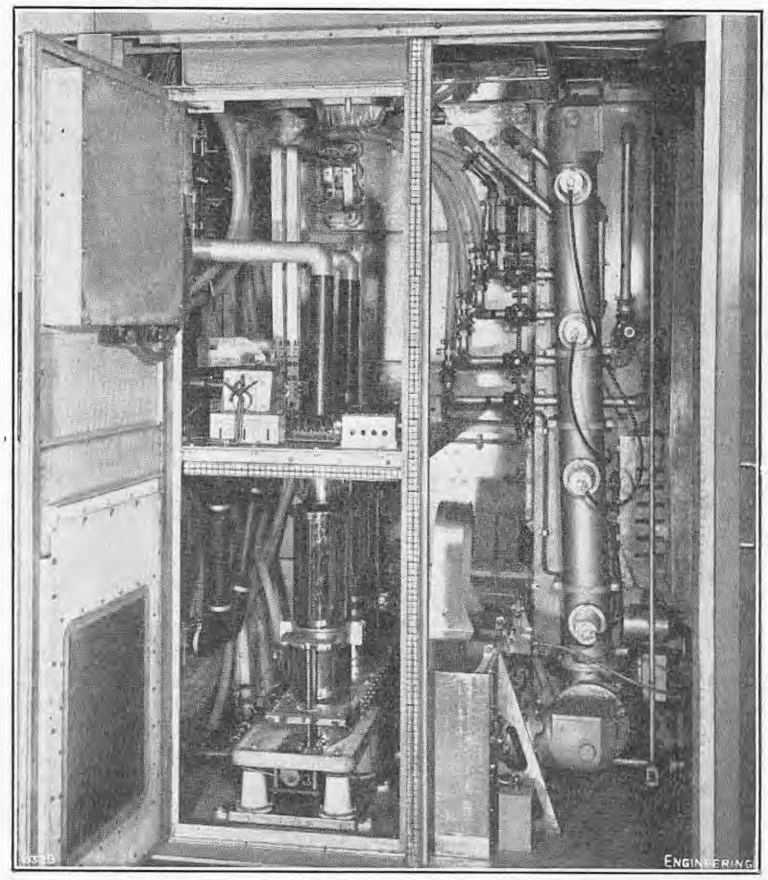

Fig. 2. Output Stage of Vision Transmitter.

HIGH-POWER TELEVISION IN SCOTLAND.

The high-power vision and sound transmitters at the Kirk o' Shotts television station of the British Broadcasting Corporation are now undergoing final tests. If these are successful, the Corporation plans to bring the new equipment into full use on August 17, the opening day of the 6th Edinburgh International Festival of Music and Drama, several events in which, including the official opening ceremony, are to be televised. Since the start of the service from Kirk o' Shotts on March 14, 1952, the programmes have been radiated on medium-power transmitters—5 kW for vision and 2 kW for sound—which have provided generally good reception in the main industrial belt of central Scotland, and, locally, in regions farther afield. The service area will be increased considerably, however, when the new equipment, which has ten times the power of that now in use, comes into service. With a normal operating power of 50 kW for vision, capable of increase to a maximum of 75 kW, and 18 kW for sound, the Kirk o' Shotts transmitter will be the most powerful television station in the world.

Details of the medium-power transmitters at Kirk o' Shotts were included in a general account of the station published in our previous volume (Engineering, vol. 173, page 361 (1952)). The high-power vision transmitter, which has been built by Emitron Television, Limited, a subsidiary of Electrical and Musical Industries, Limited, Hayes, Middlesex, differs from those installed at Sutton Coldfield and Holme Moss in that low-level modulation is employed. This is, however, also used in the medium-power transmitter, built by Marconi's Wireless Telegraph Company, Limited, which is at present radiating the Scottish programme. Although modulation in the early stages of a transmitter calls for careful design and the provision of wide-band linear amplifiers, it enables greatly increased power to be obtained from the output valves, and thus gives greater efficiency. It also makes possible a considerable reduction in the bulk of the transmitter. For example, the new transmitter is 30 per cent. more powerful than the Emitron transmitter at Sutton Coldfield, but is little more than half the size of the latter.

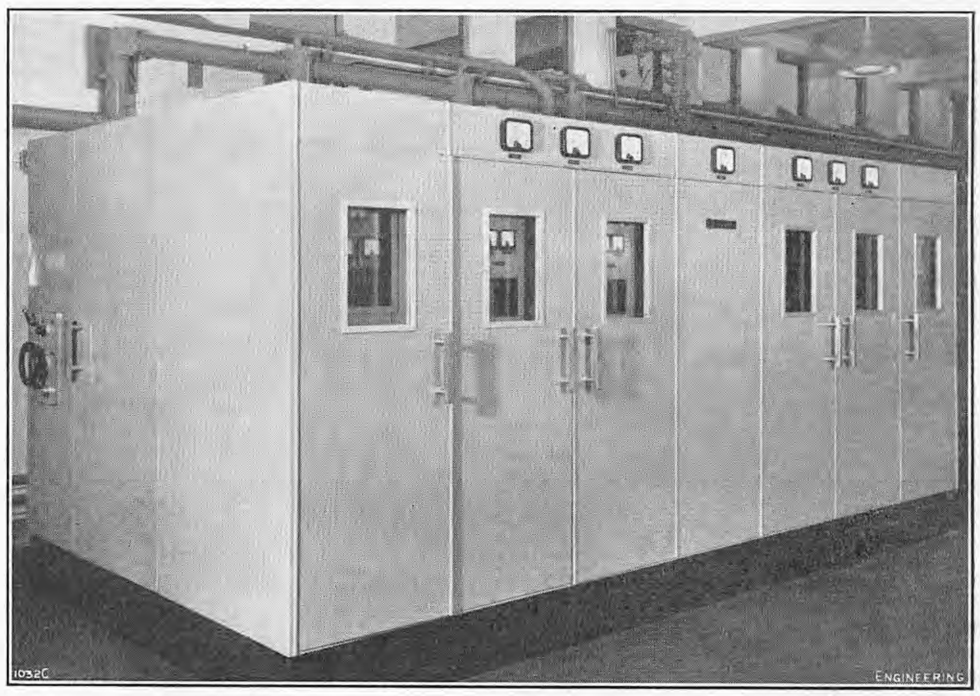

Fig. 3. High-Power Sound Transmitter.

Vision signals, received at the station over the micro-wave radio-linkage from Manchester, which is operated by the General Post Office, are fed, by way of the main control desk, to a modulation amplifier. This consists of a three-stage direct-current input amplifier, equipped with receiver-type valves and having a cathode-follower output, a linearity-correction amplifier and, finally, a pre-modulation video-frequency amplifier, which has also a cathode-follower output and feeds the valve grids of the modulated amplifier. The black level is clamped finally at the input to the pre-modulation amplifier. The separation of the point of clamping from the transmitter output by a considerable number of stages would be likely to cause variations in the transmitted black-level were special precautions not taken to prevent such an occurrence. In the present instance, any possible trouble is overcome by the inclusion of a black-level radio-frequency feed-back circuit which monitors the black-level at the transmitter output and injects a suitable correcting signal into the vision circuits. A further advantage of this technique is that it reduces any mains hum introduced by the class-B radio-frequency amplifiers in the later stages.

The modulated amplifier, referred to above, is fitted with two ACT.27 air-cooled triode valves, which are connected to operate as an earthed-grid push-pull amplifier having a peak-white output of approximately 600 watts. This stage is preceded by a pre-modulation radio-frequency amplifier, a frequency multiplier and a crystal oscillator. One

HIGH-POWER TELEVISION TRANSMITTER IN SCOTLAND.

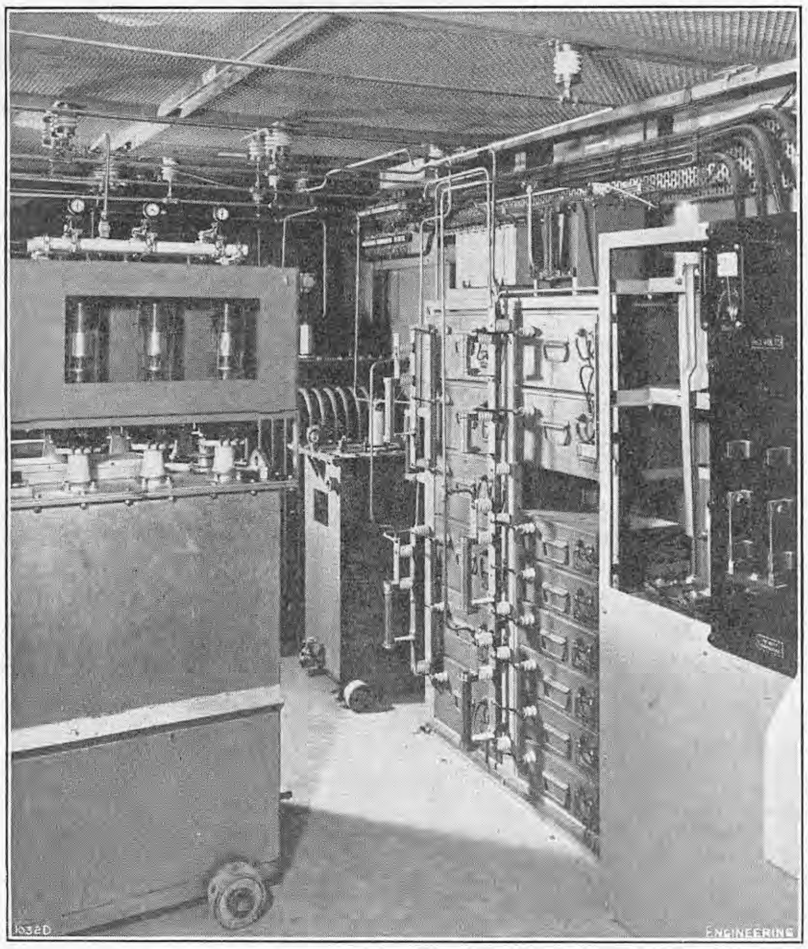

Fig. 4. Power Supply for Sound Transmitter.

Fig. 5. Aerials at Kirk o' Shotts.

of the amplifiers of the modulator unit is shown, lowered for inspection, in the photograph reproduced as Fig. 1, opposite. The output from the modulated amplifier is fed to a chain consisting of three wide-band linear class-B radio-frequency power-amplifiers connected in series. The first of these is, like the modulated amplifier, fitted with two ACT.27 triode valves, and has an output of 3 kW. The second contains two ACT.26 air-cooled triodes and has an output of 12 kW. The final stage, which is illustrated in Fig. 2, opposite, contains two BW.165 water-cooled triodes. The photograph also shows, on the right, the output feeder.

Interstage couplings of the wide-band coupled-circuit type are employed, and these are so tuned that the centre of the frequency band which is passed is a frequency approximately 0·7 megacycles per second below the carrier frequency. The side bands, therefore, are not quite symmetrical, the upper one being slightly attenuated. A filter is employed subsequently, however, to obtain the final asymmetry desired. A further three-stage coupled circuit is used at the anodes of the output amplifier, and this is also arranged to change the load from a balanced one to an unbalanced one to feed the coaxial output transmission-line.

The high-voltage direct-current supplies for the high-power stages are provided by oil-cooled metal rectifiers. An advantage of this method of rectification is that the control circuits are simpler than those required for the hot-cathode mercury-vapour rectifiers which are used at the older stations. Air for cooling the valves used in the earlier stages of the transmitter is drawn from outside, and is filtered and blown through cooling ducts at a rate of 3,000 cub. ft. per minute. Two centrifugal fans are used for the purpose, one delivering filtered air to the transmitter and the other exhausting it by suction. By this means, the air pressure in the cubicles can be controlled as desired, and both leakage and noise are considerably less than in previous installations. The air, after leaving the valves, can be either exhausted to atmosphere or circulated within the building for heating purposes.

Distilled water is used for cooling the valves in the final stage of the transmitter. Three storage tanks are installed: a main tank with a capacity of 50 gallons, a 100-gallon reservoir tank and a 15-gallon expansion tank. The water is circulated by means of a centrifugal pump at the outlet of the main tank and passes through a multi-tube radiator, where it is cooled by air supplied by a separate fan, before entering the valve jackets in the transmitter. From the latter, it returns directly to the main tank. The water-cooling system is constructed of non-ferrous metal and is a closed circuit, all air being excluded. Any expansion of the water is accommodated by the 15-gallon expansion tank, in which the space above the water is filled with nitrogen at a pressure of approximately 5 lb. per square inch above atmosphere. The quantity of water normally required for cooling two BW.165 valves is 18 gallons per minute. An inter-locking system ensures that power can be supplied to the transmitter only when the water flow is correct.

The high-power sound transmitter, which is illustrated in Fig. 3, opposite, is of the conventional class-B modulated type. It was built by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2. Modulation is applied at the anodes of both the penultimate and the final radio-frequency stages. Air-cooled valves are used throughout the transmitter, which has a carrier output of 18 kW at 100 per cent. modulation. There are five push-pull stages in the audio-frequency chain, the first two being fitted with 4074A double-triode valves. The third stage is a class-A amplifier in which two 5C.450A pentode valves are used, and this is followed by a stage of low output-impedance, which is driven by a cathode-follower and contains four valves of the same type. The final class-B stage is fitted with two 3J.192E air-cooled triodes. Negative feed-back is applied over the whole of the audio-frequency chain and is derived from the primary winding of the modulation transformer.

The radio-frequency side of the transmitter consists of a radio-frequency exciter, which comprises a crystal-controlled oscillator followed by a buffer stage, two stages of frequency trebling and an output amplifier. The first stage of the transmitter proper is fitted with a single 4H.180E air-cooled tetrode valve, and the penultimate and final amplifiers each contain a 3J.261E air-blast cooled triode. Variable inductive-coupling is used between the stages. The filaments of the three radio-frequency power-amplifiers and the class-B modulator valves are supplied with heating current from metal rectifiers. The remaining valve filaments are heated by alternating current. The main high-tension supply is derived from a 6-kV three-phase full-wave bridge-connected rectifier which is of the grid-controlled hot-cathode mercury-vapour type. The equipment is illustrated in Fig. 4, above. The main high-tension rectifying equipment is on the left, the smoothing condensers in the centre, and the filament-heating rectifiers on the extreme right.

The output of the vision transmitter is passed to a vestigial-sideband filter which is a constant-resistance filter of the transmission-line type. It contains two complementary networks, the high-pass section being terminated by a constant-resistance absorber-load, and the low-pass section being connected to the aerial system. The filter is constructed from coaxial copper-tube transmission line, of 5 in. outer diameter. The diameter of the inner conductor varies, however, so that the required impedance is obtained at the various stubs.

The vision and sound combining unit consists of a "sound-pass vision-stop" filter inserted between the sound transmitter and the common output, and a "vision-pass sound-stop" filter between the vision transmitter and the same point. The construction of these filters is similar to that of the vestigial-sideband filter. From the output of the combining unit, the signals are fed to the common aerial at the top of the 750-ft. mast. Details of the transmission line used for this purpose and of the aerial system were given previously in Engineering, in the article referred to above. The main and emergency aerial systems and the final tower of the micro-wave relay linkage are illustrated in Fig. 5, herewith.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Bowhill Colliery, Fife.—The first turf of a new shaft at Bowhill Colliery, Fife, was cut on August 6 by Mr. H. R. King, production director and a member of the Scottish divisional board of the National Coal Board. Mr. King said that, when completed, the project would employ 3,000 persons.

Factory for Making Asbestos Board.—It was announced by Scottish Industrial Estates, Ltd., on August 6, that Marinite, Ltd., who have been allocated about half of the former Government factory at Germiston, Glasgow, for the manufacture of pressed-asbestos board, will employ about 200 persons when full production is attained. Because of adaptations to the premises and the difficulty of procuring plant, production is not expected to begin until next year. The company has been formed jointly by the Cape Asbestos Company, London, who hold 53 per cent. of the shares, and the Johns-Manville Corporation of America.

Pattern Stores at Arbroath.—Keith Blackman, Ltd., engineers, Arbroath, are to build two pattern stores to replace those destroyed by fires within 48 hours of each other in June of last year. The stores are to be built as a two-storey building with reinforced concrete floors and roofs. Sliding steel fire-doors are to be fitted.

Developments at Elderslie Dockyard.—A new caisson weighing about 350 tons has been floated into position at the entrance to No. 1 graving dock, Elderslie Dockyard, by Barclay, Curle & Co. Ltd. The structure was fabricated on shore and assembled on the floor of the graving dock; it contains about 120 tons of steel and 230 tons of ballast.

Precast-Concrete Houses for Dundee.—An offer by the Scottish Orlit Co., Ltd., precast-concrete manufacturers, Edinburgh, to erect, in Dundee, a factory having an output of 500 houses a year, provided that the Town Council would guarantee to take a minimum of 400 houses a year for three years from the company, was accepted on August 4.

Glasgow Water Department: Clyde Tunnel.—The route of a proposed tunnel of the Glasgow Corporation Water Department, under the River Clyde, has been approved. It is to be between ground immediately to the east of Barclay, Curle and Company's North British Engine Works at Scotstoun, on the north bank, and the northern boundary of the Clyde Navigation Trust's timber yard at Shieldhall, on the south bank. The tunnel will be 12 ft. internal diameter and lined throughout with cast-iron segments. Most of the work will be carried out under compressed air, air locks being provided at each of the two shafts, which will be 18 ft. in diameter and approximately 110 ft. in depth and will also be lined with cast-iron segments. The tunnel will be about 340 yards in length and the crown will be about 40 ft. below the bed of the River Clyde. The estimated cost is 380,000*l*. The Corporation are seeking an Order under the Water (Scotland) Act, 1946, from the Secretary of State for Scotland, and construction will commence immediately this Order is approved. The tunnel is for the purpose of conveying the 36-in. West Main across the River Clyde.

CLEVELAND AND THE NORTHERN COUNTIES.

West Cumberland Industrial Developments.—At the annual meeting of the West Cumberland Industrial Development Co., Ltd., at Whitehaven, it was reported that, during the year, work had been completed on the erection of a 70,500-sq. ft. factory for Marchon Products, Ltd., and on a 8,800-sq. ft. extension for Messrs. Edgards (London), Ltd. An extension covering 10,000 sq. ft. was being made at Hensingham for the West Cumberland Silk Mills, Ltd., and a new heavy vehicle shop was being built at Distington for Myers and Bowman, Ltd. An extension at Maryport for Electroflo Meters Co. Ltd., was almost completed. Other firms had asked for factory extensions but, owing to restrictions on capital expenditure, it had not been possible to proceed with these plans.

Cleveland Works of Dorman Long & Co.—Outline plans for developments to the Cleveland Works of Messrs. Dorman Long & Co., Ltd., have been submitted to Eston (Yorkshire) Urban Council. The scheme involves the construction of two blast furnaces, each 227 ft. in height, and a gasholder, 315 ft. high, on the site of the old Clay Lane Works, South Bank-on-Tees. Eventually, it is understood, there will be six blast furnaces on the site. Eston Council recently approved plans for a concrete cooling tower 120 ft. high and 73 ft. in diameter at the base, at the Cleveland Works.

Works Projects in Northumberland.—A report submitted to Northumberland County Council by the County Planning Committee states that a site has been earmarked at Hope Pit, Longbenton, for a new engineering works for Vickers-Armstrongs Ltd. The National Coal Board are planning a new shaft at the Bates Pit, Blyth, and pithead baths are proposed at East Hartford. Imperial Chemical Industries, Ltd., are to extend their chalk dump at Prudhoe and build a powder magazine at High Callerton to replace premises at Lemington which must be removed to clear the site for a power station.

Closing of Road Across Opencast Site.—The Roads and Bridges Committee of Northumberland County Council have recommended the closing of part of a Class III road from Horton Grange to Blagdon, for three years, to allow the extraction of 200,000 tons of coal from the Delhi open-cast site. The road concerned crosses the Delhi site and the National Coal Board have asked the Minister of Transport to make a closing order.

South Shields Dock to be Lengthened.—Plans have been approved for an extension of 30 ft. to the No. 2 dry dock of Messrs. John Readhead and Sons, Ltd., South Shields. This will increase the length of the dock to 480 ft.

The Admiralty and the North-East Coast.—The Civil Lord of the Admiralty (Mr. Simon Wingfield Digby, M.P.) is to visit shipyards on the North-East Coast next week. His visit will start on Tuesday, August 19, in the Sunderland area, where he will call on Bartram & Sons, Ltd., Sir James Laing & Sons, Ltd., and at the repair yard of T. W. Greenwell & Co., Ltd. Later in the day, he will visit the Middle Docks & Engineering Co., Ltd., at South Shields. On the following day, on Tyneside, he will call on Smith's Dock Co., Ltd., John Readhead & Sons, Ltd., and the North-Eastern Marine Engineering Co., Ltd. On Thursday, August 21, he will proceed to the Tees, visiting the Furness Shipbuilding Co., at Haverton Hill, and will witness the launch of a tanker from the yard of Wm. Gray & Co., Ltd., at West Hartlepool.

LANCASHIRE AND SOUTH YORKSHIRE.

Developments at Darfield Main Colliery.—About 500,000*l*. is being expended on development and reconstruction work at Darfield Main Colliery, South Yorkshire, which has been yielding coal for 97 years. The completion of the scheme in about two years will bring the weekly output to between 11,000 and 12,000 tons. Recently, the highest output since vesting day, namely, 8,697 tons, was achieved. The average output in 1950 was only 5,521 tons. A steam winding engine, recently dismantled and replaced by electrical apparatus, had been working for 95 years.

Factory Extensions.—Expanding business on home and export account has influenced the International Harvester Company of Great Britain, Ltd., to embark upon a programme of extensions which, it is expected, will provide employment for an additional 1,000 employees in 18 months. In the six years since the works were re-opened after the war the number of employees has been built up to 2,000. The products of the works, which are mainly industrial and farm tractors, are made completely on the premises.

Steel Scarcity Hampers Gas Board.—Not sufficient steel is obtainable by the Gas Board to complete the construction of seven large gasholders at the promised dates. The gasholders are now in various stages of erection in the Sheffield and Rotherham areas. The largest will be that on the Meadow Hall site, Sheffield, designed to hold 8,000,000 cub. ft. of gas, and to cost 300,000*l*. This holder will need 2,250 tons of steel. The next and final stage of construction will probably have to be postponed until the end of next year.

Orders for Cutlery.—Members of the Sheffield Cutlery Manufacturers' Association are benefiting from a visit recently paid to Canada by their secretary, Mr. E. A. Tuxford. They have booked orders to the value of 30,000*l*. and are promised more substantial contracts. The business was keenly sought by German, French and Italian manufacturers. A Yugoslav trade deputation has been in Sheffield and has made preliminary arrangements to buy some thousands of pounds' worth of Sheffield cutlery.

The Late Mr. C. C. Claxton.—We regret to record the death, on August 8, of Mr. Cyril Charles Claxton, secretary and joint managing director of the Sheffield Twist Drill & Steel Co., Ltd. Mr. Claxton, who was born at Peterborough in 1899, was the son of the late Mr. Charles William Claxton, on whose death in 1943 he became joint managing director. He had been a director since 1936, and previously, on returning in 1924 from four years' engineering training in the United States, had acted as his father's personal assistant and deputy.

Demolition of Doe Lea Viaduct.—The Doe Lea viaduct, immediately to the west of the former Bolsover South railway station, is to be demolished by explosives at 8 a.m. on Sunday, August 24. It is 370 ft. long, 29 ft. wide and 70 ft. high, with eight spans, and was built in 1897 to carry the track of the Lancashire, Derbyshire and East Coast Railway (subsequently absorbed in the Great Central Railway) from Chesterfield to Lincoln. The line between Chesterfield and Shirebrook North, of which the viaduct formed a part, was closed to traffic on December 1, 1951, and the Bolsover tunnel entrances were bricked up. The removal of the viaduct will leave the National Coal Board free to work the coal measures at this point; hitherto they have been unable to do so because of the risk of causing subsidence of the viaduct. It is expected the recovery of timber shores, used to strengthen the viaduct, and the salvage of several wagon loads of blue surface bricks, will meet much of the cost of demolition.

Extension Scheme for Manvers Main Colliery.—Work is to begin immediately on the National Coal Board's extension scheme for Manvers Main colliery, in the Rotherham Area of the North Eastern Division, which will make the carbonisation plant there the biggest in the country in five years. The total cost of the extensions will be 5,700,000*l*. A contract has been placed with Simon Carves, Ltd., for 3,000,000*l*., to construct 78 new ovens with their machinery and to rebuild 14 obsolete ovens, to extend the existing by-product plant and provide plant for coal and coke handling, and screening plant. Estimated increases in annual output from the plant as a result of the extensions include: large coke, 140,000 tons to 328,200 tons; nut coke, 99,000 tons to 389,000 tons; breeze, 12,000 tons to 38,350 tons; crude benzol, 1,257,000 gallons to 3,825,000 gallons; crude tar, 15,700 tons to 49,200 tons; and saleable gas, 2,327 million to 7,227 million cubic feet.

