90,000-TON REINFORCED-CONCRETE SILO FOR AMMONIUM SULPHATE; SINDRI, INDIA.

On page 289, *ante*, we gave a description of the new artificial fertiliser factory of Sindri Fertilisers and Chemicals, Limited, which is capable of producing 1,000 tons of ammonium sulphate a day. With such a high rate of production, it is necessary to provide sufficient storage on site to be able to maintain the output at maximum capacity during the periods of reduced deliveries, which are caused by the normal seasonal fluctuations in the demand for fertilisers. Such storage also ensures that advance orders can be filled for a long period in the event of a cessation in production, due to a failure in the supply of raw materials or plant breakdown. The factory, as we noted in the previous article, is therefore provided with a reinforced concrete silo with a capacity of 90,000 tons of ammonium sulphate, which is equivalent to three months' production at maximum output. This silo, which was designed by the Cementation Company, Limited, Doncaster, and erected under their direction by Messrs. J. C. Gammon and Company, Limited, Bombay, is an interesting engineering structure and some further details of it are therefore given below.

The construction of the silo is illustrated by the drawings reproduced in Figs. 3 to 5, on page 450. It is shown completed in Fig. 1, and, while being erected, in Fig. 2 on this page; and Figs. 6 to 8, on page 464, illustrate the progress of the work. A photograph of the interior is reproduced in Fig. 9, on the same page. The building is 660 ft. long and comprises 22 independent arch sections. Each of these sections is 30 ft. long and has a span of 143 ft. between abutments and a rise of 81 ft. to the crown. The arches are built up of 6-in. reinforced slabs thickened to 2 ft. at the springings and crown. There are four external heavily reinforced stiffening ribs, shown in Fig. 3, 4 ft. 6 in. high, which are spaced at 7 ft. 6 in. centres. The gable ends, which are 5-in. reinforced panel walls framed between reinforced-concrete columns and beams, are not rigidly connected to the building, but are provided with sliding joints between the column heads and the adjacent arch ribs. This arrangement is designed to permit free deflection of the end arches under load without setting up the stresses which would arise if movement were restrained by rigid ties.

As will be seen from Figs. 3 and 4, a 9-ft. by 7-ft. conveyor tunnel is located centrally below the silo floor. There is also a 34-ft. by 28-ft. 6-in. elevator tower 90 ft. high in one gable end, as shown in Fig. 1. The sulphate is delivered by an inclined conveyor to the top of this tower, and is discharged thence on to the floor by a second conveyor, which is suspended from the arch crown and extends the full length of the building. The sulphate is extracted from the building through the tunnel below the main floor. Openings are provided in the tunnel roof through which the sulphate can be mechanically loaded on to a belt conveyor for transport to the bagging plant.

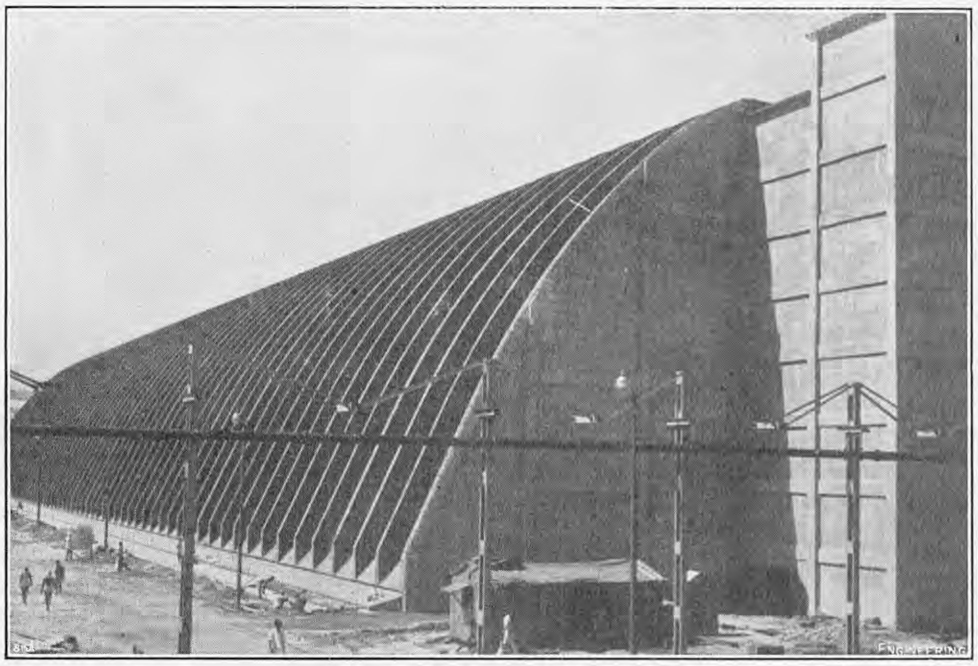


Fig. 1. Completed Silo from North End.