THE MIDLANDS.

Steel Allocations.—The announcement that the Government are to allocate 5 per cent. to 7 per cent. more steel to civilian industry is welcomed in the Midlands. The increased supplies will become available in the fourth quarter of the year, which begins in October. Most engineering firms will benefit, but preference will be given to those having the best export prospects. Shortages of steel have been responsible for a certain amount of short-time working in Midland engineering factories during the past twelve months, and some relief in this direction is expected as a result of the improved supply position. A small, but important, local industry which will find the increase particularly welcome is the steel re-rolling trade, which has not worked to capacity for some time. The allocating departments, the Ministry of Supply and the Board of Trade, expect to have the new figures worked out and in the hands of the firms concerned shortly, so that planning ahead will be possible.

New Apprenticeship Scheme.—The Dart Spring Co., Ltd., of West Bromwich, have started a training scheme for their apprentices. While it has much in common with some already operated by large firms, the Dart Spring Co. believe that their arrangements are unique for a firm of medium size. They have established a training school, and eight of their employees will act as paid instructors. Classes will be held during the evenings, and every aspect of the spring-making trade will be covered. Apprentices will be provided with tea at the company's expense before the classes begin, and full attendance will be rewarded at the end of the term with prizes of precision tools. Twenty-four apprentices are at present employed, and it is hoped, by providing specialised training facilities, to attract more labour to the trade. Spring-making is one of the most important trades in West Bromwich but there has been difficulty in recent years in obtaining the types and numbers of workers required.

Improvement in Coal Output.—Figures issued at the beginning of August by the West Midlands Division of the National Coal Board show that the output of coal in the Division during the first 30 weeks of 1951 was 10,733,914 tons. This represents a greater output than in any comparable period since nationalisation.

The figures show that a higher rate of production has been achieved in the normal five-day week, and the Saturday morning shift also has improved its output.

CAR-PARK AND MARKET BUILDING IN BIRMINGHAM.—Birmingham Corporation's proposal to complete a partly-finished building in Jamaica-row has been approved in principle by the Minister of Housing and Local Government. The building, which is intended to house a toll market and an underground car-park, was about two-thirds finished when the work was stopped by the war. Detailed specifications and plans are now being prepared for submission to the City Council, and ultimately to the Minister, for final approval.

RECRUITMENT OF LABOUR FOR SKILLED TRADES.—The quarterly report of the Brierley Hill Employment Committee shows that there is a new and growing tendency in the area for youths leaving schools to enter skilled trades by way of apprenticeship. The development is welcomed, as the majority of local school-leavers entering industry in recent years have shown a marked preference for repetition work. If the trend continues, there should be no difficulty in finding work for the newcomers, for the local engineering works are short of skilled labour.

THE LATE MR. J. B. KRAMER.—The death has occurred at Kingussie, Inverness-shire, at the age of 77, of Mr. John Baptist Kramer, who was very well known in Birmingham and district. He founded the Witton Kramer Electric Tool and Hoist Works, of which he was general manager, in 1909, and continued to be associated with the General Electric Co. until he retired in 1939. During that time he was active in the development of electro-magnetic equipment of many kinds, especially for cranes, and was also responsible for much pioneer work in other electrical and radio fields.

SOUTH-WEST ENGLAND AND SOUTH WALES.

INQUIRIES FOR COAL BY PAKISTAN RAILWAYS.—The Pakistan Railways who recently inquired for 100,000 tons of coal from Great Britain have been quoted for 50,000 tons by Welsh exporters and 50,000 tons by North-East Coast shippers. Of late years, South Wales has supplied limited quantities of patent fuel to these railways, but most of their coal has been drawn from South Africa. It is reported that the inquiry has also been circulated on the Polish market.

STRIKE OVER OMNIBUS FARES.—Miners at the Tirherbert and Tower Collieries, Hirwaun, numbering 1,600, who have been on strike since July 29 over the rise in omnibus fares, remained idle during the week. The question was discussed by a coalfield-delegate conference on August 8, when it was decided to ask the National Coal Board to give a satisfactory answer, within the next fortnight, to a demand for a subsidy towards all 'bus fares which amount to over 5s. a week.

TECHNICAL EDUCATION AT MARGAM.—The directors of the Steel Company of Wales, Ltd., have made an initial grant of 1,500*l*. to equip the laboratories at the new College of Further Education at Margam. The college is planned primarily to meet the future needs for the technological education of employees of the company.

BUILDING EXHIBITION AT CARDIFF.—The Ministry of Works are arranging, in conjunction with the makers of building equipment, to hold an exhibition of such plant in Sophia Gardens, Cardiff, from September 18 to 24. It will be opened by Sir David Maxwell Fyfe, Q.C., Home Secretary and Minister for Welsh Affairs, at 2 p.m. on September 18, when the chair will be taken by the Lord Mayor of Cardiff, Councillor W. H. J. Muston, J.P.

NOTICES OF MEETINGS.

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

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Manchester Branch:* Wednesday, August 20, 7.30 p.m., Engineers' Club, Albert-square, Manchester. "Carbon Brushes," by Mr. J. H. Pritchard. *South-West London Branch:* Wednesday, August 20, 8.15 p.m., The Guild House, Worple-road, Wimbledon, S.W.19. "Temperature Control by Energy Regulators and Bi-Metal Thermostats," by Mr. P. A. Thorogood.

HELICOPTER ASSOCIATION OF GREAT BRITAIN.—Friday, September 5, 5.30 p.m., Institution of Civil Engineers, Great George-street, S.W. 1. "Helicopter Operating Experiences," by Mr. A. V. J. Vernieuwe.

CONTRACTS.

SIMON-CARVES (AUSTRALIA) PTY. LTD., an associated company of SIMON CARVES LTD., Cheadle Heath, Stockport, have received a contract to build a large contact sulphuric-acid plant, at Port Adelaide, to produce sulphuric acid from pyrites, of which abundant local deposits exist. The plant will incorporate three Nichols Freeman flash roasters to produce sulphur dioxide gas from pyrites, and the gas will be treated in gas-cleaning and cooling units. The acid-making plant will be a single unit having a capacity of 300 tons of sulphuric acid a day.

A.C.V. SALES LTD., Southall, Middlesex, have received orders for 100 of their A.E.C. "Regent" Mark III chassis for double-deck passenger vehicles from the Liverpool Corporation, and for a further 15 of these vehicles from the City of Oxford Motor Services Ltd. The latter company have recently placed in service 16 "Regent" and 10 underfloor-engined "Regal" Mark IV omnibuses and coaches. Twenty "Regal" Mark IV underfloor-engined chassis, fitted with synchromesh gearboxes, have been ordered by the Western Welsh Omnibus Co., Ltd.

MODERN WHEEL DRIVE LTD., Lindo Lodge, Stanley avenue, Chesham, Buckinghamshire, have received an order from the National Supply Co., Springfield, Ohio, for two of their oil-operated reverse-reduction gears. They are of the firm's type M2WR size 7, for installation with National Supply engines in a new heavy-duty towing boat for the Dravo Corporation Union Barge Line, for service on the River Mississippi. The gears will each transmit 2,000 b.h.p., at 600 r.p.m., with a propeller speed of 220 r.p.m. in "ahead" and 233 r.p.m., in "astern." The gears are to be built at the firm's Slough works.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, are to design, manufacture, and install equipment for a television service to be owned and operated by Television Venezolana S.A., Caracas, Venezuela. The system will operate on the international standard of 625 lines, 50 cycles, and will consist of a 5-kW vision transmitter, a 3-kW sound transmitter, an associated aerial system, and complete studio installation. A complete mobile outside broadcasting unit is included in the order.

THORN ELECTRICAL INDUSTRIES LTD., proprietors of FERGUSON RADIO CORPORATION LTD., Enfield, Middlesex, have received a 2,500,000-dols. contract from the United States Government for radio transmitting and receiving equipment for use in N.A.T.O. aircraft.

C. M. HILL & CO. (ENGINEERS) LTD., 44-45, Tower Hill, London, E.C.3, have received an order on behalf of their principals, S. A. FAMILLEUREUX, for 50 bogie steel covered goods wagons, of 35-ton capacity, and for 20 bogie cattle wagons, for the Benguela Railways.

THE HUNSLET ENGINE CO., LTD., Leeds, 10, have received an order from the National Coal Board for 37 six-coupled steam tank locomotives of 48½ tons weight, of the so-called "Austerity" type, which, with another 12 already in hand, are considered to be likely to cover all the Board's requirements for the heaviest class of pit-head shunting-engine power over the next five years. The contract provides for gradual delivery until the end of 1957, and the value of the new order is about 350,000*l*.

During July, the British Electricity Authority placed contracts for equipment for power stations, transforming stations, and transmission lines, amounting, in the aggregate, to 12,629,687*l*. The principal orders include: two 135,000-lb. per hour boilers for Cowes power station, with DANIEL ADAMSON & CO. LTD.; two generator transformers for Goldington power station, Bedford, with the HACKBRIDGE AND HEWITTIC ELECTRIC CO. LTD.; coal-handling plant for Drakelow power station, Burton-on-Trent, with MITCHELL ENGINEERING LTD.; two 150,000-lb. per hour boilers for Northampton power station, with BENNIS COMBUSTION LTD.; a cooling tower for Meaford "B" power station, Stone, Staffordshire, with the DAVENPORT ENGINEERING CO. LTD.; a cooling tower for Bold power station, St. Helens, with FILM COOLING TOWERS LTD.; ash and dust-handling plant for Ince power station, near Ellesmere Port, with BABCOCK AND WILCOX LTD.; 3,300-volt and 415-volt switchgear for Skelton Grange power station, Leeds, with the ENGLISH ELECTRIC CO. LTD.; three 60,000-kW turbo-generators, condensing and feed-heating plants for Stella North power station, near Newcastle-upon-Tyne, and four 60,000-kW turbo-generators, condensing and feed-heating plants for Stella South power station, with C. A. PARSONS & CO. LTD.; a cooling tower for Chadderton power station, Oldham, with FRED MITCHELL & SON, LTD.; 90-MVA 132-kV oil-filled reactors for Carrington substation, near Manchester, with the HACKBRIDGE AND HEWITTIC ELECTRIC CO. LTD.; the Staythorpe (Newark) to Elstree 275-kV twin 0·4 sq. in. overhead transmission line, with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO. LTD.; and the Llantarnam to Crumlin (Monmouthshire) 132-kV overhead transmission line, with J. L. EVE CONSTRUCTION CO. LTD.

PERSONAL.

SIR ANDREW MACTAGGART has been appointed chairman of Balfour, Beatty & Co., Ltd., to fill the vacancy caused by the death of MR. WILLIAM SHEARER. MR. H. G. BALFOUR has been appointed a director. Sir Andrew has also been appointed chairman and managing director of Power Securities Corporation Ltd., in succession to Mr. William Shearer.

MR. JAMES MITCHELL, C.B.E., honorary treasurer of the Iron and Steel Institute, is to be nominated at the autumn general meeting of the Institute in London on November 26 for election as President of the Institute at the annual general meeting in 1953, to hold office for one year.

DR. S. F. DOREY, C.B.E., M.I.C.E., M.I.Mech.E., F.R.S., chief engineer surveyor, Lloyd's Register of Shipping, has been elected to serve as senior vice-president of the Institute of Metals for 1953-54. He will be the nominee of the Council of the Institute for the Presidency in 1954-55.

MR. DOUGLAS WILSON, of the United Steel Companies Ltd., has been appointed chairman of the Council of British Manufacturers of Petroleum Equipment, 79, Buckingham Palace-road, London, S.W.1, in succession to MR. E. F. E. HOWARD.

MR. GEORGE HARRISON, manager of the Derwenthaugh Coke Works of the Durham Division of the National Coal Board is to retire at the end of this year. He was appointed manager of the works when they were opened upwards of 20 years ago and has been in the coking industry for more than 50 years.

MR. G. L. F. WELHAM, A.R.Ae.S., who has been production development engineer to the Fairey Aviation Co. Ltd., Hayes, Middlesex, for the past 20 years, has been appointed deputy managing director to the Holbrook Machine Tool Co. Ltd., 44-48, Martin-street, Stratford, London, E.15, and Harlow, Essex.

MR. REGINALD CATLOW and MR. H. F. HODGSON have been appointed directors of Guest, Keen and Nettlefolds Ltd. They have both been associated with the company for many years.

MR. F. PERRY has been appointed to be the Midland installation and service manager of Prior Stokers Ltd., Prior Works, 1-3, Brandon-road, York-way, London, N.7. An office and workshop, under Mr. Perry's charge, have been opened at 8, Warrender-street, Meanwood-road, Leeds, 7.

MR. G. E. GODFREY, M.B.E., A.M.I.Mech.E., has been appointed managing director of Brynmawr Rubber Ltd., by the board of Enfield Cables Ltd. The firm of Brynmawr Rubber Ltd. is a wholly-owned subsidiary company of Enfield Cables Ltd. Mr. Godfrey took up his appointment on August 1.

Among recent appointments to the Colonial Service are those of MR. J. F. KEITH, B.Sc., to the position of executive engineer in Nigeria; MR. DAVID FULLER, B.Sc., to the Mines Inspectorate in Malaya; and MR. FRANK TURTON, B.Sc., to the post of chief broadcasting engineer in British Honduras.

MR. A. C. COOPER has been appointed general manager of I.T.D. Ltd., in association with Austin Crompton Parkinson Electric Vehicles Ltd., Hall Green, Birmingham, 28.

MR. JOHN ADAMSON, C.A., has joined the boards of Bowmaker Ltd., Bowmaker (Plant) Ltd., and Norcon Ltd.

MR. K. J. WHITEHEAD has been appointed a director of the Wolverhampton Die Casting Co., Ltd., Graiseley Hill, Wolverhampton.

MR. CHAS. F. JACKSON, B.Sc., F.Inst.Pet., honorary secretary of the Road and Building Materials Group of the Society of Chemical Industry informs us that his address has been changed recently to 16, Finsbury-circus, London, E.C.2. (Telephone: LONdon Wall 1200.)

STANDARD TELEPHONES AND CABLES LTD., 10, Essex-street, Strand, London, W.C.2, announce that their Newcastle-upon-Tyne depot for rubber and plastic cables has been moved from 7, The Side, Newcastle, to new premises at 21, Queen-street, Newcastle. (Telephone: Newcastle 20290.)

JONES AND ATTWOOD, LTD., Stourbridge, Worcestershire, have acquired the sole manufacturing and selling rights for 2-ton, 3-ton and 6-ton Worcester bench power presses from the Mining Engineering Co. Ltd., Worcester.

As from September 1, 1952, all correspondence intended for the TOXTETH TECHNICAL INSTITUTE, SPEKE EXTENSION, Woodend-avenue, Speke, Liverpool, 19, should be addressed to RIVERSDALE TECHNICAL COLLEGE, Riversdale-road, Aigburth, Liverpool, 19.

The STATISTICAL DIVISION of the BOARD OF TRADE has moved to Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411.) The headquarters address of the DEPARTMENT OF CUSTOMS AND EXCISE is now King's Beam House, Mark-lane, London E.C.3. The telephone number, MANsion House 1515, remains unaltered.

FIXED AND MOBILE RECTIFIER SUBSTATIONS; NETHERLANDS RAILWAYS.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

(*For Description, see Page* 217.)

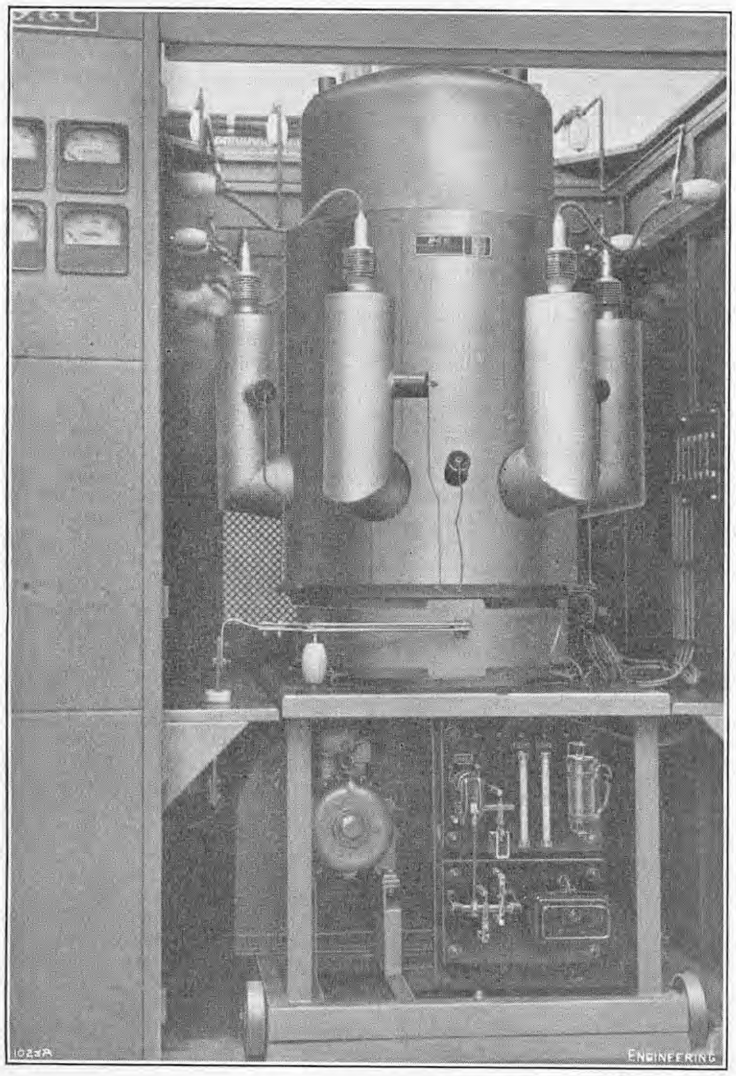

Fig. 1. 1,500-Volt Air-Cooled Pumpless Rectifier.

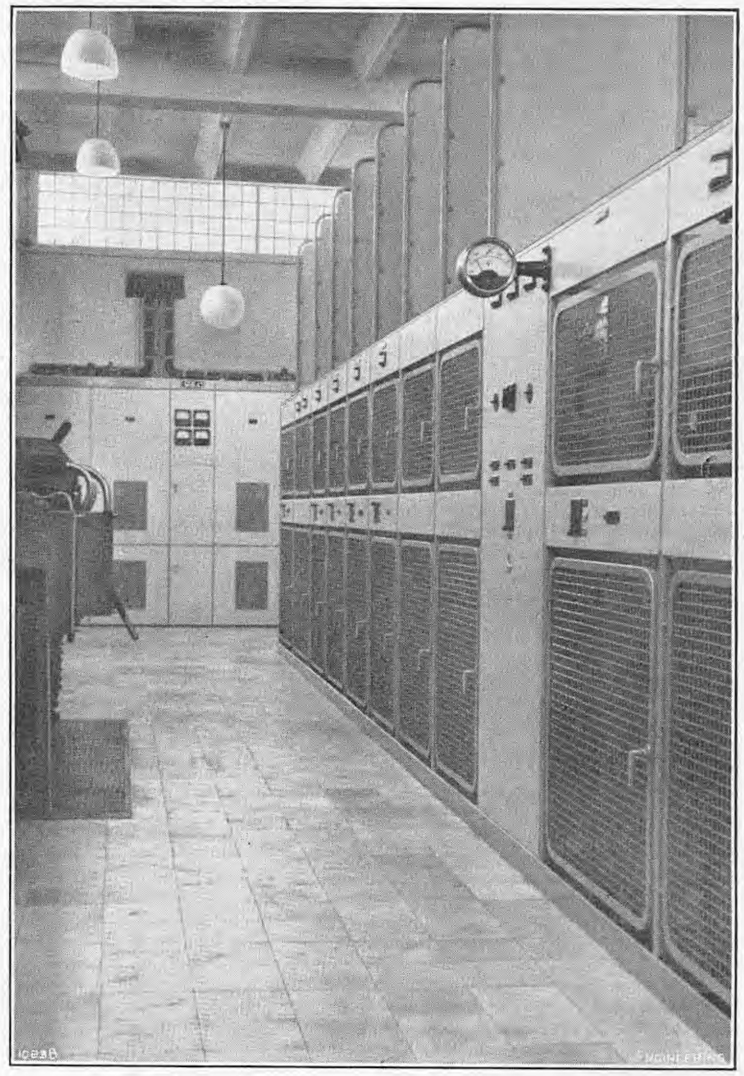

Fig. 2. Interior of Ryssen Substation.

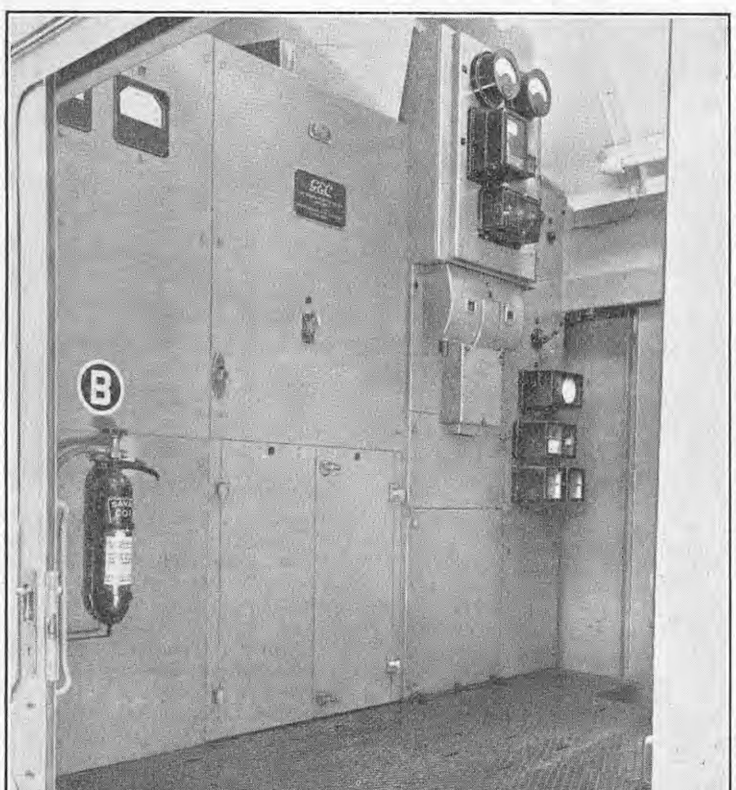

Fig. 3. Operating Platform of Mobile Substation.

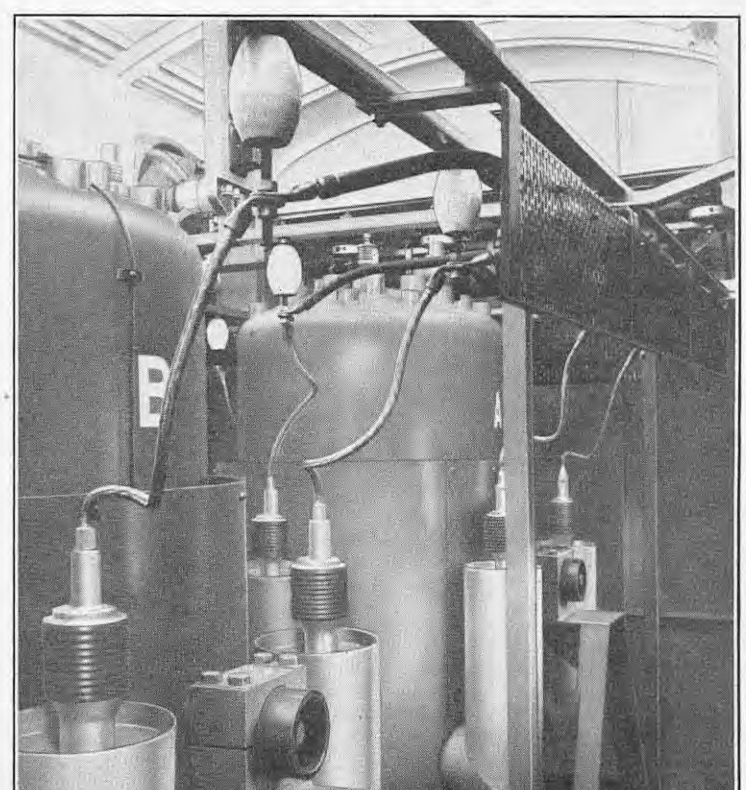

Fig. 4. Interior of Mobile Substation.

ENGINEERING

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INDEX TO VOL. 172.

The Index to Vol. 172 of ENGINEERING (July-December, 1951) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, AUGUST 15, 1952.

Vol. 174. No. 4516.

ENGINEERING AND THE STERLING AREA.