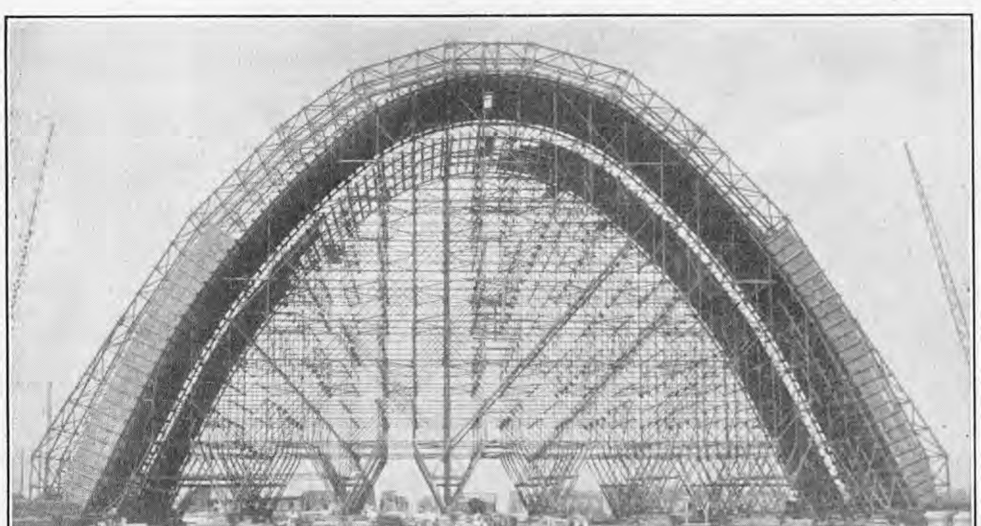


Fig. 2. Internal and External Travelling Shutters.

Work on the preparation of the foundations was begun in October, 1947, extensive excavation being necessary to uncover ground capable of sustaining the designed loading of 2 tons per square foot. In all, 13,000 cubic yards of soil were removed and replaced by Colcrete. All the excavation was done by hand, the spoil being loaded into lorries and skips for disposal to a tip. Ground level was at 496·00 and the minimum design depths for the arch foundations, main floor and conveyor tunnel were at 491·00, 491·25 and 484·00, respectively. In the cases of the arch foundations and the main floor, however, those depths were exceeded in many places before suitable ground was uncovered. In the case of the conveyor tunnel, the minimum depth was nowhere exceeded.

The Colcrete used to replace the excavated material up to the level of the underside of the 6-in. reinforced-concrete floor slab consisted of boulders laid on the prepared sub-grade into which a 3 to 1 sand-cement mix was pumped in the form of a grout. This grout was prepared in a special Colcrete mixer and was poured in lifts depending on the maximum size of boulders which could conveniently be handled. It was built up in successive layers to the required thickness, which varied from a minimum of 1 ft. 6 in. to a maximum of 12 ft. The top surface was blinded with 1½ in. to ¾ in. chippings and screeded to a level finish.

The trench for the conveyor tunnel, which is 12 ft. wide by 12 ft. deep, was successfully excavated with vertical sides without shoring as the ground, which consists of a well-compacted sand derived from the *in situ* decomposition of a quartz syenite, will stand unsupported on a vertical face, provided no water is allowed to come into contact with it. By confining excavation to the dry season and following close behind with the floor and wall concrete, side slopes and back-fill were eliminated and outside wall shutters were not needed. The shallow excavation for the arch foundations was straightforward, any extra depth being filled with 10 to 1 concrete up to the underside of the reinforced-concrete foundation at 491·00.

The conveyor tunnel, which is 9 ft. by 7 ft. in the clear, with heavily-reinforced floor, walls and roof, was concreted in bays 20 ft. long, the copper-strip water seals being placed across all construction joints. As an additional precaution against leakage, a Sika waterproofing compound was added to the floor and wall concrete. The wall shutters consisted of steel sheets framed in angle irons, which were bolted together and built up into panels of the required size. These shutters were dismantled after each pour and carried forward and re-assembled in the next position. The roof, which was also cast in 20-ft. bays, was poured on a travelling shutter. This was set by wedges off 9 in. by 4 in. timber runners which were supported on a light steel framework fitted with wheels that ran on 20-lb. rails laid on the tunnel floor. The arch abutments, which rest on 8-ft. wide mass-concrete footings with a minimum thickness of 2 ft., were poured in 28-ft. lengths, gaps 2 ft. wide being left between successive pours to minimise the development of shrinkage and temperature cracks. These gaps were filled in 12 to 15 months after the main body of the concrete had been placed in position.