To those subjects of Her Britannic Majesty who have occasion to travel overseas, whether for pleasure or on business, the phrase "the sterling area" has a familiar sound and a somewhat restrictive connotation. Especially is this so to those whose memories of foreign travel extend back, beyond the 1914-18 war, to the days when, as the late Mr. Ernest Bevin put it with immortal brevity, a man could go to Victoria Station, buy his ticket, and "go anywhere he damn well liked"; no passport needed on most journeys, and no foreign currency over most of Europe—merely a handful of gold sovereigns, which were accepted at their full value almost everywhere. Now, there are no sovereigns, a passport is a necessity (and a useful document to have, sometimes, inside its country of origin); the business of sanctioning the use of the traveller's own money in the form of foreign currency, the doling of it out, all the checking and counter-checking, has developed into a minor but flourishing industry; and the sterling area is recognised as a major economic factor in a traveller's life, even though he may not be able to define it.

Thanks, however, to the Mutual Security Agency Mission to the United Kingdom, a precise description is now available—at least for 1949-50— in a portentious volume recently issued from the office of the Mutual Security Agency in London.* It is contained in Table 40 of the report and is much too long to quote *in extenso*, but the preface to the volume (signed by Mr. Thomas K. Finletter, Mr. W. John Kenney and Mr. William L. Batt) mentions that the Sterling Area contains a quarter of the world's population and carries on a quarter of the world's international trade; a statement that is sufficient indication of the statistical and economic importance of the survey. The members of the Sterling Area, the preface continues, "all belong to the community of democratic countries and their resources make up a substantial part of of the free world's total." Engineering products and services represent an equally substantial proportion of Sterling Area trading commodities; and, as the book, of nearly 700 pages, covers much too wide a field to be reviewed as a whole, we propose, in discussing it, to confine attention to a few departments of international commerce with which this Journal is particularly concerned. It may be mentioned, however, that the survey is divided into three "books," contained in the one volume and dealing, respectively, with "The Area and its Members," "The Economics of Member Countries," and "Main Commodities in Sterling Area Trade." There is also a statistical appendix, occupying some ten pages, and a subject index which appears to be reasonably adequate. The work of compilation was directed by Dr. John M. Cassels, who was head of the Research and Statistics Division of the Economic Co-operation Administration from June, 1948, to December, 1951.

The Sterling Area—a term first used officially, it seems, in the Statutory Rules and Orders issued on July 17, 1940, under the Defence (Finance) Regulations of the United Kingdom—is well endowed with natural and acquired resources, but there are some essential commodities, largely minerals, that must be obtained elsewhere. About half of the import bill of the United Kingdom, it is pointed out, is for things that cannot be produced at home; though, at the same time, Britain imports a considerable quantity of machine tools, while relying extensively on exports of machinery to maintain the balance of trade. The United Kingdom is actually one of the world's largest exporters of machine tools, selling abroad about two-fifths of the annual output; in 1950, these exports were valued at some 17*l.* millions, but against that there were 6*l.* millions of imports—a proportion which, on the face of things, seems a little difficult to justify, even though many of the imported machines were to be used to make other articles for export.

The studies of main commodities which may be regarded as coming directly within the purview of Engineering are those dealing with iron and steel, machinery and vehicles, non-ferrous minerals, coal and chemicals, and petroleum and petroleum products. The section dealing with iron and steel is particularly interesting because it starts by reviewing the world production of iron ore, which amounted in 1948 to more than 219 million metric tons, representing a metal content of about 86¾ million metric tons. It is a remarkable indication of the industrialisation of the United States that, in the same year—the latest, apparently, for which world figures were available—the crude steel consumption per head of the population was 1,049 lb., whereas the United Kingdom, which was the next heaviest consumer, used only 547 lb. per head. Belgium came third, with 506 lb., and France fourth, with 369 lb. The corresponding pre-war consumptions (in 1938) were 415 lb., 435 lb., 296 lb., and 239 lb. Germany, in 1938, consumed 638 lb. per head. The scrap position has undergone marked changes in recent years, though the report does not comment extensively on this point.

International traffic in materials such as steel or non-ferrous metals is conditioned largely by geographical considerations, but the case is different with finished products such as machinery. Though economic stringency plays an important part, there

* *The Sterling Area: An American Analysis.* Mutual Security Agency, 1, Grosvenor-square, London, W.1; and H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 21*s.*]

are other considerations, such as rapidity of delivery, patented details of design, occasional commercial monopolies or near-monopolies, and (most often) an established reputation or especial skill in construction, which may override purely financial preference for one make rather than another. Hence, even in the most difficult economic circumstances, trade in machinery is seldom entirely in one direction between two industrially productive countries. As the report points out, by way of an example, Western Europe took 32 per cent. of Britain's exports of textile machinery in 1928, 22 per cent. in 1938, and 21 per cent. in 1948, though Britain was importing textile machinery from the United States and from Switzerland at the same time. Before the recent war, Germany was the second largest exporter of textile machinery, but took nearly 9 per cent. of the United Kingdom exports in 1928 and was the largest European importer from Britain in 1938.

Before the war, it is stated, "United Kingdom machinery imports averaged a third the value of exports; in 1948 and 1949, in spite of import restrictions and the export drive, the fraction was only reduced to a seventh." The general public, it is to be feared, do not appreciate in the least how supremely important machinery is in the nation's trading accounts; it forms the largest single class of goods exported, and, since the end of the war, has contributed a fifth of the total export earnings.

The section dealing with motor vehicles contains some arresting comparisons. In 1950, for example, the United States contained nearly three-quarters of all the motor vehicles on the roads, outside of the U.S.S.R., and had one car in use for every four persons in the population; in other words, the entire population of the country could go motoring at one and the same time, with seats to spare. New Zealand had a motor car to every eight persons, and Australia one to every eleven persons. The United Kingdom had only one to 23 persons; South Africa, one to 28; and India, one to about 3,000. In the United States, in 1949, three firms together accounted for 85 per cent. of the country's total production of motor vehicles; in the United Kingdom, six firms share between 85 and 90 per cent. of the output. In 1938, the United States produced 62 per cent. of the world output and the United Kingdom 11 per cent.; but ten years later the respective proportions were 80 per cent. and 8 per cent. Yet the United States exported only 4 per cent. of its total production in 1949—275,000 vehicles, as compared with 350,000 exported by the United Kingdom, which represented 56 per cent. of the total made.

The sections dealing, respectively, with coal and chemicals, and petroleum and petroleum products, present some interesting and rapid changes. It is observed that, in 1947, the oil used in the world had an energy content equivalent to about 70 per cent. of the energy in the coal consumed; if the energy value of natural gas were added to that of petroleum, oil and coal ranked about equally. Both coal and oil are of importance, of course, as basic materials of the chemical industry, but in this field the more rapid advances in recent years have been in petrochemicals. Modern chemical production is as remarkable for its variety as for quantity; for instance, it is stated that, in 1950, "more than 40 per cent. of the sales of the larger American companies consisted of products that had not been on the market at all 20 years before." Britain is now the second largest producer of chemicals, surpassed only by the United States; a circumstance which emphasises the growing importance of the chemical-engineering industry in this country, although, rather curiously, this branch of engineering manufacture receives no mention in the index.

SEARCHING FOR INFORMATION.

Faced with a new problem, most engineers are inclined to seek a solution based on their past experience and first principles, supplemented, perhaps, by a hopeful, but not always fruitful, reference to the text-books that are to hand. It is a praiseworthy inclination, fostered at universities and technical colleges, where fundamental knowledge and the scientific method are rightly considered more important than specialised information; but an engineer thus brought up is in danger of forgetting that there is an immense fund of recorded information, some of which, if only he could find it, might go a long way towards answering his problem. In many subjects, the thought of having to search the literature is enough to make a man work out a solution for himself. The certainty of evolving some sort of answer, even if it is not ideal, is better, he feels, than the uncertainty of delving into indexes and abstracts. In highly organised establishments, of course, there are librarians and information officers, backed by extensive resources, who take pride in being able to refer the inquirer to useful sources of information. Many engineers, however, are without such facilities, and certainly most engineering firms would not find it economical to set up a service of this kind.

The chief obstacle in the way of anyone who wishes to be enterprising in searching for existing data is the difficulty of knowing where to begin. Even in the most specialised fields there is a bewildering number of journals that might conceivably contain something of value, as well as reports, theses and similar documents which, for the most part, are not extensively publicised. Systems of classifying information are helpful to those who make a study of such matters—though they are often cumbersome or inflexible in embracing expanding fields of knowledge—but to the engineer or scientist who, not unnaturally, tries to concentrate on engineering or science, they are too much trouble to be worth mastering and applying to occasional inquiries. The severity of the situation varies throughout industry; in aeronautics and chemical engineering, for example, the pace of development is rapid and the rate of interchange of information is correspondingly high, though even here improvements could be made. In most of the older branches of engineering, however, there are large numbers of small and medium firms who are not able to attempt a thorough technical-information service. Very often, the work they do is of a kind in which technical improvements cannot have the striking influence that is common in newer industries, and there is therefore little incentive to turn aside from tradition and explore new techniques.

This is no new problem. Considerable advances have, in fact, been made by research associations and abstract journals, and by professional institutions, whose librarians are continually helping individual inquirers. Nevertheless, there is a widespread feeling that much more could be done. The Royal Society took the lead in 1948 by organising a Scientific Information Conference, at which the essential factors were brought to light, and some of the possible lines of attack which were suggested are still being pursued. A few months ago, the Association of Special Libraries and Information Bureaux (Aslib) formed an Engineering Group, with the object of doing some useful work on the subject for the engineering industry. The salient facts relating to this Group are reported on page 211. At present, it is an organisation for mutual self-help rather than for serving, or attempting to serve, any of the needs of the industry as a whole; and it is, of course, open to any individual or firm with engineering interests who joins Aslib. The Director and staff of Aslib have deliberately avoided issuing, or even suggesting, a clear-cut policy, because they rightly believe that the impetus and direction must come from the members. For the Aeronautical Group, which was formed by Aslib last year, the task has proved to be straightforward, since the members have reasonably similar interests and already had the advantage of frequent and close liaison.

In the Engineering Group, however, the field of knowledge is so wide and the potential membership so large that the first requirement is to be sure that the preparatory work of the Group is best calculated to serve the long-term interests of the members. At the first meeting it was suggested that there should be a number of separate groups, dealing with separate branches of engineering, rather than an omnibus group, but this idea was rejected on the grounds that the lines of demarcation between the several branches of engineering (however they are defined) are not clear, and that it would be better to postpone a decision on subdivision to the time when the nature of the task has been clarified. For the present, therefore, the Group and its committee are seeking, by inquiry and discussion, to formulate a policy which will ensure a solid foundation for future enterprise. The Group is not intended to be an agency for finding specific engineering information (Aslib headquarters maintains an inquiry bureau which undertakes to direct the inquirer to possible sources of information); the members of the Group aim to co-operate among themselves on any work which will improve their ability to locate information. The first useful step is to pool their knowledge of such matters; thereafter, it is hoped, something more positive may be attempted.

The engineering aspects of Aslib's work are to be prominent at the annual conference which is to be held at The Hayes, Swanwick, Derbyshire, from September 19 to 22. Professor T. U. Matthew, Ph.D., of the Department of Engineering Production at the University of Birmingham, is to open the conference with a paper on "The Significance of Information in Present-Day Industrial Society"; and "A Review of the Results of the Royal Society Scientific Information Conference, 1948," is to be given by Dr. D. J. Urquhart, of the Department of Scientific and Industrial Research, and Mr. Leslie Wilson, M.A., Director of Aslib. As the titles of these papers suggest, the basic problems are being tackled by various organisations and individuals. A revolution in methods of publishing technical information to accord with an idealised and rational system is out of the question, as the Royal Society Conference showed, but there is good reason to believe that, even with existing heterogeneous publications and unpublished material, the gap can be bridged between the vast store of technical information and the people who could use parts of it if they knew where to look. At the present stage the initiative is coming mainly from people who are professionally concerned. Greater progress could be made if more engineers with the imagination to appreciate the potentialities were to take part in the spade work which must be done before the harvest can be reaped. Between those, at one extreme, who know exactly what they are looking for, and those, at the other, who are not even aware of the fact that they and their work could profit by keeping an eye on developments, there is a large number of engineers who are anxious to find a practical method of searching for information and keeping themselves *au fait* with current progress. When such a method has been found, then, perhaps, an engineer faced with a new problem will find it easier to go farther than the reference book he won as a student, and will use his knowledge of first principles and his past experience to appraise the significance ,to him, of the material that a reasonable system has put before him.

NOTES.

The British Association Meeting at Belfast.

The British Association for the Advancement of Science meets this year in Belfast, under the presidency of Professor A. V. Hill, C.H., O.B.E., F.R.S. The first general assembly of the members will be held in the Sir William Whitla Hall of the Queen's University on Wednesday, September 3, when the Chancellor of the University will confer the hon. degree of LL.D. upon Professor A. V. Hill and Dr. D. W. Bronk, F.R.S., and the hon. degree of D.Sc. upon Dr. E. D. Adrian, O.M., P.R.S., Sir William Slater, and Sir Richard Southwell, F.R.S. The graduation ceremony will be followed by the inaugural general meeting, when the members of the Association will be welcomed by the Lord Mayor of Belfast, the Rt. Hon. J. H. Norritt, and by Dr. Eric Ashby, Vice-Chancellor of the University, and Professor A. V. Hill will then deliver his presidential address, entitled "The Ethical Dilemma of Science." H.R.H. the Duke of Edinburgh, K.G., F.R.S., who was President for last year's meeting in Edinburgh, will be present and will move a vote of thanks to the President. The sectional meetings will commence on Thursday morning, September 4, most of the sections being accommodated in Queen's University. Section G (Engineering), however, will meet in the Methodist College, Malone-road, and, as has been the case in recent years, two sessions, A and B, will be held simultaneously throughout the meeting. The first item in the programme of Section G is the reading and discussion of four papers relating to the Biology of Flying, jointly with Section I (Physiology). The four papers are: "The Biology of Flying," by Dr. K. G. Bergin; "Physiological Problems of High-Performance Military Aircraft," by Group Captain W. K. Stewart; "Skill and the Airman," by Dr. W. E. Hick; and "Engineering Problems of Conditioning Aircraft for Human Occupation and Control," by Mr. D. G. A. Rendel. While this discussion is in progress, Session B will hear and discuss a paper by Mr. D. A. Stewart on "Vibrated Concrete," and one by Professor R. O. Kapp on "The Calculation of Transmission-Line Constants." For the Friday morning meeting only one session will be held, in the Sir William Whitla Hall, where the President of the Section, Sir Ben Lockspeiser, K.C.B., F.R.S., will deliver his address on "Progress in Aeronautical Science and Engineering," after which Dr. Denis Rebbeck, C.B.E., will present a paper on "Ships and Shipbuilding in Belfast." When the meetings are resumed on Monday, September 8, Session A will hear a paper by Mr. D. Keith-Lucas on "The Shape of Wings to Come," and one by Mr. H. Knowler on the "Future Development of the Flying-Boat Airliner." At the same time, Session B will hear a paper on "The Training of Chemical Engineers," by Professor D. M. Newitt, M.C., F.R.S., and one by Dr. E. H. T. Hoblyn on "The Chemical Engineer in Industry." The discussion on the two papers will be opened by Sir Harold Hartley. The meetings of the Section will conclude on Tuesday, when Session A will hear a paper by Mr. F. W. Meredith, on "Servo-Mechanisms in Aircraft," and one by Lt.-Cdr. J. R. D. Walker entitled "Ships and Servo-Mechanisms." In Session B, four papers by young engineers will be read and discussed. They are: "The Analysis of Statically-Indeterminate Structures by the Complementary Energy Method," by Mr. T. M. Charlton; "The Effect of Shot Peening on the Fatigue Life of Steel," by Mr. A. G. H. Coombs; "Textile Engineering," by Mr. A. V. Pringle; and "The Bending Strength of Corrugated Plate," by Mr. J. B. Caldwell. An attractive programme of visits to works, factories and other places of technical interest has been arranged for the afternoons and on Saturday, September 6, there will be a full-day visit to the Silent Valley Reservoir. The officers of the Section, in addition to the President already mentioned, are as follows: Vice-Presidents, Principal D. H. Alexander, O.B.E., Professor A. H. Naylor, and Dr. Denis Rebbeck; Recorder, Professor W. Fisher Cassie, whose address is King's College, Newcastle-upon-Tyne, 1; secretaries, Dr. E. C. Cherry and Mr. R. Hiscock; and local secretaries, Dr. W. G. Godden and Mr. T. E. Goligher.

Engineering Information.

The special requirements of the engineering industry in locating sources of technical information have been under consideration by the Association of Special Libraries and Information Bureaux—known, for convenience, as Aslib—and an Engineering Group has been formed. The members of the Group are firms and individuals who are members of Aslib and who have engineering interests. Their work consists of co-operative projects of practical utility, and as more and more members join the value of the Group activities will increase. Aslib groups already functioning include those dealing with aeronautics, textiles, economics, and food and agriculture. The Engineering Group were able to benefit from the experience of the existing groups, though the possible field of interest is so wide that, for the present, attention is confined to a number of basic projects which will clarify the issues involved. For example, there are numerous indexes, bibliographies, etc., which are used in the industry as keys to technical information. Not everyone is familiar with them, however, so the members of the Group steering committee are pooling their knowledge of these publications. To overcome the difficulty of locating a particular issue of a scarce journal, to which a reference is known, steps have been taken to compile a "union list" of those periodicals which members of the Group receive in their offices or libraries. When replies have been received from members of the Group, they will be consolidated and a copy of the union list will be sent to each member; mutual arrangements can then be made whenever one member requires access to a copy of a periodical held by another member. The exploratory meeting at which members first discussed the formation of the Group was held at Aslib headquarters, 4, Palace-gate, London, W.8, on June 5. The steering committee elected at that meeting consists of the chairman, Mr. F. B. Roberts (chief assistant editor of Engineering), Mr. G. Gilfillan (University of Birmingham), Dr. M. Goyer (Ministry of Supply, Rocket Propulsion Department), Mrs. J. D. Hooley (Kellogg International Corporation), Mr. F. H. Smith (Royal Aeronautical Society), and Mr. H. W. Worrall) D. Napier and Son, Limited). An informal talk on difficulties in acquiring engineering information was given on July 11 by Mr. Gilfillan, who is concerned with this subject in his work in the Department of Engineering Production at Birmingham University. He stressed the importance of providing simpler methods of fact-finding suitable for engineers who have not ready access to library and information facilities. A leading article on page 210 of this issue discusses the situation which has led to the formation of the Group and the potential usefulness of the Group's work.

Royal Air Force Apprentices.

On Friday, July 25, Her Majesty the Queen presented the Queen's Colour to No. 1 School of Technical Training, Royal Air Force, Halton, Buckinghamshire, the first Royal Air Force school to be built for technical training. "The Royal Air Force," said Her Majesty, "must be able to place the same reliance on the technical skill of its tradesmen as on the gallantry of its pilots and the experience and imagination of its commanders." The Royal Air Force three-year aircraft apprentice course is designed to provide a core of highly-skilled technicians to service the complicated equipment of the modern military aircraft. Boys entering at ages between 15 and $17\frac{1}{2}$ years may be trained in aircraft engineering at Halton or in radio at Locking, Somersetshire. Entry is by examination, but boys with a general certificate of education, with passes in mathematics and a science, are exempt. In addition to practical training, the course includes educational training in general and technical subjects. In certain trades, apprentices may qualify, at the end of their course, for the Ordinary National Certificate in engineering, depending upon their progress during training and their results in the final examinations in technical educational subjects. Since 1946, 590 aircraft apprentices have gained certificates, 150 with distinction, and three Whitworth Society prizes have been obtained. Those apprentices who do sufficiently well in their final examination in educational subjects are exempted from the Common Preliminary Examination of the Engineering Joint Board; they are also eligible for cadetships at the Royal Air Force College, Cranwell, leading to a permanent commission in the flying branch, or at the Royal Air Force Technical College, Henlow, leading to a permanent commission in the technical branch. Suitably qualified apprentices are also eligible for cadetships at universities. Since 1947, 11 ex-apprentices have been awarded university degrees in engineering. Three ex-apprentices, now holding commissions in the technical branch, have recently completed the two-year diploma course at the College of Aeronautics, Cranfield, Bedfordshire, two with distinction. Out of approximately 20,000 apprentices, more than 4,000 have been awarded commissions, and many of the senior officers of the Royal Air Force to-day are ex-apprentices.

Seaweed Research.

In the hope of developing an industry, based on local seaweed resources, for the crofters of the Scottish highlands and islands, the Scottish Seaweed Research Association was formed in 1944, most of the members being organisations interested in the development of the industry. Unusual problems had to be solved, and since the seaweed industry is small, most of the funds for carrying out research were supplied by the Treasury. The Government decided, therefore, to take over the sole responsibility for the work when the grant period ended. The Association was therefore dissolved on June 30, 1951, and its place was taken by the Institute of Seaweed Research. To maintain contact between the Institute and the industry, a Seaweed Utilisation Society is being formed. The annual report for 1951 of the Institute has been published recently. The Institute possesses two vessels, used for harvesting and collecting samples, and two other vessels have been chartered for the quantitative investigation of Scotland's sub-littoral seaweed resources. The preliminary sub-littoral brown-seaweed survey, by aerial photogrammetry, has been completed, but some areas are to be re-photographed. Among the regions in which seaweed beds have been found may be mentioned the Shetland Islands, the Orkneys, the Outer Hebrides, South Arran, the Lossiemouth-Fraserburgh coast, and the Forth estuary. The chemical engineering problems studied during the year were concerned mainly with tests of seaweed dryers, with dewatering and pressing by centrifuging, and with a pilot plant for the production of algal chemicals. The small-scale production plant has revealed that various problems on extraction times, methods, and solvents, require further study. The mechanical engineering staff have continued development work on harvesting methods. In the the cutting-and-entrainment method, the principal unsolved problem is that of guiding the cut plants to the entrainment system inlet. A steel-mesh conveyor belt was used to transport the weed from the cutters to a suction-hose inlet, suction being provided by a jet pump in conjunction with a 4-in. centrifugal pump driven by a 30-h.p. Kelvin Ricardo engine. Although tests were not complete when the report was compiled, it is believed that a horizontal lead-in from the belt to the suction pipe will be effective in overcoming belt-jamming, which was experienced in some of the tests as a result of a momentary reduction in water flow. As recorded in the previous annual report, the continuous-grapnel method of harvesting has been proved satisfactory on an experimental scale. A harvester with two continuous-grapnel equipments is now being designed for continuous operation. Underwater photography has been used for recording the intermittent grapnel at work; although costly, underwater filming is considered to be a promising research tool.

Franco-Crosti Boilers for British Railways.—The Railway Executive are to experiment with a type of locomotive boiler which has been tried successfully on the Continent and is claimed by its Italian inventor to achieve considerable fuel economy. The Franco-Crosti boiler, as it is called, is to be fitted to ten Class-9 2-10-0 heavy freight locomotives of a new standard design, which are to be built under the 1953 locomotive building programme. The design is such that the engines can be fitted with either these or the orthodox type of locomotive boiler with only slight modification.

LETTERS TO THE EDITOR.

STEAM POWER IN FARMING.

To the Editor of Engineering.

SIR,—Dr. J. Bronowski, speaking at the 18th annual conference of the Smoke Abatement Society, said that the people of this country had a number of curious habits. He counted among these a certain leaning towards Mr. Emett, the caricaturist of the locomotive, and the late Heath Robinson. He did not differentiate between them, but it appears that, whereas the Heath Robinson bias leads us to make ingenious mechanisms out of anything that is handy, the Emett characteristic leads us to preserve things which should be decently and firmly buried. "Emettism" flourishes among model-makers and has infected particularly the branch of industry formerly concerned with the manufacture of steam engines. It is responsible, in my opinion, for the complete absence of any lightweight steam power plant or tractor capable of running on wood fuel, or even oil. At the present time, the disciples of Emett are trying to create a vogue for the steam traction engine, and otherwise worthy people, instead of allowing these anachronisms to depart to the cupola, where they should be, are buying and preserving them, organising races for them, and almost worshipping them.

I was so fortunate as to serve my time under one of the finest traction-engine designers this country has ever had, the late Henry McLaren, of Leeds. He concentrated on direct steam ploughing, using the engine to haul the implements, and in this he led Europe, if not the world, winning practically every ploughing competition he entered. He did not bother about the home market, but went to such places as Argentina, South Africa and Hungary, where his engines would pull 14-furrow ploughs at 3 miles an hour; but he would never depart from the locomotive type of boiler.