The silo arches, because of their shape and size, required special equipment for construction. The main features of interest on this part of the work were the travelling shutters and the technique employed in placing the concrete. Two travelling shutters were provided for the arch centring. Each of these was 30 ft. long and consisted of galvanised-iron lined timber sheeting bolted to a braced steel framework, which was mounted on eight pairs of bogies running on 75-lb. flat-bottom rails laid on the silo floor. In the idle position, the travellers rested on the rails and the sheeting was then 4 in. clear of both abutments. The travellers were moved as required by a squad of men using pinch bars on the wheels. The forms were set by jacking them up on 32 five-ton jacks until the crown height was correct. At this point, the tail boards on both sides were in contact with the sloping face of the abutments and the setting was complete. In addi-

90,000-TON REINFORCED-CONCRETE SILO FOR AMMONIUM SULPHATE.

Fig. 3.
PART HORIZONTAL SECTION AT NORTH END.

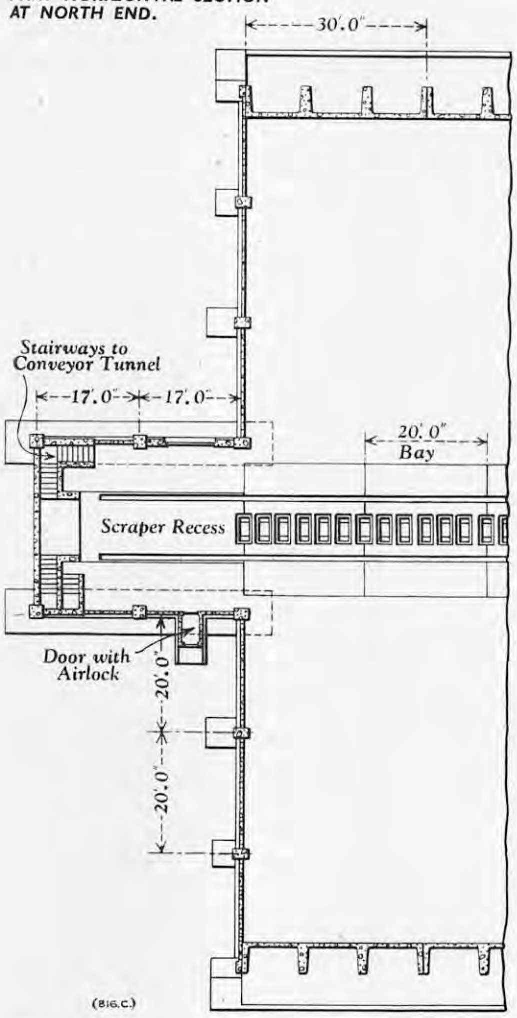


Fig. 4.
CROSS SECTION.