Years afterwards, *c.* 1926, I was brought into contact with the Sentinel Wagon Works, Limited, of Shrewsbury, and had some part in the design of the tractor that they called the "Rhino." For some reason, they never sought publicity for it; but, as I still feel that we may come back some day to direct steam ploughing, some particulars of it may be of interest. It is illustrated in Figs. 1 and 2, herewith. The excellent Sentinel wagon engine was used in conjunction with the largest available size of Sentinel boiler, which could supply ample steam at a good superheat; a combined unit which was literally tons lighter than the conventional locomotive boiler and ordinary steam engine used in heavy traction work. The chassis consisted of two pressed-steel frames, joined at each end by water tanks, which were connected by a pipe. The feed pump drew from the rear tank, but the steam injector which filled the tanks was placed at the front end; this was done because, if the tractor became bogged when taking water, it was always possible to get out if the driving wheels were on firm ground. The ordinary three-point suspension of the steam traction engine was combined with a steam-wagon steering gear by pivoting the front axle about a centre pin and spring, while constraining it, by means of hornplates, to move vertically only. The engine lay horizontally, and was suspended by two spherical bearings formed by the end doors of the crank-case, and a bracket fastening between the cylinders.

The transmission was by chain from the engine to the input shaft of a gearbox embodying a differential gear and two gear ratios, the final drive being by chains from the countershaft carrying the differential to chain wheels on the driving wheels. (Personally, I am convinced that a 100 per cent. chain drive is best, being easier to maintain than gears, easier to replace, and less liable to damage in the event of failure to lubricate.) Locking the differential was achieved by using a solid back axle on which the road wheels normally revolved. To lock the differential, it was only necessary to lock the wheels to the axle by slipping in round pins; the axle then rotated in bearings together with both wheels, and the differential could not function. The winding drum, carrying 50 yards of wire rope, ran loose on the back axle and could be connected to the transmission at will. The rope could be run forward or backward; a feature impossible with the conventional steam traction engine, and one of great value. The driving wheels had built-up steel hubs, with the spokes welded to the discs forming the hub ends. The rims were double, of the customary T section, and were joined by diagonal strakes. Spaces were left between the T rings and between the strakes, as can be seen in Fig. 2, to give a better grip on the ground.

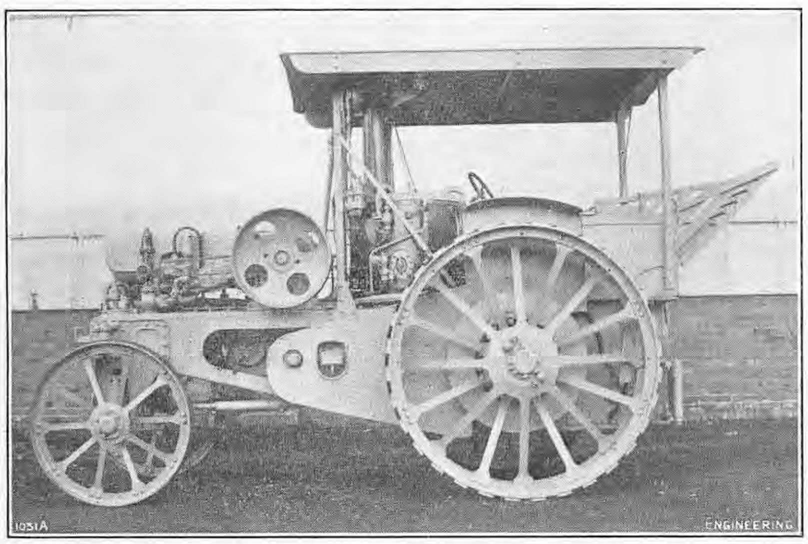


FIG. 1. THE "RHINO" STEAM TRACTOR.

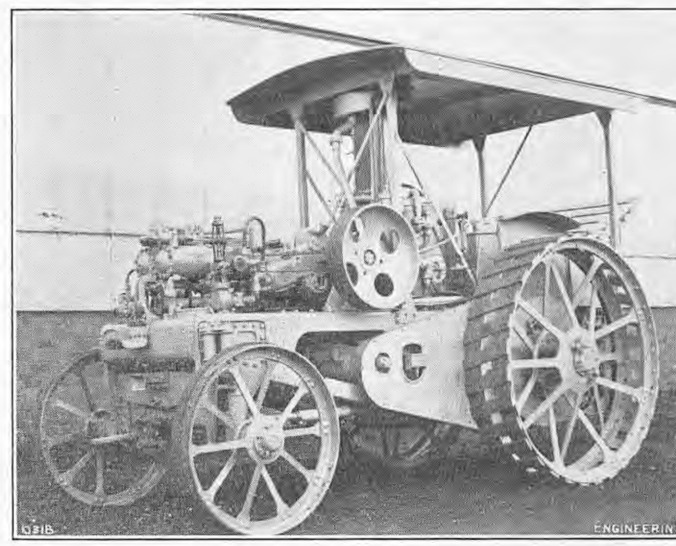


FIG. 2. VIEW SHOWING CONSTRUCTION OF WHEELS.

The tractor was tested near Shrewsbury, burning both coal and wood fuel, and simply played with two MacLaren four-furrow ploughs on what would be considered "three-horse" land. Remembering a saying of McLaren that a Pickering governor could think more quickly than the best of drivers, I had the governor belt put on, opened the regulator fully, and let the governor do the thinking. Eventually, the Rhino went to Kenya, where it fully justified itself; but the agricultural depression, and improved forms of internal-combustion tractors, coupled with their lower first cost, checked development overseas, while the burden which British taxation placed on the steam wagon so reduced the demand for Sentinel products that there was no hope of reducing the cost by quantity production at home.

Because of the increasing cost of oil, and a feeling on the part of power users that wood fuel should be used if available, a renewed interest is now being evinced in small steam power units. This can be and should be fostered, but it is to be hoped that the disciples of Emett will now transfer their affections from the old type of steam traction engine (if they must worship the past) to something more like the system of the White steam car. How many people are aware that, about 1910, an American professor, testing the 15-h.p. White car engine, recorded a consumption of 11·96 lb. of steam per brake horse-power per hour when developing 40·7 brake horse-power, an evaporation of 10·15 lb. of water per lb. of distillate, and 10·7 lb. per square foot of heating surface?—and I should imagine that the combined weight of engine and steam generator did not exceed 5 cwt.

Yours faithfully,
K. W. WILLANS.

Rose Cottage,
All Cannings, Devizes, Wiltshire.
August 4, 1952.

WATER HAMMER IN PIPE-LINES.

To the Editor of Engineering

SIR,—The letter by Mr. L. E. Adams on water hammer in pipe-lines, on page 148 of your issue of August 1, is a welcome sign that greater interest is being shown in the problem connected with the absorption by the pipe material of the stresses caused by rapidly varying fluid pressures.

In a field such as water hammer, which is of necessity rather complicated, it is inadvisable to suggest new and more complex formulæ without adding some estimate of the correction thus made to the old-established equations. The present lines are intended to discuss whether the use of Mr. Adams' more complicated formula is justified in practice by the improved accuracy of the results obtained with it, and also to point out a serious error in the Adams Formula:

$$p = \mathrm{C}_p \sqrt{\frac{\mathrm{K}\,\rho\,v^2}{1 + \dfrac{\mathrm{K}}{\mathrm{E}}\left(\dfrac{k\,r_m}{c\,d}\right)}} + \mathrm{p}_1^2 \quad . \quad (1)$$

repeated here for the sake of convenience. The symbols used in this letter are the same as those employed by Mr. Adams.

It is a well-known fact, confirmed both theoretically from the equations of unsteady flow* and experimentally by numerous tests, that the surge pressure rise $p - p_1$ is independent of p_1 (except, of course, as far as the pipe material may not follow Hooke's law). The surge pressure has to be added to the pressure present in the fluid before the flow is stopped, and the total fluid pressure is the sum of surge pressure p_s and the initial pressure p_1, i.e.,

$$p = p_s + p_1$$

$$= \mathrm{C}_p \sqrt{\frac{\mathrm{K}\,\rho\,v^2}{1 + \dfrac{\mathrm{K}}{\mathrm{E}}\left(\dfrac{k\,r_m}{c\,d}\right)}} + p_1 \quad . \quad (2)$$

It is very interesting to compare Mr. Adams' newly-derived formula, as corrected above, with

* *Théorie Générale du Coup de Bélier* (page 18), by C. Jaeger. Dunod, Paris (1933).

the standard equation for water-hammer pressure :

$$p_s = \frac{w}{g} a v \quad . \quad . \quad . \quad (3)$$

where a is the velocity at which pressure surges are transmitted along the pipe, derived from the ordinary hoop-stress formula for thin pipe :

$$a = \sqrt{\frac{g}{w} \frac{1}{\frac{d}{E t} + \frac{1}{K}}} . \quad . \quad . \quad . \quad (4)$$

Combining equations (3) and (4) leads to the conventional expression for the surge pressure

$$p_s = \sqrt{\frac{\rho v^2 K}{1 + \frac{K}{E} \frac{d}{t}}} . \quad . \quad . \quad . \quad (5)$$

When comparing this equation (5) with equation (2), the difference is found to lie in the (apparently empirical) coefficient C_p, and in the term multiplying the fraction $\frac{K}{E}$ in the denominator. Leaving the first out of account for the moment, the latter may readily be shown to be approximately the same in the two equations. In equation (3) we have

$$r_m = \frac{d}{2} + \frac{t}{2} = \frac{d}{2}\left(1 + \frac{t}{d}\right) = \frac{d}{2}\left(1 + \frac{1}{2c}\right),$$

and

$$\frac{k r_m}{c d} = \frac{k}{c d} \frac{d}{2} \left(1 + \frac{1}{2c}\right) = \frac{k}{2c} \left(1 + \frac{1}{2c}\right) = \text{A, say,}$$

the value of k being given by the long expansion quoted by Mr. Adams (his equation (2)). From equation (5), on the other hand, we obtain

$$\frac{d}{t} = 2c = \text{B, say.}$$

The ratio $\frac{A}{B} = \frac{1 + \frac{1}{2c}}{4c^2} k$ represents the effect of the refinement taking into account Kelvin's strain-energy function, as was done by Mr. Adams. The value of the ratio depends partly on c, the wall thickness ratio, and partly on the value of k. In the case of steel pipe, a few calculations show that $\frac{A}{B}$ ranges from 1·05 for 3-in. class-B pipe, to 0·98 for 44-in. class-B pipe. Since there is an additive term in the denominator and a square-root sign over the whole expression, Mr. Adams' correction for these two cases cannot be greater than − 3 per cent. and + 1 per cent.

Cast-iron pipes, the walls of which are relatively thicker, may be expected to be much more sensitive to the effect of strain energy. Unfortunately, apart from being a completely heterogeneous material whose properties vary considerably with the depth from the surface, cast iron shows a large scatter in its mechanical properties, even when these are measured on test bars under standard conditions. Marks' *Mechanical Engineers' Handbook* quotes the following values : $E = 13{\cdot}5 - 21$, $G = 5{\cdot}2 - 8{\cdot}2$ (both in 10^6 lb. per square inch), $\sigma = 0{\cdot}211 - 0{\cdot}299$. Since these constants have a marked effect on the value of k in the Adams formula, a comparison of the calculated values with those measured by Joukowsky in 1897 on cast-iron pipe of unknown mechanical properties is, to say the least, of doubtful validity. Incidentally, Mr. Adams will find the correct wall thickness of the pipe used in these tests in a paper by O. Simin.*

It appears, therefore, that the strain-energy correction to the standard pressure surge formula is negligible (compared with the accuracy usually obtainable) in steel pipes and that further tests are required before it can be accepted for thick-walled cast-iron pipes of small diameter.

A more fundamental objection may perhaps be raised to the verification of the new formula as given by Mr. Adams : a theoretically-derived expression cannot possibly be confirmed by means of a multiplying coefficient which appears to vary for different cases, while the accuracy with which the value of C_p is given (say, 1 in 100), certainly exceeds what Joukowsky would have claimed for his own test results.

Yours faithfully,
P. LINTON, B.Sc., A.M.I.E.E., A.M.I.Mech.E.

The British Hydromechanics Research Association,
Harlow,
Essex.
August 7, 1952.

* "Water Hammer," by O. Simin, *Proc. Am. Water-Works Assoc.*, page 341 (1904).

UPPER BOAT POWER STATION, SOUTH WALES.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with much interest your article on the Upper Boat power station, on page 85, *ante*, as I was in charge of the station for the contractors from the end of 1904 to the middle of 1906. The station started operating on two Willans engines, the third being installed in 1905. The speed of these engines was 250 r.p.m., not 150 as stated in the article ; also, there were eight of that type built, I think, not four. The first engine was sent to the Paris Exhibition in 1900, and went from there to the Grove-road station in London. There were two at Glasgow, but I cannot remember where the remaining two went ; I think they were sent overseas.

Yours faithfully,
E. S. ORMSBY.

Huthwaite Hall,
Thurgoland, Sheffield.
August 12, 1952.

[We are obliged to Mr. Ormsby for these first-hand addenda to our article—the material for which, it may be remarked, was supplied to us by the British Electricity Authority. The engine which was exhibited in Paris was described and illustrated in ENGINEERING at the time, on page 552 of our 69th volume (April 27, 1900). The particulars then printed were provided, presumably, by Messrs. Willans and Robinson, Limited, and differ in some respects both from those of the B.E.A. and Mr. Ormsby's ; though it is to be borne in mind that the figures we quoted in 1900 related to the designed performance. We then stated : "The engine is intended to give 2,400 horse-power in normal working, but is capable of developing 3,000 indicated horse-power on [*sic*] emergencies. Its designed speed is 200 revolutions per minute, its weight 120 tons, and it occupies a floor space of 31 ft. by 11 ft. 1 in. . . . The crankshaft is in one piece, the eccentrics being forged solid on the crankpins, though the shaft is 14½ in. in diameter at the journals and weighs about 12 tons. . . . The cylinders . . . measure 18⅞ in., 30 5/16 in., and 49 in. in diameter, by 23⅝ in. stroke." The engine drove a Siemens multipolar dynamo, to which it has coupled directly, and which served also as a flywheel. It was used to supply current for power and lighting during the run of the Exhibition.—ED., E.]

ENGINEERING AND METALLURGICAL RESEARCH BY BABCOCK AND WILCOX, LIMITED, AT RENFREW.

TO THE EDITOR OF ENGINEERING.

SIR,—The apparent contradiction in the letter by Dr. Harris and Mr. Webb, on page 179 of your issue of August 8, in reply to our previous letter, leads us to believe that one of the main points we wished to make was badly put. Since we regard this particular point as important, we would beg a little more of your space to enlarge upon it.

It would seem that the misunderstanding might arise in this way. Dr. Harris and Mr. Webb argue that defects such as fine cracks, when edge on to the ultrasonic beam, return very small signals which may be masked by other signals of similar intensity returning from quite insignificant adjacent but differently orientated defects ; or, if a filter circuit is used, will be eliminated. Thus, we have the apparent anomaly of the method being referred to as being too sensitive on the one hand, and yet, on the other, liable to miss a dangerous defect if the sensitivity is reduced.

It seems generally agreed that, provided the incident ultrasonic beam does not strike a planar defect at nearly zero incidence, then defects of engineering significance, however small, give comparatively large return signals, provided that the receiving probe is placed in the optimum position on the surface of the piece. It is, therefore, fundamental to the successful inspection of welds that the "primary" or searching scan be planned so that every part of the weld is searched in such a way that echoes returning in any direction can be picked up, and that any planar flaw is irradiated by the searching beam from more than one direction—a primary scan which may allow of a crack being irradiated at zero incidence is dangerous.

If we assume a properly planned primary scan, then flaws of significant magnitude will return comparatively strong signals, and the purpose of the filter circuit is to assist the operator in distinguishing these signals from other minute indications due to weak surface waves in the oil film, valve noise, etc. The effect on the amplifier performance of such a circuit may perhaps be better described as that of introducing a "contrast" control. The amplification of minute signals which do not come from any significant defect is reduced, while amplification of significant signals remains virtually unaffected. Since, during the primary scan, the contrast control is set just to eliminate extraneous signals from the trace (which in practice the operator would find extremely difficult to distinguish from flaw signals of small magnitude, e.g., crack edge on) there is no diminution of the effective sensitivity of the instrument during the primary detection scan. The raising of the reject level during subsequent scans as an aid to the operator in assessing the size of a defect after it has been detected and identified is, of course, quite another matter.

Yours faithfully,
J. W. FOX.
E. M. LEWIS.

W. S. Atkins and Partners,
158, Victoria-street,
London, S.W.1.
August 11, 1952.

REFRESHER COURSE FOR WORKS ENGINEERS.—An opportunity for works engineers employed in the Eastern Region of the Ministry of Fuel and Power's fuel engineering advisory service to obtain up-to-date information concerning the efficient utilisation of heat and power is being offered through a special refresher course which is being organised by the Ministry at the Cambridge University Engineering Laboratories from September 22 to 26. We understand that this will be the first time that such a course has been held in the Eastern Region. The course will include a number of lectures by specialists. Among the papers to be given will be some dealing with steam, gas and electricity utilisation ; the economical use of compressed air ; the application of heat pumps and gas turbines ; the insulation of buildings and hot surfaces ; boiler-plant operation and instrumentation ; refrigeration-plant usage ; heating, hot-water supply and ventilation ; boiler feed-water treatment and the self-generation of electricity and the use of exhaust steam. Further information concerning the course may be obtained from the Fuel Efficiency Secretary, Ministry of Fuel and Power, Brooklands-avenue, Cambridge.

RESEARCH AND DEVELOPMENT WORK ON CAST IRON.—Since August, 1949, the British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, have made available their *Journal of Research and Development* to non-members of the Association on a subscription basis. Typical recent contributions to the *Journal* include original work on the fluidity of cast iron ; methods of improving working conditions in ironfoundries ; an investigation of the relation between the stress/strain properties of moulding sands and expansion "scabs" on iron castings ; and the harmful effects of certain residual elements in magnesium-treated nodular iron and its neutralisation by cerium. The *Journal* is intended to assist the ironfounding industry in this country and overseas and it contains reports of completed research investigations conducted by both the research and development departments of the Association, at Alvechurch, and also papers presented at conferences on foundry topics arranged at intervals by the Association. The *Journal* is published in February and in the following alternate months, making six issues a year. It is available on subscription at 3*l*. per annum.

SAFETY PROVISIONS OF THE FACTORIES ACTS.

By C. F. Mayson, A.M.I.E.E.

Almost exactly 15 years ago—on July 30, 1937—the Factories Act, 1937, which consolidated and amended previous enactments and introduced many new requirements and changes of great importance, received the Royal Assent. Part II of the Act, dealing with safety precautions, was considerably extended, and further legislation, additional regulations and a number of judicial decisions have since affected these provisions in no small degree. During this period, engineers have been active in devising improved methods of safeguarding dangerous parts of machinery, and several learned papers have been written.* That the lawyers have not been inactive, either, is evidenced by the fact that the safety provisions of the Act have received more judicial consideration than any other section. The endeavours of both professions would, perhaps, be more fruitful were each to understand something of the other's problems. A broad review of the present legal position might, therefore, be of interest and assistance to engineers engaged in the practical application of safety precautions. For detailed treatment the reader is referred elsewhere.†

As is well known, civil action can be commenced under the Act irrespective of whether criminal proceedings have been brought. The field covered by the former is fairly wide, as claims can be, and are, made on the ground of common-law negligence as an alternative plea to that alleging breach of statutory duty. An employer's liability seems, at first sight, to be somewhat onerous, especially when it is realised that damages awarded in a civil action may easily amount to several thousand pounds, whereas a fine is unlikely to exceed 100*l*., and may be considerably less. Though, on the same set of facts, there may be liability both for breach of the duty laid down by statute and for negligence at common law, the damages will not be affected, for they are regarded as compensation and never as a penalty.

Actions at law for the recovery of damages for injuries received in the course of employment have increased in recent years. For this, two events at least are responsible. The doctrine of common employment was abolished, and the Employers' Liability Act of 1880 repealed, by the Law Reform (Personal Injuries) Act, 1948, and the employer thereby lost one of his defences. The National Insurance (Industrial Injuries) Act, 1946 (which came into force in 1948), repealed and replaced the Workmen's Compensation Acts, 1897 to 1943, with the result that whereas, under the latter Acts, an employee had to elect whether to claim compensation or to bring an action, by the 1946 Act he can both claim compensation and sue his employer. A further incentive was provided by the Law Reform (Contributory Negligence) Act, 1945. Previously, any degree of negligence by the plaintiff which was shown to have contributed to his injury was an absolute bar to his recovering anything. Now, if the claim is proved, damages will be awarded in the usual way, but negligence on the part of the plaintiff will be assessed as a percentage of the whole cause of his injury, reducing the damages actually recovered in that proportion. The natural result is that many claims are made by injured workpeople which would have had no chance of success before 1945. The judiciary are undoubtedly aware of the position, and there is a tendency, both at first instance and on appeal, for the scales to be weighted slightly in favour of the defendant employer in doubtful cases. As has been said many times in the Courts, the employer is not to be regarded as an insurer.

The principal theme of Part II of the Act is the fencing of dangerous machinery, and most of the claims which come to Court allege breach of these provisions. It has been made clear, time after time, that the duty to fence is absolute, and it simply does not suffice to say that to fence a particular part of a machine is impracticable because it would thereby become virtually unusable. Fencing must be secure; "somewhat secure" will not do at all. Sections 13, 14 and 15 give a certain amount of latitude to occupiers as to whether a machine, or part of it, is "dangerous." There is no real definition of that word in the Act, and its proper meaning has been argued many times. The best test is still that enunciated by Mr. Justice Wills in 1897*, and it is of value to quote it in full:—"It seems to me that machinery or parts of machinery is or are dangerous if in the ordinary course of human affairs danger may be reasonably anticipated from the use of them without protection. No doubt it would be impossible to say that, because an accident had happened once, therefore the machinery was dangerous. On the other hand, it is equally out of the question to say that machinery cannot be dangerous unless it is so in the course of careful working. In considering whether machinery is dangerous, the contingency of carelessness on the part of the workman in charge of it, and the frequency with which that contingency is likely to arise, are matters that must be taken into consideration. It is entirely a question of degree."

The safety provisions have been designed to ensure the highest degree of safety for the employee, and for that reason they must be strictly construed. That does not mean that, as an accident has occurred, there must also have been a breach; nor does it imply that, because there has been a breach, a particular accident has been caused by that breach, even though it could have been so caused. In every case it is a question of fact, coupled with assessment of the human factor. The "contingency of carelessness" must be approached from the point of view that the behaviour of human beings is to be regarded in the light of what is reasonably foreseeable and not what might be considered reasonable in the circumstances.

The "foreseeability test" cannot be used to decide whether a machine is or is not securely fenced; if there has to be fencing at all, it must be secure in the fullest sense. But the test can be important, for example, in considering whether the second limb of Section 13 (1) applies. This is to the effect that transmission machinery must be securely fenced "unless" it is by position or construction "as safe to every person employed or working on the premises as it would be if securely fenced." Section 15 expressly provides for the application of the test in determining whether machinery is as safe as if it were fenced, but does not apply it to the question whether a machine is, in fact, fenced securely. The Courts do not, in a civil action, regard the fact that the factory inspector has not required a machine or parts of a machine to be fenced, as having any bearing upon the question of whether fencing should have been provided. *Per contra*, it does not follow that, because the occupier has been prosecuted successfully for failure to fence, an injured person will be able to claim damages in consequence of injury due to the breach.

At one time it was thought that special regulations, made under the Act with reference to particular types of machine, automatically excluded the general provisions of Section 14. The Court of Appeal in a recent case* has decided that this is not so. Reg. 3 of the Horizontal Milling Machines Regulations provides that "the cutter or cutters of every machine shall be fenced by a strong guard." The Court held that the regulation applied only to the cutter as specified, and the absolute obligation laid down by Section 14 still applied to the fencing of other dangerous parts.

It is a rule of law that, where an Act prescribes penalties for breach, its provisions are to be construed strictly, even in civil actions. This, of course, works both ways, as the following examples will show. Fencing is provided to protect the worker from the machine, but the House of Lords has held that the obligation does not extend to preventing the escape of spoil from a woodworking machine† or even to broken parts of a machine which fly out and cause injury.‡ The House has also ruled§ that sections 14 (1), 16 and 20 do not apply to machinery which is in the course of manufacture or test while still in the factory in which it is made; Lord Normand went so far as to express the opinion that it was doubtful whether any of the provisions of Part II would apply in such a case. Though the Act makes the occupier responsible for breach, a manufacturer can be fined for supplying equipment which fails to comply with S. 17. However, it was decided recently|| that a manufacturer is liable only to the penalty, and he owes no duty to a person injured as a result of such breach.

As to what constitutes a "factory" has been most fully defined in Section 151, but there have been quite a few decisions on whether or not the Act applies in particular cases. Thus, a separate building within the curtilage of a factory, used solely for the repair of machinery used in the factory, is within the Act. In that case, a ventilating fan was undergoing test and the tester was injured by the unguarded blades. The Court of Appeal ruled that there had been a breach of Section 14 in that guarding should have been provided.¶ But in another case the Lord Chief Justice chose to distinguish major repairs to vehicles from running repairs and routine maintenance, holding that a garage used principally for parking or storing vehicles, but in which minor adjustments were made from time to time, was not a factory.** An extension to a generating station, still in the hands of contractors installing new plant, but separated from the main building by a tarpaulin only, is neither part of that station nor a separate station or factory so as to render the occupiers liable.††

Section 119 is of great importance, as it sets out the duties of employed persons. If safety appliances are provided they must be used, and if an employer has supplied such an appliance, in good condition, in its proper place and ready to hand, then he has "provided" it. He is not under any obligation to tell his employee to use it, and even if he has gone so far as to acquiesce in its not being used, the employee is himself still liable.‡‡ The section also forbids workers to take unnecessary risks so as to endanger themselves or others; in civil actions this has the same effect as the contributory negligence rule.

The *nexus* between injury and breach of duty has already been touched on when discussing the definition of "dangerous." A recent case§§ has

* For example: "The Fencing of Dangerous Parts of Machinery," by H. A. Hepburn. *Proc. I. Mech. E.*, vol. 152, page 149 (1945); and "Electrical Control of Dangerous Machinery and Processes," by W. Fordham Cooper, Part 1, *J.I.E.E.*, vol. 94, Part II, page 216 (1947); Part 2, *Proc. I.E.E.*, vol. 98, Part II, page 349 1951); Part 3 is not yet published.

† *Redgrave's Factories, Truck and Shops Acts*, 17th edition, 1951, by John Thompson and Harold R. Rogers. (Butterworth & Co., (Publishers), Ltd., London.)

* Hindle *v.* Birtwistle (1897), *Law Reports*, 1 Q.B. 192.

* Benn *v.* Kamm (1952), *Law Reports*, 2 Q.B. 127.

† Nicholls *v.* Austin (1946), *Law Reports* A.C. 493.

‡ Carroll *v.* Barclay (1948), *Law Reports* A.C. 477.

§ Parvin *v.* Morton Machine (1952), 1 *All England Reports* 670.

|| Biddle *v.* Truvox (1951), 2 *Times Law Reports*, 968.

¶ Thurogood *v.* Van den Berghs (1951), *Law Reports*, 2 K.B. 537.

** Griffin *v.* L.T.E. (1950), 1 *All England Reports* 716.

†† Street *v.* B.E.A. (1952), 1 *All England Reports* 679.

‡‡ Norris *v.* Syndic Mfg., (1952), *Law Reports* 2 Q.B. 135.

§§ Watts *v.* Enfield Rolling Mills (1952), 1 *The Times Law Reports*, 733.

BLAST-FURNACE AND STEEL-MELTING PLANT AT SHOTTON.

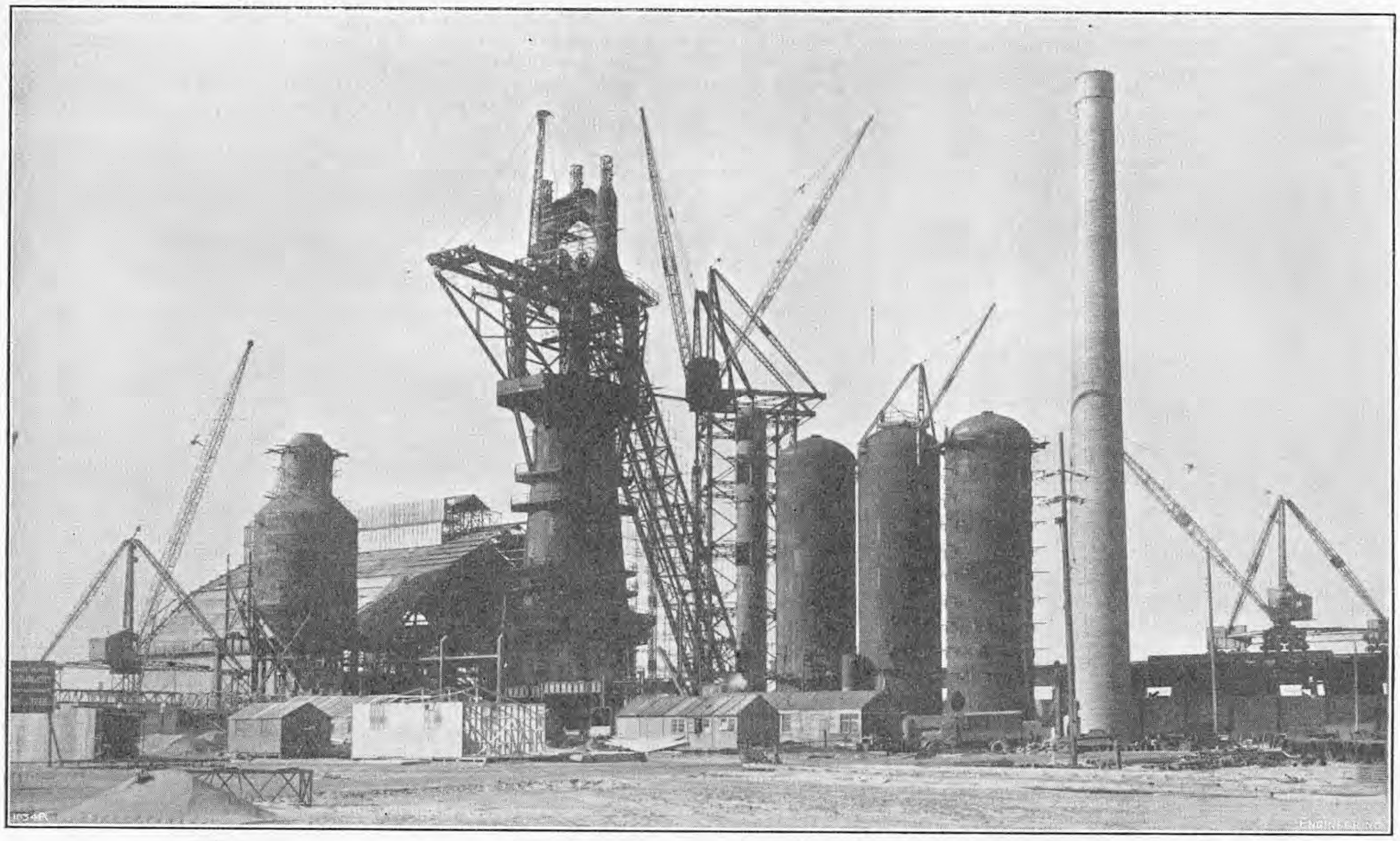


FIG. 1. BLAST FURNACE UNDER CONSTRUCTION.

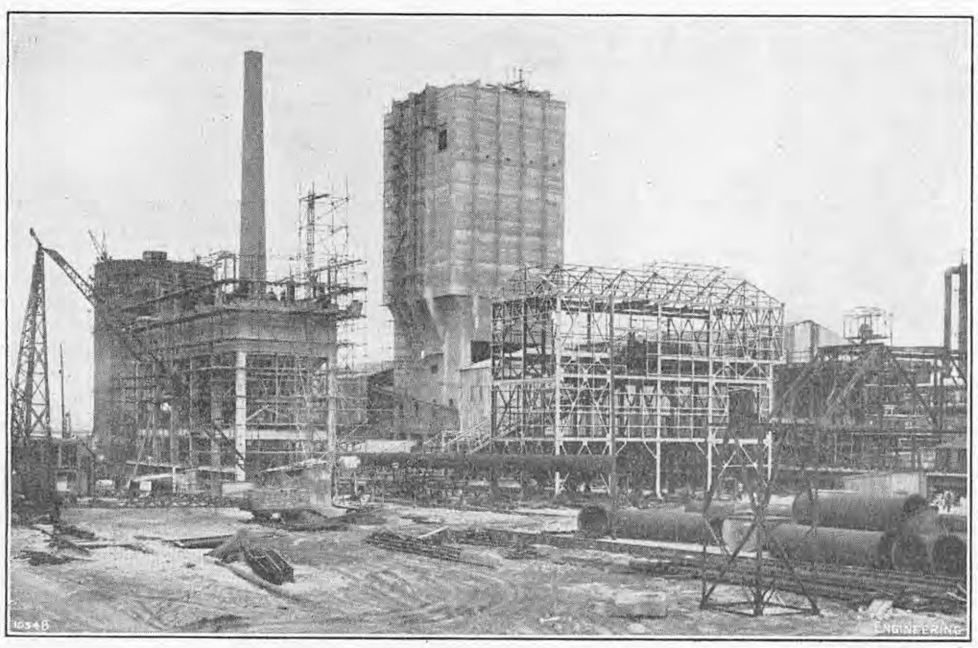


FIG. 2. COKE OVENS.

clarified the law on this, particularly as to the onus of proving a claim for damages. The plaintiff must show first that there was, in fact, a breach of a statutory duty owed to him by the occupier. Having done that successfully, he must then prove, not merely that his injury could have been caused by the breach, but that it was so caused. Further, the danger that caused the injury must be one contemplated by Parliament when imposing the duty. Two cases referred to (Nicholls *v.* Austin, and Carroll *v.* Barclay) illustrate this point.

Any discussion of the question of safety in factories would be incomplete were no reference made to the common law rules dealing with an employer's duty of care for the safety of his employees.* There are inevitably many loopholes in a statutory code of safety, and where these have not been blocked by subsequent judicial decisions, the common law steps in with its three comprehensive rules that an employer is duty bound to provide safe and suitable plant and equipment, a safe place in which to work and a safe system of working. The Factories Acts and regulations made thereunder are merely a particular and carefully codified application of these rules, which have been formulated in the decisions of generations of judges.

* The author has dealt with this in "Safe Systems of Work," *Electrical Review*, vol. cl, page 675 (1952).

BLAST-FURNACE AND STEEL-MELTING PLANT AT SHOTTON.

A BLAST furnace with 16 tuyeres and a hearth 27 ft. in diameter—believed to be the largest outside the United States—is being constructed at the Hawarden Bridge Steelworks of Messrs. John Summers and Sons, Limited, Shotton, near Chester. A new steel-melting shop with eight 150-ton open-hearth furnaces is nearing completion, and the first furnace is expected to be put into service shortly. These developments date from 1939, when hot and cold strip mills, then the second in this country, were installed. It was considered that, if the demand for strip and sheet increased as it was expected to, the steel-melting capacity at Shotton would have to be increased, so that the continuous mills could be operated nearer to their capacity than the existing steelworks would allow. The war held up these plans, but the work was started in 1947.

By this time it was realised that, owing to the shortage of scrap consequent on a general increase in world steel production, it would be necessary to provide for the production of pig-iron at Shotton, in addition to expanding the steel-melting capacity. This extension of the works covers an area of 283 acres, and comprises two batteries of 44 coke ovens each, with the necessary by-product plants; the large blast furnace already mentioned; ore-handling plant; sinter plant; ore-stocking grounds; a power station and blower house combined; and the new melting shop with eight furnaces, but with accommodation for two more furnaces in case, at a later date, they are required. The provision made for stocking coking coal is noteworthy in that it is designed to ensure thorough mixing of the coal before it is delivered to the coke-ovens. The coal will be laid on the stocking ground, and picked up for delivery to the coke-ovens, by a system of conveyors, etc., thereby overcoming to some extent difficulties due to the use of coals that are not of ideal coking quality.

The coke ovens are designed to give an output of about 8,000 tons of coke a week. The blast furnace, assuming the availability of suitable iron ore, is expected to produce 8,000 tons of pig iron a week, and the melting ship between 14,000 tons and 15,000 tons of steel a week—a steel output about 50 per cent. more than that of the two old shops which are to be scrapped. These figures are only estimates, because the outputs of the various units will not be known accurately until the plant has been operating for a while, though there is not likely to be any substantial variation. All eight open-hearth furnaces are expected to be working by January next year; half the coke-oven batteries by the second or third week of October this year, and the remainder by the end of the year; and the blast furnace will probably be blown in about the end of the year. The power station, with a capacity of 25,000 kW, is being brought into use in stages, starting this month.

The present work will cost about 17,000,000*l.* In addition, a second stage of development, costing 5,000,000*l.*, is planned. It provides for another two batteries of 44 coke ovens each, and a second blast furnace of the same size as the present one. Allowing 5,000,000*l.* for the strip-mill in 1939, Messrs. John Summers and Sons will then have a modern integrated plant for producing 1,000,000 tons of steel per annum from the ore at a capital cost of 27,000,000*l.* The extended works is laid out on spacious lines, with almost unlimited room for later expansion. It is founded on marsh-land, which was reclaimed by pumping sand from the estuary of the nearby River Dee. This reclamation work, which was described in ENGINEERING, vol. 165, page 241 (1948), raised the ground level by as much as 37 ft., and the dried sand has proved to be an excellent base for the heavy plant of the steelworks.

15,000-KW GAS TURBINE FOR ELECTRICAL POWER GENERATION.

THE first gas-turbine electrical generating plant to be used by the British Electricity Authority has recently been brought into commission at Trafford power station, Manchester. Built by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, it is of 15,000 kW capacity and operates on an open-compound cycle. The non-electrical components consist of a low-pressure compressor, an air intercooler, a high-pressure compressor, a heat-exchanger, a main combustion-chamber, a high-pressure turbine, a reheat combustion-chamber, and a low-pressure turbine, through which the air and products of combustion flow in the order named. The exhaust from the low-pressure turbine passes back through the heat-exchanger before it discharges into a 250-ft. reinforced-concrete chimney-stack.

The low-pressure turbine, which is directly-coupled to the low-pressure compressor and to the alternator, runs at 3,000 r.p.m., this speed being maintained by a governor which controls the fuel admitted to both combustion chambers. The high-pressure turbine is coupled to the high-pressure compressor. Its speed is determined by the loading, and is 5,500 r.p.m. at full load. The plant is started by means of a 400-h.p. alternating-current motor which is coupled to the high-pressure turbine and compressor shaft, the motor being de-clutched automatically when a sustained speed in the neighbourhood of 3,000 r.p.m. is reached.

Before its admission to the low-pressure compressor, the incoming air passes through an electrostatic filter which removes from it any dust which might impair the efficiency of the compressor blading. Since the gas temperatures at entry to the turbines are high, special care has been taken over the materials for the turbine blades. The latter have been manufactured from alloys consisting mainly of nickel and chromium and containing only minute quantities of iron.

The plant can be started up quickly and is, therefore, particularly suitable for peak-load and emergency duty. It is also smaller than equivalent steam plant and has a comparable thermal efficiency. At present, gas oil is being used as the fuel, but it is hoped to modify the plant later to use heavier oils.

LABOUR NOTES.

DIFFICULTIES respecting wage claims have overshadowed all other aspects of the industrial field during the past week. The dominant question has been the action to be taken by the trade unions concerned following the rejection by the employers' Federations of the claims made on behalf of adult male manual employees in the engineering and shipbuilding and ship-repairing industries. It may be recalled that the claim of the engineering employees for an extra 40*s.* a week all round was refused outright by the Engineering and Allied Employers' National Federation on July 31, and that the demands of the shipyard employees for a "substantial" advance was similarly turned down by the Shipbuilding Employers' Federation on August 6.

After a private meeting of the executive council of the Confederation of Shipbuilding and Engineering Unions at York on August 7, it was announced that the leaders of the Confederation had discussed the issue only very briefly and had decided to defer consideration of the whole matter until the opening of the Confederation's annual conference at Southsea on Tuesday last. Some differences of opinion, however, appear to have been shown by members of the council at the meeting on August 7. Mr. Jack Tanner, the President of the Amalgamated Engineering Union and a member of the executive council, was stated to have expressed strong doubts as whether the claim for an extra 40*s.* a week all round could be sustained. At a further meeting of the executive council on Monday last at Southsea, on the eve of the annual conference, it was eventually decided to recommend the conference to accept, as a matter of urgency, an emergency resolution, the details of which were not then publicly disclosed.

The terms of the emergency resolution were made known at the opening of the full conference on Tuesday. An official announcement issued then stated that the executive council had carefully considered the situation arising from the total rejection of the Confederation's claims by the Engineering and Allied Employers' National Federation, the Shipbuilding Employers' Federation and the Railway Executive, and declared its profound dissatisfaction with those refusals. The council therefore recommended the conference to authorise it to seek immediate meetings with the respective employers' organisations to inform them of the serious situation which existed. It was added that the council had arranged to call a special conference of executive committees of affiliated unions at York on September 10. This resolution was debated by the full conference on Wednesday, when it was unanimously approved, but only after several delegates had given different interpretations of what its terms implied.

Earlier, at meetings of individual unions, proposals for strike action had been put forward. The Electrical Trades Union held a delegate meeting at York on August 8 which was attended by 49 shop stewards from the main engineering and shipbuilding centres and a resolution was approved instructing the union's delegates to the Confederation conference to support any move for strike action. This resolution was later endorsed by the union's executive committee. The United Society of Boilermakers and the Amalgamated Union of Foundry Workers were also stated to favour strike action. Delegates at a special meeting of the national committee of the Amalgamated Engineering Union, on Saturday last, decided to ask the Confederation to hold a ballot among the members of its 38 affiliated unions on the alternatives of whether they favoured strike action or a national ban on overtime and piecework to enforce the wage claims. The national committee rejected, by four votes, a proposal that the rejected claims should be submitted to the Industrial Disputes Tribunal for arbitration.

Returns issued by the Ministry of Labour and National Service on August 8 show that the number of unemployed persons in Great Britain registered for work on July 14 was 393,464, compared with 440,100 on June 16, a decrease by 46,636 in four weeks. The July figure represented 1·9 per cent. of the estimated total number of persons in employment, compared with 2·1 per cent. in June and 0·9 per cent. in July, 1951. Of the total of 393,464 persons unemployed on July 14 last, 202,085 were men aged 18 and over, 7,853 boys less than 18 years old, 170,868 women aged 18 and over, and 12,658 girls less than 18 years old.

The Ministry estimates that there were then 101,077 persons temporarily disengaged and 292,387 wholly unemployed. Of the latter figure, 132,325 persons (80,580 men and boys, and 51,745 women and girls) had been out of work for more than eight weeks. Of the remainder, 77,020 persons had been unemployed for periods of from over two weeks to not more than eight weeks. Just over 83,000 men, women and juveniles had been disengaged for periods varying from one day to not more than two weeks. The total number of unemployed persons on July 14 included 86,216 married women.

There was a decrease of some 47,000 persons in the total working population of Great Britain during June last, of whom about 32,000 were men and boys and about 15,000 were women and girls. At the end of that month, the number of persons, aged 15 and over, who were working for pay or gain in Great Britain, or who had registered themselves as available for such work, numbered 23,436,000, of whom 16,023,000 were men and boys, and 7,413,000 women and girls. The total number comprises persons in the Forces, men and women on release leave not yet in employment, the registered unemployed, and all persons in civil employment, including employers and persons working on their own account as well as employees. Private indoor domestic servants and gainfully-occupied people over pensionable age are also included. Part-time employees are counted as full units.

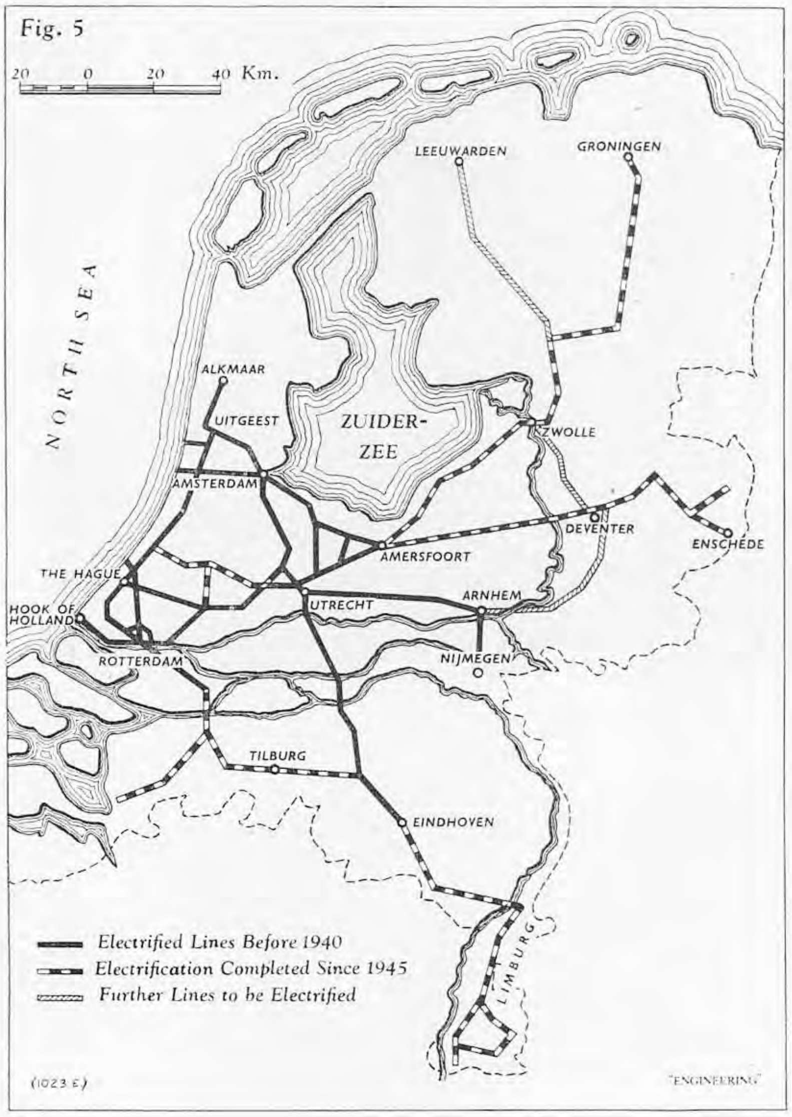
Of the total working population at the end of June, some 22,141,000 persons (14,950,000 men and boys and 7,191,000 women and girls) were engaged in civil employment, including industry, commerce and services of all kinds, a decrease by 11,000 on the total for the end of May. The size of the armed Forces rose by 1,000 during June, to an end-of-the-month total of 872,000, and there were 8,000 ex-Service men and women on release leave seeking work at the end of the month. The remainder of the working population on June 30, 415,000 persons, were registered as unemployed.

There was an increase of 14,000 during June in the number of persons employed in the basic industries, which comprise mining, quarrying, agriculture, fishing, and the gas, electricity, water, transport and communications services. The total number employed in this group of industries and services at the end of that month amounted to 4,145,000. In the manufacturing group, however, there was a decrease of 52,000 in the total number of persons employed at the end of the month. There were 18,000 fewer men and women engaged in the engineering, metal-goods and precision-instrument industries, thereby reducing the number of persons employed in these industries to 2,570,000. In the textile industry, there was a decline of 20,000 in the number of employees, bringing the end-of-the-month total to 883,000.

A decline of 8,000 took place in the clothing industry, which, at the end of June, employed 667,000 persons. Employees in the chemical and allied industries decreased by 3,000, to 481,000. In the metal-manufacture and vehicle-building industries, numbers declined slightly, to 556,000 and 1,080,000, respectively. In the food, drink and tobacco industry, there was an increase by 18,000, to an end-of-month total of 861,000, but the other, manufacturing industries lost 20,000 employees thereby reducing the end-of-month total to 1,473,000. In all, some 8,571,000 persons were at work in the manufacturing group of industries at the end of June. At the same date, there were, 9,425,000 persons engaged in building and contracting, the distributive trades, professional and financial services, and public administration.

FIXED AND MOBILE RECTIFIER SUBSTATIONS; NETHERLANDS RAILWAYS.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.



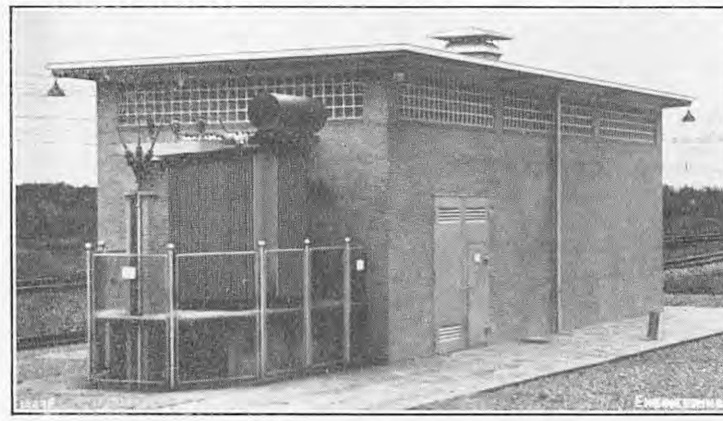


FIG. 6. EXTERIOR OF FIXED SUBSTATION.