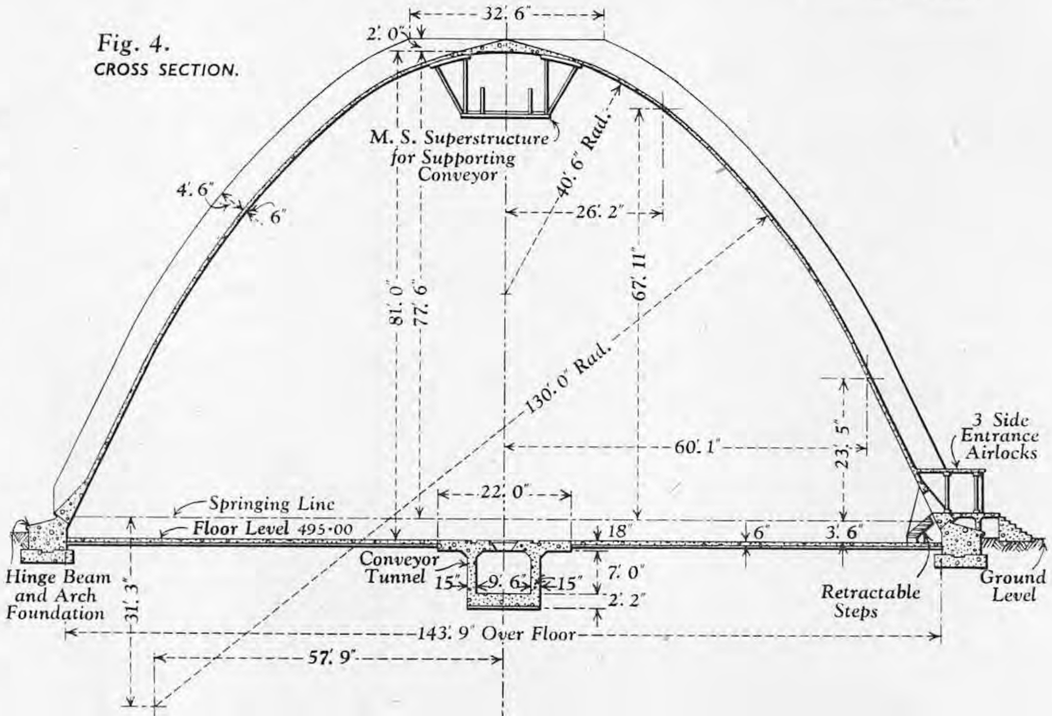
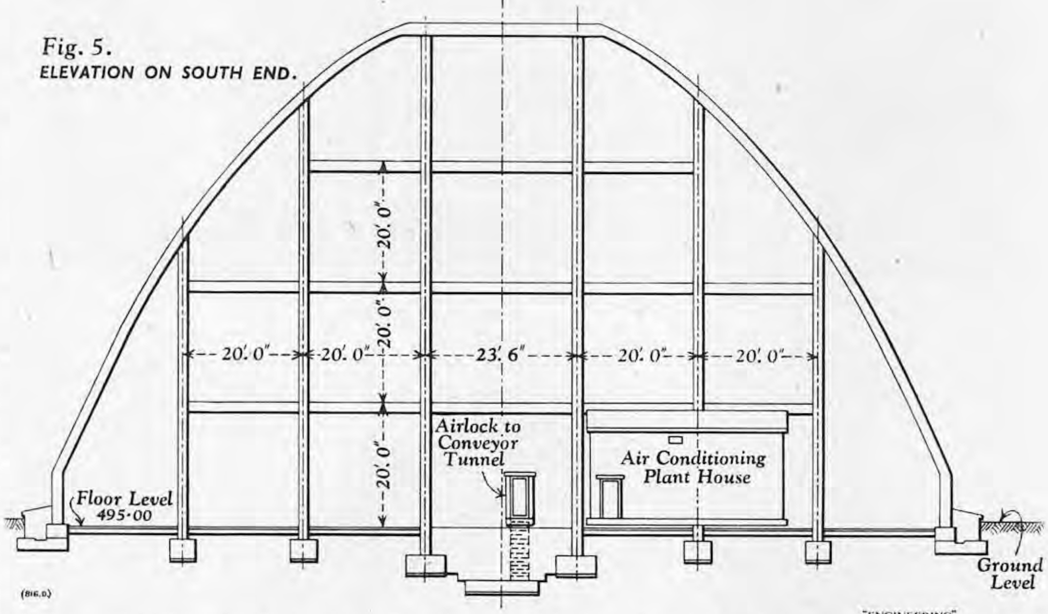


Fig. 5.
ELEVATION ON SOUTH END.



tion to the two inside travellers, an outside gantry was also provided. This consisted of five sets of steel trusses braced together to form an arched framework, 30 ft. long and of 180 ft. span with an overall height to the crown of 96 ft. Special foundations for the rails were laid clear of the building and the gantry could then be moved as desired along the length of the site by means of four five-ton hand-operated winches. The internal shuttering is shown in Figs. 2, 6 and 9, and the external shuttering in Figs. 2, 6, 7 and 8.

The arch sections were constructed on a "hit-and miss" system which was adopted to provide maximum flexibility in the use of the equipment. A cycle started by jacking-up and setting one of the inside shutters for line and level. At the same time the beam shutters from a completed section were being dismantled and the beam reinforcement cages were being assembled. By means of chain blocks, hung from the outside gantry, the beam shutters were lifted clear of the concrete and the gantry was then moved forward into the new position where the shutters were lowered and bolted through precast spacer blocks laid on the arch shutter to maintain the correct thickness of concrete in the slab. Each half-beam from the springing to the crown was 112 ft. in length. The reinforcement could not, therefore, be prefabricated on the ground, owing to the damage which would have been caused to the long slender cages during erection; neither was it feasible to assemble the steel on the arch during construction, because of the delay which this would have involved. To maintain the planned speed of construction it was essential that the steel should be ready to place as soon as the beam sides were set. To make this possible the reinforcement cages were prefabricated some days before they were needed on one of the finished arch sections and were transported thence by the gantry and lowered into position between the shutters.