FIG. 7. ELECTRONIC ARC-SUPPRESSION EQUIPMENT.

FIXED AND MOBILE RECTIFIER SUBSTATIONS ON THE NETHERLANDS RAILWAYS.

ELECTRIC traction was first utilised on the Netherlands State Railways in 1908, when the line connecting Rotterdam with The Hague and Scheveningen was converted on the 10-kV 25-cycle single-phase system. Ten years later the line from Rotterdam to Amsterdam was also converted, the 1,500-volt direct-current system being used on the grounds of the greater reliability of the motors. Between that time and 1934, a number of other lines connecting with the Rotterdam-Amsterdam section were converted, while in 1938 the Hague-Rotterdam-Utrecht-Arnhem and the Amsterdam-Utrecht-Eindhoven lines were electrified, as shown in the map reproduced in Fig. 5. All these lines were operated with direct current at 1,500 volts.

In 1944, the Netherlands railways system was pillaged by the Germans. In fact, of the 36 substations only seven were not entirely stripped, while only 11 of the 71 rectifier sets remained; two mobile rectifier cars had disappeared. After the end of the war, considerable restoration was, therefore, necessary and was energetically undertaken. Further schemes of electrification were also put in hand. These included the line from Eindhoven into the coal-mining district of Limburg and the lines from Amersfoort via Deventer to Enschede and from Amersfoort to Leeuwarden and Groningen via Zwolle. At present, some 912 miles of double track are electrically operated, 530 miles of which have been converted since 1949. The line from Zwolle to Arnhem via Deventer is also to be converted, as indicated in Fig. 5.

Power for operating these lines is obtained from the main Dutch 150-kV three-phase system, which not only interconnects the country's own generating stations, but is tied to the German and Swiss networks. It is transformed for traction purposes to either 25 kV or 10 kV, and is then converted to 1,500-volt direct current in rectifier substations, which are spaced at roughly six-mile intervals along the track. Before the war these substations each contained one or more 1,800-kW transformers with six-phase secondaries, from which a supply was given to a corresponding number of 1,200-kW water-cooled rectifiers. These rectifiers were capable of withstanding an overload of 150 per cent. for two hours and of carrying a peak load of 4,000 amperes lasting 10 seconds every 10 minutes. They were fitted with the usual auxiliaries and arc-suppression devices, and on the direct-current side were controlled by reverse-current high-speed circuit-breakers. The aggregate rectifier capacity was sufficient to provide an ample safeguard against breakdown.

The introduction of the air-cooled pumpless rectifier, however, made it possible to reduce the spare plant capacity and a contract for supplying equipment of this type for installation in 16 fixed substations was therefore placed with the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, in 1947. Since then two further fixed substations have been equipped with the same type of plant. In addition, four mobile rectifier substations have been supplied by the same firm to take the place of units which are out of commission for maintenance or to supply a load which is temporarily in excess of the capacity of the fixed plant. The total capacity of these new rectifiers is over 26 MW.

The adoption of air-cooled pumpless rectifiers for the new substations made it possible to use two, instead of one, rectifier per transformer, and this raised the question whether it would not be advisable to employ 12-phase rectification. This would have had the advantage that the transformer could have been built with twice the amount of reactance for the same regulation, thus halving the fault current. This, in turn, would have made for simplification, since arc suppression and therefore control grids in the rectifiers would have been unnecessary. Moreover, it would have been possible to eliminate the fifth and seventh harmonics on the alternating-current side of the rectifier and the 300- and 600-cycle voltage ripple on the direct-current side. As, however, a number of the original six-phase double-secondary transformers were recovered from the Germans and were again available for use in the fixed substations, it was decided to retain the six-phase system and to employ twin-cylinder rectifiers with arc suppression in the fixed substations. In the mobile substations, on the other hand, twelve-phase rectification was used for the sake of simplicity and reliability. In both cases, the new rectifiers are of the pumpless air-cooled steel-tank type. It may be added that this policy has proved satisfactory in practice, as is shown by tests, of which some details are given below.

A view of a typical fixed substation from the transformer end is given in Fig. 6. Owing to the nature of the ground, the buildings are constructed on concrete rafts, while a second similar raft carries the transformer. Both rafts are supported on 12 hollow-concrete piles. Flat roofs are generally standard and the larger buildings have three equally-spaced ventilators for the outlet air. The inlet air is drawn in through louvred doors at each end of the longer walls. Both single-unit and double-unit substations have been built, the latter

FIXED AND MOBILE RECTIFIER SUBSTATIONS: NETHERLANDS RAILWAYS.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

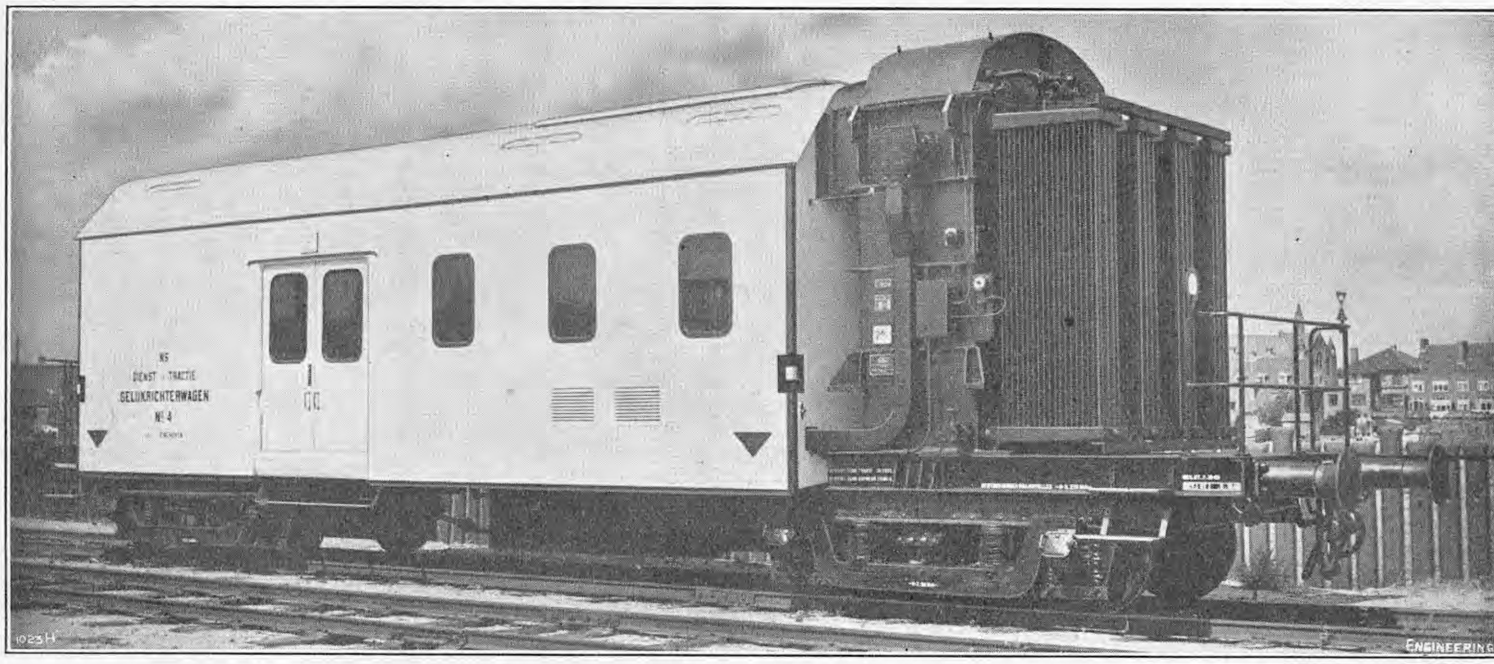


FIG. 8. 1,224-KW 1,530-VOLT MOBILE SUBSTATION.

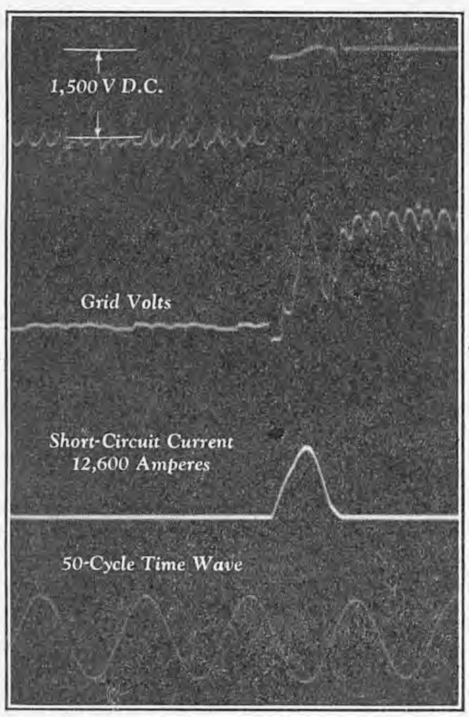
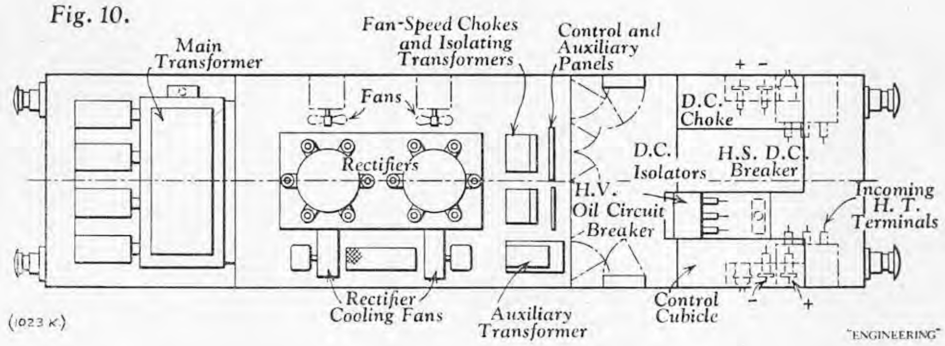


FIG. 9. OSCILLOGRAM SHOWING OPERATION OF ARC-SUPPRESSION GEAR

Fig. 10.



being about 80 ft. long by 14 ft. 8 in. wide by 18 ft. high, thus providing a spacious enclosure with ample room for air circulation.

The interior of the fixed substation at Ryssen is illustrated in Fig. 2, on page 208. The equipment consists of one or two 1,800-kW transformers, which, in South Holland, are usually connected star/star, although in the area north-west of Amsterdam a delta/star connection is also employed. Tappings at plus and minus 2 per cent. and 4 per cent. are provided. The transformers are designed for six-phase rectification using interphase transformers, and are double wound to give two circuits on the low-tension side. Two air-cooled rectifiers are provided for each transformer and these operate as a six-phase unit. An auxiliary transformer, operated from the same supply as the main transformer, is installed to supply the rectifier auxiliaries and control gear, as there are no tertiary windings on the main transformer. The rectifiers are each rated at 1,224 kW and supply direct current at 1,530 volts. They have an overload capacity of 150 per cent. for two hours during which period a series of further overload peaks, including two of 4,000 amperes for one minute, can be sustained. They are designed for a regulation of 2·7 per cent. and are provided with control grids for fault protection by means of arc suppression.

As shown in Fig. 1, on page 208, the rectifiers are mounted on withdrawable trucks and are housed in sheet-steel cubicles of brake-press construction, the sheet-metal parts being flanged over to provide a rigid structure. Between each pair of rectifiers is a panel on which two main and two auxiliary ammeters are mounted to indicate the output from each cylinder and the currents in the auxiliary anode circuits. The motors on the fans used for cooling the rectifiers are equipped with saturable chokes, so that their supply voltage, and therefore their speed, are varied with the rectifier load.

The arc-suppression equipment, of which mention has already been made, is electronically controlled and is therefore practically instantaneous in action. The operation of this equipment is based on the fact that when a negatively-biased grid is placed in the arc path close to the rectifier anode, there will be no conducting path to the latter as long as the arc has not been established. An arc cannot, therefore, be transferred from one anode to the next and is extinguished when the current falls to zero. On the Dutch rectifiers, each anode is normally made conducting by giving the grid a sinusoidal bias, the positive half-cycle of which occurs at the correct time. The supply for this bias is obtained from the main three-phase auxiliary transformer through phase-adjusting transformers and a special six-phase sine-wave transformer. A suitable amount of excess negative bias, which is obtained from a metal-oxide rectifier, is also superimposed upon the sinusoidal bias, thus making all the grids strongly negative. As a result, the anodes are prevented from becoming conducting and arc suppression is ensured.

This arc suppression is actually effected on the triple-frequency tripping system devised by the General Electric Company, in which a 150-cycle signal, derived from current transformers on the alternating-current side of the rectifier, is increased in the event of a fault or excessive overload current flowing. The result is that the grids of "biased off" thyratrons are energised and cause excess negative bias to be applied to the control grids of the rectifiers. As the 150-cycle signal operates in both half waves, the maximum delay, in terms of the 50-cycle supply, which can arise in the application of arc suppression is half a cycle. Means are provided in the electronic circuit so that the rectifier is locked out if the protective gear is called upon to operate an excessive number of times in quick succession. A time-delay unit is also included to retard the operation of the auto-close relay for a suitable period after the "on" signal has been given; and thus to provide time for the thyratrons to heat up. The re-set lockout and other relays incorporated with the arc-suppression gear are illustrated in Fig. 7, page 217. Tests under no-load and short-circuit conditions and with fault currents exceeding 13,000 amperes were made on this arc-suppression gear before it left the works. Fig. 9 is a typical oscillogram of the results obtained and shows the removal of the 1,500-volt direct-current from the line when the negative bias produced by the short-circuit current is applied. This negative bias is also applied when a station is shut down to prevent unnecessary wear on the contacts of the oil circuit-breakers.

Interlocks are provided to prevent the oil switch being closed before the arc-suppression gear, the cooling-fan motors and the excitation circuit come

FIXED AND MOBILE RECTIFIER SUBSTATIONS; NETHERLANDS RAILWAYS.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

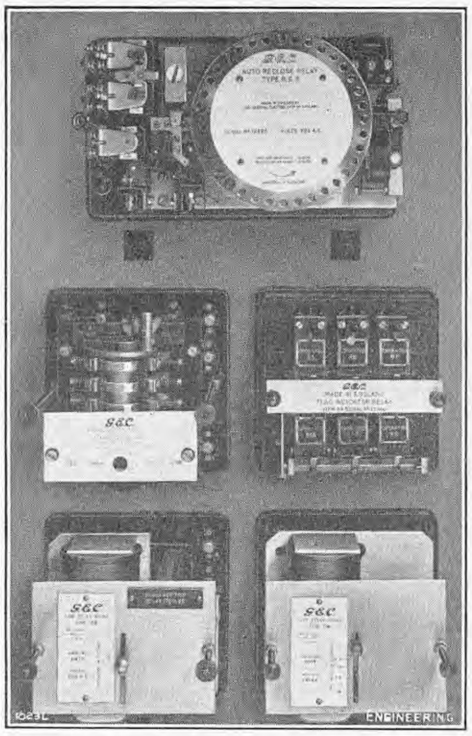


FIG. 11. CONTROL PANEL.

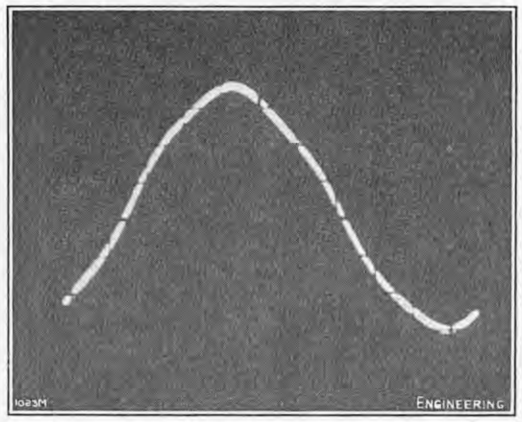


FIG. 12. 10-KV VOLTAGE WAVE FORM BEFORE 7.25 P.M.

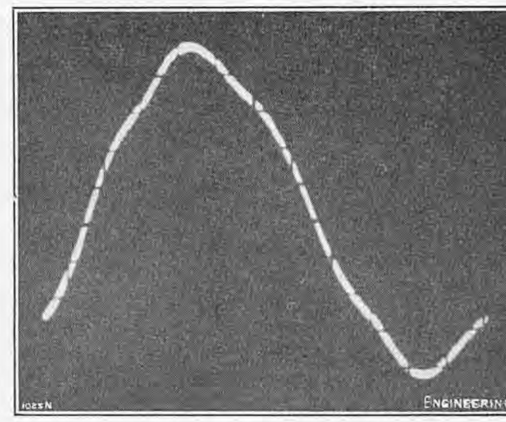
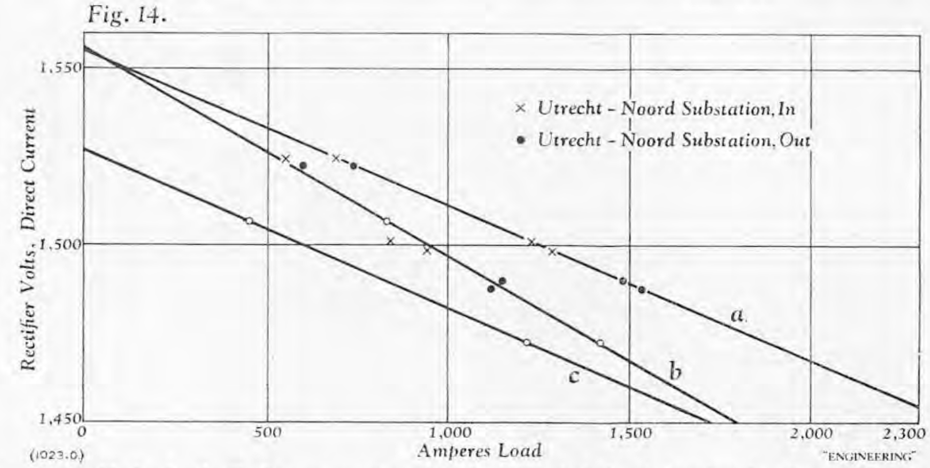


FIG. 13. 10-KV VOLTAGE WAVE FORM AFTER 7.25 P.M.

Fig. 14.



into operation. The equipment is also automatically locked out if three unsuccessful attempts to start are made or if the transformer temperature becomes excessive, as well as if the Buchholz relays operate, the voltage on the arc-suppression gear fails, or that gear operates repeatedly; failure of the supply to the heater circuit of the valve in the arc-suppression gear and the operation of the overload relay of the cooling-fan motor also cause locking out. In addition, the breakers are tripped and the auto-reclose relays operate if an overload occurs on the alternating-current side, the current on the direct-current side reverses, or the excitation fails.

An exterior view of a mobile substation is given in Fig. 8, opposite. The vehicle used is of the flush-deck type, which has enabled the layout shown in Fig. 10 to be adopted. As will be seen, the transformer is mounted transversely above the bogie at one end, while the rectifier cylinders are arranged in line along the longitudinal axis. The rectifiers are housed in a ventilated compartment to which access is gained through doors leading from the control compartment. The switchgear compartments contain the extra high-tension oil circuit-breaker, the main choke, the high-speed circuit-breaker, and the control cubicle. Access to the operating platform, of which a view is given in Fig. 3, on page 208, is by steps on the side of the vehicle. Connection to both the extra high-tension and to the direct-current circuits can be made on either side, depending on conditions at the site. The extra high-tension terminals are arranged horizontally at roof level and the direct-current terminals and plug sockets in recesses at floor level. Connection to the fixed substation, with which the mobile substation is working in parallel, is made by flexible tough rubber-insulated cables, which are used for both the alternating and direct-current circuits. There is an isolating switch in each fixed substation for controlling the 10-kV connection to the mobile substation.

To maintain the proper working temperature in the rectifier compartment during the extremely cold weather to which the plant may be subjected, the inlets to the rectifier fans are provided with thermostatically-controlled heating elements, while four extractor fans, arranged in pairs on the sides above and in line with each rectifier cylinder, are provided to meet summer operating conditions. The operation of these fans is also controlled by thermostats.

The equipment of a mobile substation which was installed in the vehicles at one of the maintenance depots of the Netherlands Railways, consists of a 1,800-kW/10-kV/1,530-volt 12-phase transformer of the oil-immersed naturally-cooled outdoor type. This transformer is provided with tappings on the primary side to give a voltage adjustment of ± 2 per cent., the corresponding range on the secondary side being ± 4 per cent. Detachable radiators are arranged on one side with a conservator on top. The secondary winding is of the usual type, 12-phase operation being secured by inter-phase connection. The various auxiliaries are supplied from a tertiary winding and Buchholz protection is provided.

By designing the transformer for an output of 1,800 kW, it has been possible to obtain a voltage regulation of 2·7 per cent. between no load and full load. An interesting contrast is therefore provided with the practice of designing the transformer with a lower nominal output than that of the rectifiers on the grounds that, while the latter have a high overload capacity for a short time, the transformers, owing to their higher thermal capacity, need only be designed on the basis of the root-mean-square rating of the whole substation taken over several hours. A fairly steep regulation for traction rectifiers is also sometimes advocated to improve load sharing between adjacent substations and to provide a high reactance which will limit possible fault currents.

The rectifier cylinders are of the air-cooled steel tank pumpless type and embody the General Electric's vitric seal for supporting the anodes in the usual side-arm construction. The ignition is of the standard floating-cup type, in which the cup is drawn below the surface of the mercury to break a circuit and to cause an arc to be drawn from a fixed rod supported axially within the rectifier. The usual auxiliary anodes are provided in stub arms to maintain the cathode spot under no-load conditions. As shown in Fig. 4, on page 208, the rectifier is mounted resiliently on a triangular angle-iron frame, which is integral with its plinth and the latter forms a chamber into which air is blown for cooling purposes.

On the incoming side, the supply is controlled by a metal-clad air-insulated oil-switch unit with vertical isolation. This switch embodies a triple-pole solenoid-operated circuit-breaker with a rupturing capacity of 250 MVA, which is fitted with two quick-acting overload trips and an overload relay with a fixed time-lag that is set at a lower value. The direct-current switchgear consists of a 2,000-ampere single-pole air-break high-speed circuit-breaker, which is mounted on the floor and is electrically operated and arranged for high-speed reverse-current tripping. The control gear is designed for remote operation so that the substation can be left unattended. The apparatus used for this purpose is shown in Fig. 11, and consists of an auto-close relay, which is operated by the incoming "on" signal and closes the alternating-current circuit-breaker. Subsequently, ignition, excitation and closing of the high-speed direct-current circuit-breaker follow automatically. If, for some reason, the high-speed circuit-breaker does not close, the relay operates up to three times at 15-second intervals before finally locking-out the station. Locking-out also occurs if the cooling-fan motor fails or the Buchholz relay operates, as well as in the case of excessive transformer temperature or earth leakage. The lock-out relay can only be reset by hand on site. If reverse-current or alternating-current overload occurs or the excitation fails, the circuit-breakers are tripped and the auto-reclose relay operates and restarts the station.

After the combined equipment for each mobile rectifier substation had been subjected to load runs and short-circuit tests at the Witton Works of the General Electric Company, it was shipped to Holland and re-erected on a standard vehicle of the Netherlands Railways. It was then used to calibrate the track-feeder overload relays on a new line, where overload "kicks" up to 10,000 amperes occurred without any basic load, and to investigate certain technical problems which had arisen owing to the nature of the power network in Holland and the existence of a large six-phase rectifier load. For example, while perfect load-sharing between the rectifier cylinders occurred at Utrecht, in the centre of the country, under all conditions of load, at

Tilburg, in the south, the same equipment showed a tendency to slight unbalance between the two rectifiers, this unbalance being in one direction at one time of day and in the opposite direction at other times. Oscillograph investigations showed that this condition was caused by a pronounced change in the alternating wave-forms, a change due to the behaviour of the fifth harmonic, the amplitude of which was accentuated by the star/star connection of the power transformers on the network. In addition, a change in the phase occurred about 7 p.m. each evening. The wave-form before 7.25 p.m. is shown in Fig. 12 and that afterwards in Fig. 13. Attempts were made without success to discover the origin of this phenomenon, but it is thought possible that it might be due to conditions in Germany or Switzerland, to both of which countries the main transmission line is connected. The difficulty was eventually overcome by rearranging the rectifier connections so as to give perfect balance at all loads independently of the behaviour of the fifth harmonic.

Tests were also made at Uitgeest to investigate the parallel running of one of the mobile substations with the six-phase fixed substation on the same site. It was found that load sharing between the two substations was relatively good, the fixed equipment carrying a load of 600 amperes when there was a current of 950 amperes on the mobile unit. A more comprehensive test was made at Blauwkapel to determine the load sharing between the mobile equipment and the local fixed equipments, and to discover whether this was affected by the parallel working of the fixed equipment at Utrecht Noord station. Owing to the difficulty of obtaining steady measurements under actual running conditions, the tests were carried out under static-loading conditions. This was done by temporarily short-circuiting the overhead line a considerable distance from the substation, so as to provide a current path with a resistance of about 1 ohm. A number of tests were made with the mobile substation and the local fixed substation each working alone and then both in parallel with and without the station at Utrecht Noord sharing the load. The results of these tests are given in Fig. 14, page 219, where curve *a* shows the regulation of the mobile substation, curve *b* the regulation of the fixed substation, and curve *c* that of the mobile substation with its transformer on a higher tapping, that is, using a greater number of primary turns to give a lower direct-current output voltage.

It was found that the influence of the Utrecht Noord substation was very slight, but that the difference between the regulation of the mobile substation and that of the fixed substation was greater than could be accounted for purely on the basis of six-phase and twelve-phase operation. The difference in load caused by this discrepancy in regulation was not, however, large enough to necessitate any special measures being taken although, as is clear from curve *c*, when heavy overloads are expected the mobile transformer could be placed on a higher primary tapping so as to ensure perfect load sharing of a total load of about 4,000 amperes. As a result of these experiments, it was decided to increase the regulation of the second pair of mobile equipments to 4·5 per cent. and thus to improve their load-sharing properties. In fact, the parallel operation of the six-phase and twelve-phase rectifiers has proved satisfactory in practice and has provided a large-scale verification of the theory of rectifier operation under these conditions.

Production Management Course.—An intensive residential course for senior executives of small firms engaged in engineering and general production has been arranged jointly by the British Institute of Management and the Institution of Production Engineers. Subjects to be dealt with during the course will include the administration and servicing of Government contracts, material supply and control, production management, quality and inspection requirements and organisation, and the management of personnel. The course will be held at the College of Aeronautics, Cranfield, Buckinghamshire, commencing on Sunday afternoon, September 21, and continuing until Saturday morning, September 27, 1952. The fee, including full board and accommodation, will be 20*l*. Application forms may be obtained from the course secretary, Institution of Production Engineers, 36, Portman-square, London, W.1.

CUT-OFF DEVICE FOR GAS-FIRED BOILERS.

THOMAS DE LA RUE AND COMPANY, LIMITED, LONDON.

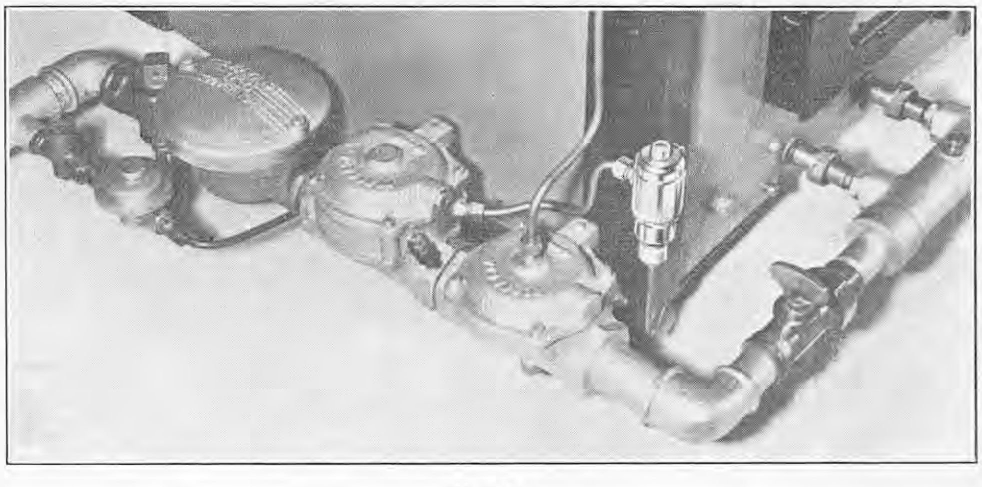
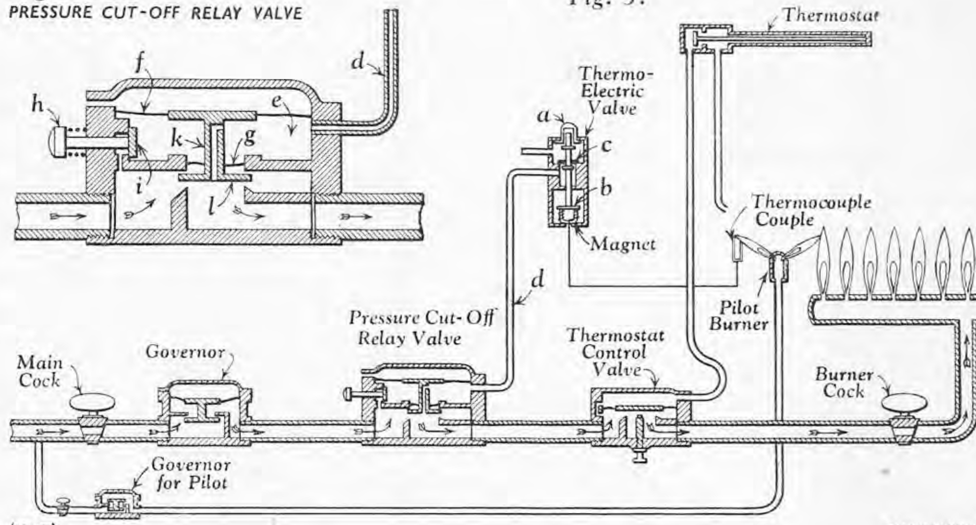


Fig. 1.

Fig. 2. ENLARGED VIEW OF PRESSURE CUT-OFF RELAY VALVE

Fig. 3.



SAFETY CUT-OFF DEVICE FOR GAS-FIRED BOILERS.

To overcome certain shortcomings experienced with the flame-failure devices most commonly used with their Rex series of Potterton gas-fired boilers, the Gas Group of Thomas de la Rue and Company, Limited, Imperial House, 84-86, Regent-street, London, W.1, have introduced a new form of flame-failure and pressure cut-off device. The main drawback of previous devices of this type was that certain failures, such as a leak in the relief line from the control valve or a blockage of the control valve orifice, did not shut off the gas supply to the main burners. Furthermore, explosions could be caused by a brief shut-down of the gas supply or use of the incorrect lighting sequence. With the new safety control, however, these disadvantages are obviated as all orifices likely to become choked are eliminated and any failures such as a severe drop in the gas-supply pressure causes the valve to close to safety, it being impossible for gas to reach the burners.

The new safety control is known as the Perfecta combined flame-failure and pressure cut-off double-duty device. It consists of a permanent pilot light, a thermocouple and a thermo-electric valve arranged to operate a reversed-action relay valve. A typical installation is illustrated in Fig. 1, where the relay valve is shown installed between a standard constant-pressure governor on the left and a thermostat control valve on the right with the thermo-electric valve above, and to the right of, the thermostat control valve. This installation is shown diagrammatically in Fig. 3, and a drawing showing the relay valve to a larger scale is given in Fig. 2. The method of operation can best be described by referring to the lighting sequence, the first operation of which is the closing of the burner cock; this allows the gas pressure to build up in the system as a result of later operations. The pilot jet is then ignited, the flame from which plays on, and produces an electromotive force in, the thermocouple, thus energising the magnet of the thermo-electric valve. The button *a* of this valve is then depressed momentarily by hand; this brings the plate *b* into contact with the magnet, and the valve *c*, as a consequence, is held on its seating. This closes the relief line *d* and prevents the escape of gas from the upper chamber *e* of the relay valve through the thermo-electric valve. It will be noted from Fig. 2 that this chamber is isolated from the atmosphere by the diaphragm *f* and from the lower chamber by the diaphragm *g*.

Once the relief line *d* is closed, the reset button *h* at the side of the relay valve is depressed by hand for 10 seconds, thus allowing gas to enter the upper chamber *e* through the valve *i*, the gas subsequently passing down the hollow valve spindle *k* and filling the system as far as the burner cock. The gas, of course, is at mains pressure and this is sufficient to lift the main valve *l* from its seat by acting on the underside of the diaphragm *f*. It only remains now to open the burner cock for the main burners to be ignited from the pilot light.

It will be appreciated from the foregoing that gas at mains pressure must be admitted to the chamber *e* of the relay valve before the main valve *l* can be raised from its seat: the correct lighting sequence must, therefore, be adhered to at all times, for, unless the thermo-electric valve and burner cock are closed, it is impossible for this pressure to be built up. Furthermore, once the chamber *e* is exhausted to atmosphere, or the pressure falls to a predetermined value, the valve *l* closes and automatically shuts off the gas to the burners, and it is this attribute that forms the safety feature of the device. It will, in fact, shut off the gas at the burners if the pilot flame is extinguished or the thermocouple fails; if the main gas-cock is turned off momentarily or the gas pressure falls below 1-in. water gauge; and if a leak develops in the relief line *d*. In the event of a flame failure, the thermocouple cools and the magnet, as a consequence, is de-energised. A light spring then lifts the valve *c* from its seat, and the chamber *e*, as a result, is vented to atmosphere through the relief line *d*, the subsequent loss of pressure under the diaphragm *f* causing the valve *l* to close and shut off the gas. If, on the other hand, the pressure of the gas supply falls below 1-in. water gauge, the pressure inside the chamber *e* is relieved through the hollow valve spindle *k* a sufficient amount to cause the valve *l* to close. In the case of a flame failure, it takes approximately 30 seconds for the device to operate, but in the event of a mains failure, the response is almost instantaneous. It will be realised that the device not only shuts off the gas in the event of a mains failure but prevents the gas automatically being available at the burners with restoration of the mains pressure, as, once the valve *l* has closed, the burner cock must be closed and the correct lighting procedure repeated before gas can be re-established at the burners.

SUPER-ELEVATION OF RAILWAY TRACK CURVES.

Until recently, the amount of super-elevation, or cant, and the rate of build-up of super-elevation that could be applied to railway track have been the subject of varying opinions among different authorities and engineers. In order to correlate opinion, experience and ordered observation, the problem has been studied at length by the Track Committee of British Railways. A full account of their researches and a statement of their recommendations, on which future practice of British Railways will be based, has been given in a paper entitled "Recent Developments in Railway Curve Design," by Mr. J. C. Loach, M.Sc.(Eng.), A.M.I.C.E., and Mr. M. G. Maycock, B.Sc.(Eng.), A.M.I.C.E., presented to the Institution of Civil Engineers and to be published in the *Journal* (Part II) for October, 1952. The recommendations of the Committee are also given in an instruction manual, entitled "Railway Curves," that has been circulated to the staffs of the civil engineering departments of the railways.

In order that a vehicle should change its direction of motion, a sideways force must be applied to the vehicle, and the magnitude of the required force will depend on the forward speed of the vehicle and on the radius of curvature of the track being followed. In the interests of the safety and comfort of passengers, it has been found necessary to provide an opposing reaction by canting the vehicle until the horizontal component of the normal reaction between the wheels and the track balances the centrifugal force; under these conditions, the weight of the vehicle is equally shared between the two rails. In order to simplify the design of track alignment, it has been standard practice to sub-divide the track into sections of straights and of circular curves; the former require no cant, but the latter require an amount of cant that is dependent on the radius of the curve and on a selected speed representing the mean speed of all trains operating over that section of the track. Since, in conjunction with the radius of the curve, the cant could only be provided in relation to one particular speed, termed the equilibrium speed, trains travelling at some other speed will be subject to a condition of cant deficiency or excess. Between the straight track and the circular curve a transition curve has to be provided in which the cant is built-up from zero to that of the circular curve. The standard form of the transition curve has been a cubic parabola, that being a curve in which the curvature is nearly proportional to the distance from the origin, at which point the radius of curvature is made infinite to correspond to that on the straight and, at the junction between the circular curve and the transition, the radius of curvature is made equal to the radius of the circular curve. Since the curvature of the transition is directly proportional to the distance from the origin, and the cant required on the track is proportional to the curvature, it necessarily follows that the cant has to be applied at a uniform rate along the length of the transition curve.

The problems before the Track Committee were to decide and fix limits for the following factors: the maximum cant that could be applied to a track; the maximum cant defficiency that could be tolerated; the maximum rates of gain and loss of cant and of cant defficiency that could be accepted without passengers experiencing discomforture; and the maximum cant gradient that would not cause vehicles to climb the rail and so be derailed. The Committee also gave thought to the factors involved in the choice of the particular equilibrium speed for any section of the track, and considered the implications of crossings and turnouts and the means of applying cant through them.

Practice had long put the maximum permissible cant at 6 in. and this figure was accepted for future practice. Track maintenance became excessive above $4\frac{1}{2}$ in., the track tending to slew under traffic and constant packing of the ballast then being necessary. Furthermore, at cants greater than 6 in. the stability of high unloaded vans that were standing is reduced to an undesirable degree; and when moving off the leading wheels may climb the rail and so lead to a derailment.

It was known that the too rapid application of cant, or the existence of too great a cant deficiency caused discomforture to passengers, but opinions differed considerably as to the limits that could be accepted. In order to gain first-hand information and to make precise observation on these points, a series of test runs at different speeds were made over a prepared length of track, when the observers recorded the sensations felt, according to an agreed code, at indicated points in the journey coinciding with the critical points along the route. The route chosen for the tests was in North Wales and, in the $9\frac{1}{2}$ miles, there were 52 curves with radii varying between 9 and 80 chains; the first 14 of the curves were carefully set out and the super-elevation applied for an equilibrium speed of 30 m.p.h. From an analysis of the returns made by the observers the Committee concluded that a cant deficiency of $3\frac{1}{2}$ in. could be tolerated on first-class tracks, but that this figure should be reduced to $2\frac{1}{2}$ in. on all other tracks, and through all junction work. The Committee recommended, however, that, where cant was applied, the permissible cant deficiency should be reduced by a quarter of the applied cant, thereby making an allowance for the greater influence of track imperfections at high speeds. The maximum permissible rate of gain, or loss, of cant and cant deficiency was also determined from the observations made on the test journeys and a figure of $2\frac{1}{4}$ in. per second adopted, corresponding to a sensation designated "noticeable." The Committee noted that the foregoing limits could be used with confidence and without modification for track deterioration or allowance for faulty judgment of speed by the driver; it was pointed out, however, that the figures were maxima, and designs should be made to easier conditions wherever possible.

The papers continued by noting that, if the rate of gain of cant was expressed as inches of cant per second, the travelling speed of the train was involved; if the selected equilibrium speed was low, then a steep cant gradient could be provided that was within the stipulated rate of gain of $2\frac{1}{4}$ in. per second. The tendency for the leading wheel of a wagon to climb the rail depended upon the ratio of the flange force P, to the wheel load W; P was dependent upon the speed, the curvature of the track and the cant deficiency, while W would be dependent on the twisting effects of the load distribution and on the stiffness of the wagon frame. From tests made to investigate this point the Committee decided that an overruling limit to the rate of gain of cant should be applied by restricting the maximum permissible cant gradient to 1 in 300.

No precise rules could be given for choosing the equilibrium speed from which the required cant could be calculated for a given track radius. Where traffic was of one type, travelling at about the same speed, the equilibrium cant should be provided to suit this speed. Where the traffic was mixed the cant should be arranged to suit the mean speed of the ordinary express train, but, after making the allowance for cant deficiency, no speed restriction should be imposed on the fastest train. It might also be necessary to restrict the cant on lines chiefly used by slow freight traffic so as to avoid excessive wear on the low rail. The permissible cant that could be applied might also be restricted by the existence of limited clearances, or it might not be possible to provide the necessary length of transition curve, which would also limit the amount of cant that could be applied. Where the limitations were such that the required amount of cant could not be applied, the design problem was reversed and became one of assessing the maximum speed for the track-work to be constructed.

Compound curves, i.e., two successive circular curves of like hand but of differing radius and without an intervening straight, should be joined directly by a transition curve in which the cant is suitably modified. For reverse curves, the committee recommended that each curve should be completed by a transition curve at each end and further advocated that the introduction of a short length of straight between the transitions was to be avoided, experience having shown that steadier running was achieved when the gradual rotation of the vehicle due to reversal of cant was not interrupted. Where the circular curve butted directly on to a straight—a condition rarely found on plain track, but which was common to junctions and crossings—a bogie vehicle entering the circular curve was subjected to a "virtual transition" while the leading bogie was travelling along the curve and the trailing bogie was still running over the straight track. Such a condition gave rise to an effective or virtual transition length equal to the wheelbase of the wagon or coach, which the committee proposed should be taken as 40 ft., the shortest distance between bogie centres on British passenger coaches. In these cases, cant may be applied at a rate not exceeding the maximum cant gradient of 1 in 300 and be commenced on the straight at a point 20 ft. before the tangent point; in special cases, where other features permitted it and where large cants were necessary, cant could be run up in 80 ft., commencing 60 ft. before the tangent point. The provision of cant could be achieved along a turnout, independent of the main line, by the use of two-level chairs or baseplates.

Finally, the Committee stressed the need for designing a series of curves along a route as an integrated whole and not as a series of individual curves. It was of great importance that a uniform speed value should be achieved for considerable sections of track if speed restrictions were to be observed and good running times regularly maintained.

TRADE PUBLICATIONS.

Roughening of Concrete Surfaces.—For roughening concrete floors and other surfaces so as to provide a key for subsequent floor toppings, or to eliminate a smoothness which might be dangerous on roads, etc., the Met-texture process has been developed in recent years by the Metropolitan Construction Co., Ltd., 66, Queen-street, London, E.C.4. The process was described in Engineering, vol. 171, page 401 (1951), and is now the subject of a booklet, "Surfacing of Concrete Floors," which the firm have issued.

Prestressed Concrete Construction.—In the Lee-McCall system of prestressing concrete, the concrete is allowed to set before the stress is applied by nuts on the ends of alloy-steel bars, the bars passing through holes in the concrete. The subject is fully expounded in a series of booklets we have received from McCalls Macalloy, Ltd., Templeborough, Sheffield.

Tool and Cutter Grinding.—A useful booklet of practical advice on the grinding of tools and cutters has been issued by A. A. Jones and Shipman, Ltd., Narborough-road South, P.O. Box 87, Leicester. It is intended primarily for operators of Jones-Shipman tool and cutter grinding machines, but it will be of service to operators of other similar machines.

Floors with Embedded Heating Panels.—Technical guidance on the design of floors which are to have embedded heating panels is given in a leaflet issued by the Invisible Panel Warming Association, 136, Grand Buildings, Trafalgar-square, London, W.C.2. The arrangement of insulating material and of expansion and contraction joints, and the choice of floor finishes, are among the subjects discussed.

MAPLE LODGE SEWAGE WORKS, RICKMANSWORTH.

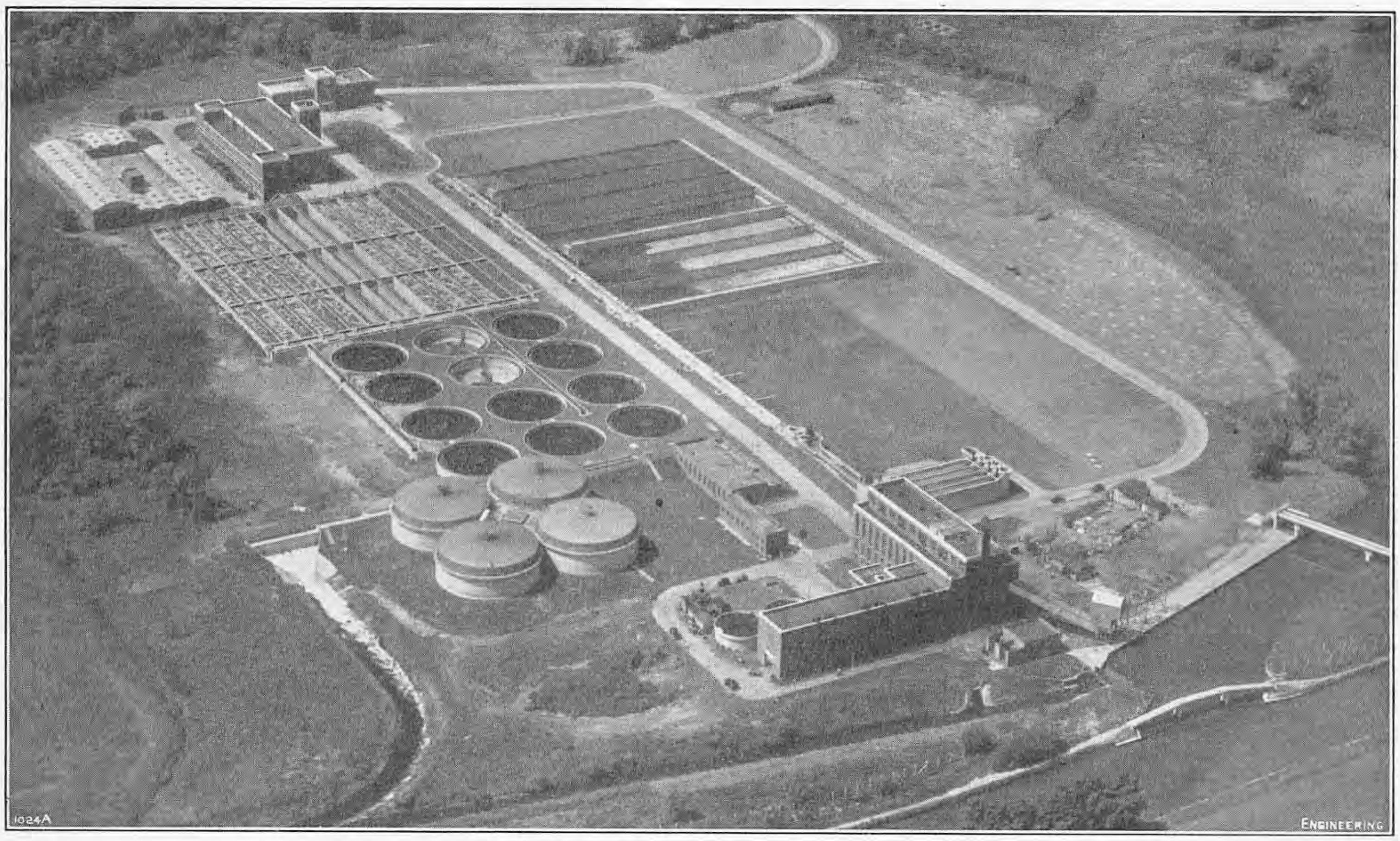


FIG. 1. AERIAL VIEW.

PRODUCTION OF COMBUSTIBLE AND FERTILISING SLUDGE AT MAPLE LODGE SEWAGE WORKS.

COMBINED mechanical dewatering and flash-drying of sewage sludge is now being used for the first time in Europe; and the final product, a fine black powder, rich in nitrogen, and with a calorific value of 6,000 B.Th.U. per pound, can be used either as a fuel for drying more sludge, or as a fertilizer. This innovation is at the Maple Lodge sewage-disposal works of the Colne Valley Sewerage Board, a few miles from Rickmansworth. The works were formally opened by the Lord-Lieutenant of Hertfordshire, the Hon. David Bowes-Lyon, on July 12, and are designed to serve an ultimate population of 550,000 over an area of 150 sq. miles. Twenty-six existing local sewage works are being closed down, as the new works will serve the combined needs of a number of authorities, including those of St. Albans City and rural, Hemel Hempstead borough and rural, Watford borough and rural, Bushey urban, Chorley-wood urban, Potters Bar urban, Rickmansworth urban, Elstree rural, and Hatfield rural districts. Twenty-one existing pumping stations are also being closed down. The estimated total cost of the new plant, 6,250,000*l*., is much higher than the original pre-war estimate, but this is not surprising as most of the construction work has been carried out since the war.

Sewage is treated at Maple Lodge by the diffused-air activated sludge process. Primary sludge is digested in heated tanks and the organic matter is reduced by about 40 per cent., leaving a residue which is free from objectionable odour. The digestion process produces sludge gas, a mixture of methane and carbon dioxide, having a calorific value of 630 B.Th.U. per cubic foot, which is used as a source of power. The methods used for dewatering this sludge and the surplus activated sludge, together with the method of drying, constitute the feature of special interest at the works, and its operation will be watched with interest by sanitary engineers. The Board decided to adopt this system because of the difficulty that would have been experienced in drying the sludge atmospherically on beds; surplus activated sludge is extremely difficult to dry in this way, and at Maple Lodge it would have been necessary to provide costly water-tight beds to comply with certain clauses in the Board's Act of Parliament, which were inserted to protect local water interests. After investigating existing processes, therefore, especially those in use in the United States and Canada, it was decided to employ digestion of primary sludge only, in order to produce sludge gas for generating power; followed by vacuum filtration to remove as much of the water content as possible; flash drying to remove the remainder; and, finally, incineration of that part of the sludge, if any, which is not used as a fuel or fertiliser. The fine ash which results is dumped in a disused gravel pit adjoining the works. Surplus activated sludge is treated similarly, except that it is not digested.

Vacuum filtration is employed as being the most economical way of removing the first part of the water; heat is necessary to remove the remainder. The filter house and incinerator house are the L-shaped building shown in the lower right corner of Fig. 1. Six vacuum filters of the type shown in Fig. 2 have been supplied by the Dorr-Oliver Company, Limited, Abford House, Wilton-road, London, S.W.1, who were also responsible for the flash-drying and incineration plant. A large drum has a cloth "blanket" filter wrapped round it, and the drum is rotated slowly with its lower part in a shallow bath that is kept supplied with sludge. The blanket picks up a layer of sludge about ⅛ in. thick. The drum is divided internally into a number of compartments, which, in cross-section, are arranged segmentally. As each compartment passes up and beyond the sludge bath, a vacuum is created within it, thus drawing the water through the blanket filter and leaving the sludge, partly dried, on the outside. At the next stage in the rotation of the particular compartment, air is fed in under pressure, causing the sludge to be loosened on the surface of the blanket, so that it comes off readily when, with the drum rotating, it meets a fixed scraper mounted longitudinally in contact with the blanket. Vacuum filtration is therefore a continuous process, and the partly-dried sludge falls on to a belt conveyor, running alongside the line of six units, which transports it to the heat-treatment plant.

In order to coagulate the sludge particles before they are filtered, it is necessary to use a chemical "conditioner," i.e., a mixture of ferric chloride and ferric sulphate which changes the hydrogen-ion concentration. Since, however, some of the substances dissolved in the water content of digested sludge have a chemical affinity for ferric chloride, they are removed by elutriation before the sludge is conditioned, thereby limiting the amount of conditioner required. The two elutriation tanks are just visible behind the filter house in the lower right corner of Fig. 1. They are 30 ft. in diameter and 10 ft. deep and are equipped with rotating scraping and thickening mechanisms. The digested sludge is passed from the four digestion tanks (visible above ground level in Fig. 1) to the elutriation tanks, where it is elutriated with final effluent.

The filter cake, i.e., the sludge after vacuum-filtration, still contains 75 or 80 per cent. of water, and ultimately, when the works is dealing with sewage from the whole area it is to serve, there will be about 150 tons of it a day. The filter cake is mixed in a "pug-mill" type paddle mixer with a quantity of previously-dried sludge, thus rendering it more suitable for drying. The resulting product, in the form of small flaky particles, is passed through a flash-dryer where it meets a stream of furnace gases at a temperature of about 1,200 deg. F. The particles are dispersed through the stream of hot gases and the moisture is driven off almost instantaneously. The dried sludge is carried with the now cooled gases to a cyclone separator, in which the two are separated, the gases returning to the furnace where all odours are destroyed by the high temperature before they are discharged to the atmosphere. The furnace supplying the heat is generally similar to a pulverised-fuel boiler installation, and can be run on dried sludge or, if the sludge is being sold as fertiliser, on pulverised coal, or on a mixture of the two fuels. Four furnace units, each with sludge mixer, flash dryer, cyclone

MAPLE LODGE SEWAGE WORKS.

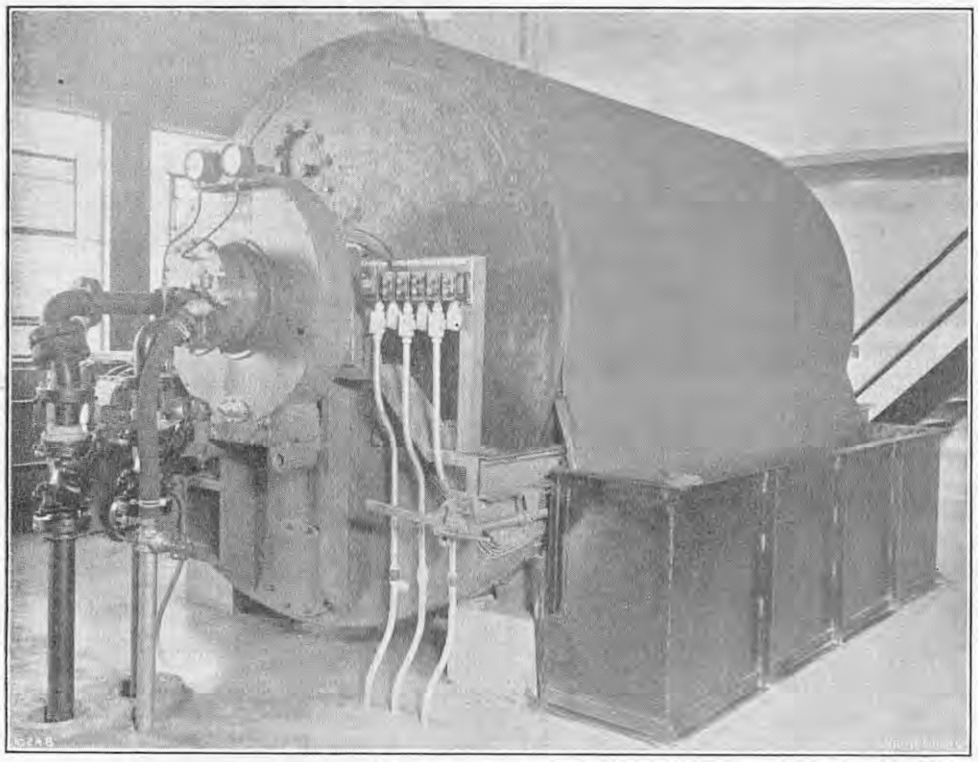


FIG. 2. VACUUM FILTER.

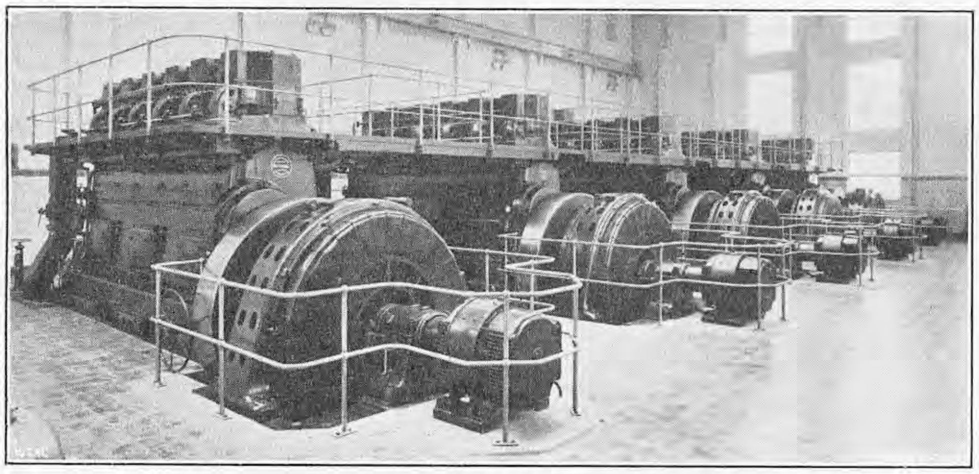


FIG. 3. POWER STATION.

separators, coal pulverisers, vapour and air blowers, etc., are provided. Each unit is arranged to dry and incinerate, or dry only, either activated or digested sludge separately, or a mixture of the two. All the sludge can be dried to produce fertiliser, or, if only the surplus activated sludge, with its higher nitrogen content, is worth drying, the digested sludge can be burned. Thus, complete flexibility is assured to enable the plant to be regulated to suit conditions, particularly the market value of the dried sludge as a fertiliser. If there is a ready sale for it, storage silos and bagging and handling plant will be provided.

For a description of the Maple Lodge sewage works as a whole, the reader is referred to an article published in ENGINEERING, vol. 164, page 403 (1947), when the works were under construction; also to "The Colne Valley Sewerage Scheme," a paper presented by Mr. W. Fillingham Brown, B.Sc., M.I.C.E., chief engineer and manager to the Sewerage Board, to the Institution of Sanitary Engineers, on July 2, 1948. Some of the information on the sludge-treatment plant given in this article is taken from that paper. As stated in our 1947 article, the works power station contains five (ultimately six) dual-fuel engines supplied by the National Gas and Oil Engine Company, Limited, for running either on oil or on methane gas produced by the digestion of the sewage sludge. These engines, which are shown in Fig. 3, herewith, are coupled to 750-kVA 3·3-kV Crompton Parkinson alternators. The consulting engineers for the works were Messrs. Sandford, Fawcett and Partners, 53, Victoria-street, London, S.W.1.

THE INSTITUTE OF METALS.

THE 44th annual autumn meeting of the Institute of Metals will be held at Oxford from Monday to Friday, September 15 to 19. It will open at 8.30 p.m., on September 15, in the Sheldonian Theatre, Broad-street, when Professor H. W. Swift, M.A., D.Sc., M.I.Mech.E., will deliver the 23rd annual Autumn Lecture entitled, "On the Foothills of the Plastic Range."

On Tuesday, September 16, at 9.30 a.m., at the Clarendon Laboratory, Parks-road, the Institute will be officially welcomed to Oxford by the Mayor of the city, Councillor W. C. Walker, O.B.E., and the Vice-Chancellor of the University, Sir Maurice Bowra. Following this, and again on Wednesday morning at the same times, from 9.30 a.m. until 12.30 p.m., two simultaneous sessions for the discussion of papers will be held. Session "A," at the Clarendon Laboratory, will deal with papers of industrial interest and session "B," at the Electrical Laboratory, Parks-road, with papers on physical metallurgy.

Tuesday's papers in session "A" comprise: "Observations on the Structure and Properties of Wrought Copper-Aluminium-Nickel-Iron Alloys," by Dr. M. Cook, Mr. W. P. Fentiman and Mr. E. Davis; and "Flow of Liquid Metals on Solid Metal Surfaces and its Relation to Soldering, Brazing and Hot-Dop Coating," by Dr. G. L. J. Bailey and Mr. H. C. Watkins.

The papers in session "B" on Tuesday, September 16, comprise "Application of Polarised Light to Examination of Anisotropic Metals and Intermetallic Phases," by Mr. B. W. Mott and Mr. H. R. Haines; "Metallography of Uranium," also by Mr. B. W. Mott and Mr. H. R. Haines; "Deformation of Polycrystalline Zinc," by Mr. J. A. Ramsay; "Opaque-Stop Microscope for Studying Surface Relief," by Mr. W. M. Lomer and Dr. P. L. Pratt; and "Twin Accommodation in Zinc," by Dr. P. L. Pratt and Mr. S. F. Pugh.

The papers in session "A" on Wednesday morning, September 17, will comprise: "Grain Refinement of Aluminium-Alloy Castings by Additions of Titanium and Boron," by Mr. A Cibula; "Nucleation of Cast Metals at Mould Face," by Mr. J. A. Reynolds and Mr. C. R. Tottle; "Effect of Mould Material and Alloying Elements on Metal/Mould Reaction in Copper-Base Alloys," and "Effect of Metal/Mould Reaction on 85 : 5 : 5 : 5 Leaded Gunmetal Sand Castings," by Mr. N. B. Rutherford.

Two series of papers will be presented on Wednesday at session "B." The first series, containing five papers which will be taken jointly, will deal with the equilibrium diagrams and the theory of copper alloys with zinc, germanium, gallium, silver indium, and other metals. A discussion will be based on the five papers which are by Messrs. R. Cabarat, P. Gence, R. Le Roux and Professor L. Guillet; Dr. P. Greenfield and Professor G. V. Raynor; and by Dr. W. Hume-Rothery, F.R.S., and his collaborators, Dr. J. O. Betterton, Mr. J. Reynolds, and Mr. W. A. Wiseman. The second series contains nine papers, which again will be taken jointly and will form the basis of a discussion on the theme of the equilibrium diagrams and theory of alloys of the transition metals. The alloy systems dealt with include the nickel-manganese, molybdenum-tantalum, titanium-zirconium, nickel-aluminium, chromium-tungsten and nickel-vanadium. The authors are Dr. W. Hume-Rothery, F.R.S., and Messrs. B. R. Coles and N. B. Pearson; Dr. G. A. Geach and Mr. D. Summers-Smith; Dr. A. H. Sully, Professor P. Duwez; Dr. A. Taylor and Mr. R. W. Floyd; Mr. H. T. Greenaway and Mr. Z. S. Basinski and Dr. J. W. Christian.

On Thursday morning, September 18, from 9.30 a.m. until 12.30 p.m., an informal discussion on "Grain Boundaries" will be held as an experiment, in the Clarendon Laboratory. In the afternoons of Tuesday, Wednesday and Thursday, visits will be paid to the Atomic Energy Research Establishment, Harwell; the works of British Railways, Swindon; M.G. Car Company, Limited, and Riley Motors, Limited, Abingdon; the Northern Aluminium Company, Limited, and Aluminium Laboratories, Limited, Banbury; Morris Motors, Limited, and Pressed Steel Company, Limited, Cowley; Associated Electrical Industries, Limited, research laboratory, Aldermaston, and other places of interest.

BRITISH ELECTRICITY AUTHORITY APPOINTMENTS.—In a written reply in the House of Commons on August 1, Mr. Geoffrey Lloyd, the Minister of Fuel and Power, said that he had re-appointed Lord Citrine as chairman of the British Electricity Authority and Sir John Hacking and Sir Henry Self as deputy chairmen. He was also reappointing two other existing members of the Authority, namely, Dame Caroline Haslett and Lieut.-Colonel E. H. E. Woodward. In accordance with the provisions of the Electricity Act, 1947, four chairmen of Area Electricity Board (at present Mr. H. H. Mullens, Mr. H. Nimmo, Mr. S. F. Steward and Mr. C. T. Melling) and also the chairman of the North of Scotland Hydro-Electric Board, Mr. Thomas Johnston, would continue to be members of the Authority. Two members, Sir William Walker and Mr. E. W. Bussey, would retire, and he had appointed Councillor J. Sullivan, at present a member of the South-West Scotland Electricity Board, as a member of the Authority and he proposed to fill the other vacancy shortly.

NOTES ON NEW BOOKS.

Oil Shale and Cannel Coal, Vol. 2.

Edited by GEORGE W. SELL, F.Inst. Pet. The Institute of Petroleum, 26, Portland-place, London, W.1. [Price 63s., post free.]

THIS volume of Proceedings of the Second Oil Shale and Cannel Coal Conference forms the most up-to-date and authoritative compendium of information available on the exploitation of oil shale and the recovery of shale oil. Technical developments which have occurred since the first conference was held in 1938 have been of sufficient importance to warrant the holding of another conference, and this the Institute of Petroleum organised in 1950. That year was the centenary of Dr. James Young's patent, which formed the basis of the oil shale industry, and the first paper in vol. 2 is the Young Centenary Lecture, by Dr. William M. Cumming. Thereafter, 49 technical papers are reproduced in full, with a brief report of the main points raised during the discussions. The first 19 papers deal with the geology, classification and mining of retortable oil-yielding materials such as oil shales, torbanites and cannel coals. This work is by no means confined to the Scottish oil-shale field, and useful papers are included on work carried out in the United States, Australia, South Africa, France and Sweden, where the Ljungström *in-situ* method for shale-oil recovery was developed. The 30 papers which follow, presented by authors from seven countries, cover the range of retorting, refining, assaying and utilisation, and there is even a paper on the manufacture of bricks from spent shale. This 830-page reference book is attractively presented and should be of service to engineers and chemists interested in the oil-shale industry.

Chronicles of a Country Works.

By RONALD H. CLARK, A.M.I.Mech.E. Percival Marshall and Company, Limited, 23, Great Queen-street, London, W.C.2. [Price 63s. net.]

THE "country works" of Mr. Clark's title is—or was—that of the Burrells of Thetford, in the county of Norfolk; and there is a good deal to be said for his claim that "what the railway locomotive owes to Messrs. Robert Stephenson & Co., Ltd., the road locomotive owes to Messrs. Charles Burrell & Sons, Ltd." as producers of the first heavy-duty traction engine and pioneers in a number of subsequent developments. They certainly deserved that their history should be put on record, and we adhere firmly to the view that the value of such a record is not to be assessed solely by the number of individuals to whom it makes a direct appeal; but we do deplore that it should be found necessary (even with the aid of sundry pages of advertisements) to charge three guineas for a volume that is so largely sentimental in conception and execution. An appendix contains details (so far as they could be ascertained) of every Burrell engine known to have been made—and the serial numbers run to 4,094; tables of standard dimensions, reports of road and brake trials, etc.—all are set down and, no doubt, will interest many. If these things are worth recording, however, they should be produced in a style that will make them accessible to thousands; then there is a chance of making converts to the study of engineering history, which needs them sorely if it is not to languish in the country which has made so much more of that history than any other. It is to be hoped that libraries in general, and especially in East Anglia, will buy this book for the benefit of the impecunious enthusiasts who cannot afford it.

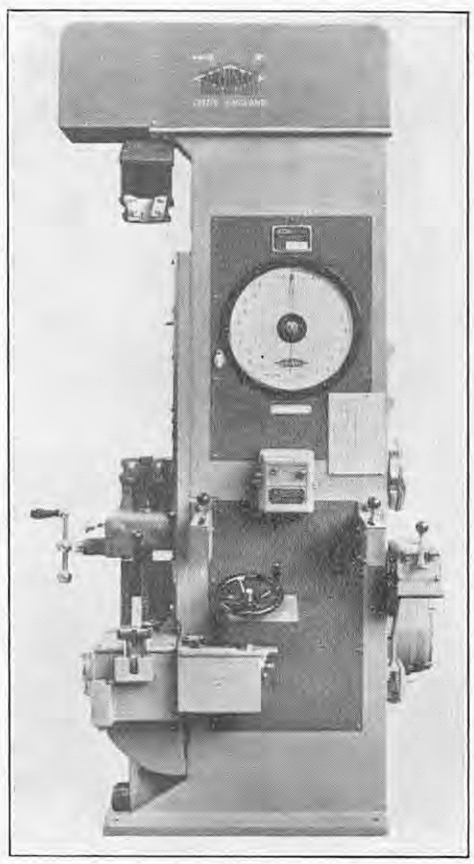
Exhaust Hoods.

By PROFESSOR J. M. DALLAVALLE. Second edition. The Industrial Press, 148, Lafayette-street, New York 13, N.Y., U.S.A. [Price 3·50 dols.]; and Bailey Brothers and Swinfen, 26-27, Hatton Garden, London, E.C.1. [Price 30s.]

THE greater part of the material in this book appeared originally in the American periodical *Heating and Ventilating* and was first collected in book form in 1945. To it has now been added, to form this second edition, a considerable amount of research and experimental work, and results of practical experience in many industrial establishments, on the design of hoods for the withdrawal by suction of fumes, dust, detritus, etc., arising in such operations as grinding, woodworking, smelting, paint-spraying, tinning and soldering, pickling, etc., the removal from enclosed spaces of the exhaust fumes from internal-combustion engines, and of dust from such operations as shaking out sand from foundry moulds. The most suitable shapes for hoods are discussed in great detail, together with the volumes and velocities of air, etc., required to effect removal in numerous specific cases. The books is one deserving of careful study by heating and ventilating engineers, factory supervisers and inspectors, and welfare organisers.

TENSILE TESTING MACHINE.

THE accompanying illustration shows a standard model T.24 tensile testing machine, manufactured by Samuel Denison and Son, Limited, Hunslet Foundry, Leeds, 10, that has been modified so as to make available 16 straining speeds, by combining two two-speed gearboxes in series, and a four-speed electric motor. The gears in each of the two-speed gearboxes are connected by dog-clutches, controlled by levers at the front of the machine, that enable straining speeds to be selected varying between 0·005 and 1·50 in. per minute. In addition to the power drives there is also a hand drive, and a reversing gear enables all the drives to be used in either direction. The maximum distance between the steel wedge boxes is 34 in. and the initial gap



between them can be set rapidly by means of a hand lever conveniently placed so that the operator can observe the test-piece while using it.

The load on the specimen is determined by a sensitive lever system and is read from a dial indicator. The upper wedge box is suspended from the main column of the machine. The beam is connected to the dial through a subsidiary lever fitted with four knife edges. A bush bearing, moved by the rotation of a handwheel, can be brought in contact with any one of the four separate knife edges to provide a fulcrum for the lever, so giving the machine four load ranges. These load ranges are from zero to 1,500 lb. by 2-lb. increments, zero to 3,000 lb. by 4 lb., zero to 7,500 lb. by 10 lb. and zero to 15,000 lb. by 20 lb. Movement of the handwheel controlling the load range of the machine also brings into use the appropriate load scale on the dial indicator, the maximum load applied during test being indicated by a marker mounted on the glass.

BOOKS RECEIVED.

Year Book of the Heating and Ventilating Industry. 1952. Technitrade Journals Limited, 8, Southampton-row, London, W.C.1. [Price 8s. 4d. post free.]

Worked Examples in Illuminating Engineering. By R. W. AMES and J. B. HARRIS. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 21s. net.]

The Railway Fuel and Traveling Engineers' Association. Fifteenth Annual Proceedings. 1951. The Railway Fuel and Traveling Engineers' Association, Room 1213, 139, W. van Buren-street, Chicago 5, Illinois, U.S.A.

Elementary Heat Power. By PROFESSORS HARRY L. SOLBERG, ORVILLE C. CROMER, and ALBERT R. SPALDING. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6·50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52s. net.]

Elementary Analysis. By PROFESSOR KENNETH O. MAY. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 40s. net.]

Farm Power. By PROFESSORS BEN D. MOSES and KENNETH R. FROST. 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, London, W.C.2. [Price 46s. net.]

Die Gestalt der Elektrischen Freileitung. By DR. MILAN VIDMAR. Verlag Birkhäuser, Elisabethenstrasse 15, Basle, Switzerland. [Price 16·65 Swiss francs in paper covers, 19·75 Swiss francs bound.]

Canada. Department of Mines and Technical Surveys. Mines Branch. Memorandum No. 118. *Sulphur and Pyrites in Canada.* By T. H. JANES. The Director, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.

Second Memorandum by the Federation of British Industries to the Royal Commission on the Taxation of Profits and Income. Federation of British Industries, 21, Tothill-street, London, S.W.1. [Price 1s. 4d.]

Radio Interference Suppression. By G. L. STEPHENS. Second edition. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 10s. 6d.]

LAUNCHES AND TRIAL TRIPS.

M.S. "NOSSI BE."—Single-screw vessel carrying 27 passengers and cargo, built by Ateliers et Chantiers de la Seine Maritime, Le Trait, for the Madagascar service of the Nouvelle Compagnie Havraise Péninsulaire, Paris. Third vessel of three for these owners. Main dimensions: 445 ft. between perpendiculars by 60 ft. by 37 ft. 5 in.; gross tonnage, about 8,000; maximum deadweight capacity, 10,000 tons; draught, 25 ft. 11 in. Burmeister and Wain eight-cylinder two-stroke single-acting Diesel engine, developing 7,000 h.p. at 125 r.p.m. in service. Speed, about 15 knots. Launch, July 10.

M.S. "SELECTIVITY."—Single-screw cargo vessel, built by the Grangemouth Dockyard Co., Ltd., Grangemouth, for F. T. Everard & Sons, Ltd., London, E.C.3. Main dimensions: 225 ft. by 37 ft. 10 in. by 16 ft.; deadweight capacity, about 1,800 tons on a draught of 15 ft. 8 in. Sirron four-cylinder Diesel engine, developing 800 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Speed on trial, 10 knots. Trial trip, July 17.

M.S. "FOURAH."—Twin-screw tug, built by Henry Robb, Ltd., Leith, for the Crown Agents for the Colonies, London, S.W.1, for service at Freetown, Sierra Leone. Main dimensions: 122 ft. by 30 ft. by 14 ft. 6 in.; gross tonnage, 310. Two British Polar four-cylinder oil engines, together developing 1,000 b.h.p., constructed by British Polar Engines, Ltd., Glasgow. Trial trip, June 24.

M.S. "RAEBURN."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Lamport and Holt Line, Ltd., Liverpool. Main dimensions: 435 ft. between perpendiculars by 63 ft. by 39 ft. 6 in. to shelter deck; gross tonnage, about 8,000. Harland-B. and W. seven-cylinder two-stroke opposed-piston heavy-oil engine. Launch, August 6.

S.S. "TWYFORD."—Single-screw cargo vessel, built and engined by John Lewis and Sons, Ltd., Aberdeen, for Risdon Beazley, Ltd., Southampton. Main dimensions: 200 ft. between perpendiculars by 36 ft. by 17 ft. 6 in. Triple-expansion steam engine, and one oil-fired Scotch boiler manufactured by William Denny and Brothers, Ltd., Dumbarton. Launch, August 7.

H.M. COASTAL MINESWEEPER NO. 14.—One of a new series of minesweepers, capable of operating in shallow coastal waters, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the Royal Navy. Length 152 ft. by 28 ft. 9 in. beam. To carry three small guns. Main oil engines, constructed by Mirrless, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, August 8.