Concrete was supplied from two 14/10 mixers, one on each side of the building. These mixers discharged into $5\frac{1}{2}$ cub. ft. buckets, which were suspended on rollers from mono-rails fixed to the gantry. Electric winches hoisted the buckets to working level, where the concrete was discharged on to platforms spanning the gap between the gantry and the arch beams. From the platforms, which were moved higher for each day's work, the concrete was distributed by hand to the beam and slab shutters. Concreting was, however, not continuous, construction joints being formed at the end of each day's work and brushed and grouted before starting the next day's pour. Operations were carried on from both sides of the arch simultaneously and in this manner each arch, comprising over 300 cubic yards of concrete, was poured in four days.

The only items of equipment which were not handled by the gantry were the top panels that retained the slab concrete. These were spanned between the beams and were fixed one by one between the beams and as the concrete rose to the top edge further panels were added. Sufficient of these were provided for one day's concreting; and they were stripped and moved into their new positions higher up each morning before the concreting was begun.

The setting time for each arch was from 12 to 14 days and the sequence of operations was so arranged that this was complete on the second or third day after concreting the arch, so that the idle shutter could be lowered and reset when concreting was finished and the beam sides were free to be used again. The maximum progress attained was two complete arches a month for a period of four months, but owing to delays due to shortage of materials and the difficulty of obtaining peak output during the monsoon, this rate could not be maintained. The construction of the arches started on February 8, 1949, and was finished on May 17, 1950, giving an average output of one complete arch every $2\frac{1}{2}$ weeks. The construction of the gable walls, elevator tower and conveyor-tunnel extension proceeded simultaneously with that of the arches, so that all major items were completed by the end of July, 1950. The building was waterproofed by the application of a bitumen compound to the slab and beams. Special precautions were taken with the joints between sections to accommodate relative movement of the arches.

JUBILEE OF THE EYRE SMELTING CO., LTD.—To mark the fiftieth anniversary of its formation, the Eyre Smelting Co., Ltd., Tandem Works, Merton Abbey, London, S.W.19, has issued a special tear-off wall calendar, showing two months on each sheet. The calendar is current until March next year and its six pages contain photographic representations illustrating places of interest in Surrey, together with sketch maps showing their position in relation to the firm's works. Copies will be sent, free of charge, in response to applications on business letter paper. The company was started at Tonbridge in 1902 by Mr. Eyre F. Ievers, M.I.Mech.E., and moved its head office and works to Merton 15 years later.

LITERATURE.

Fundamentals of Automatic Control.

By G. H. FARRINGTON, B.Sc., A.C.G.I. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 30s. net.]

DESPITE the varied and important applications of automatic control and servo systems already in common use throughout the mechanical and process industries, it is probably a fair statement that relatively few technical practitioners and students are familiar with the methods—some of them of great elegance—that have been devised in recent years for analysing practical control problems and designing accurate working solutions to them. It is fitting, therefore, that one of the few books introducing this field at all comprehensively should deal with fundamental matters that have been less than thoroughly explained hitherto. Mr. Farrington, with an enviable knowledge and practical experience of control theory, has anticipated many of the difficulties facing technologists coming new to the subject, by proceeding so gradually from the known to the unknown, so clearly from the simple to the complex, that every forward step can be confidently taken from firmly consolidated ground.

This attractive mode of presentation is exemplified in the introductory chapters by explanations of elementary ideas about automatic control in relation to physical instruments and simple engineering devices with which the reader is likely to be already familiar. Technical terms that have new or special connotations in control theory are all lucidly defined when first used in the text and are printed in bold type to facilitate back-reference. By comparing or contrasting analogies, the reader is quickly led to appreciate the convenience of representing a control system by an appropriate electrical circuit, where the elements and the relationship among them lend themselves readily to vectorial analysis and mathematical manipulation. After showing how the various stages of control may be examined separately, the author considers the synthesis of the control system as a whole, and its behaviour, especially as regards sensitivity and stability, when subject to arbitrary, externally imposed conditions. Thereafter the characteristics of the plant to be controlled are considered, emphasis being given to the importance, for a successful control design, of analysing as completely and accurately as possible the inherent behaviour and interconnected performance of the plant and its controlling apparatus.

In developing his treatment of automatic control through progressive stages of increasing complexity, Mr. Farrington exploits with skill the mathematical methods that are essential, on the one hand, for visualising the simultaneous operation of the several elements in a control system and, on the other, for expressing symbolically the fluctuating physical conditions to be controlled and for designing a synthetic control system to deal with them. He is able, consequently, to conclude his book with a constructive discussion of the selection and adjustment of that control system and its components which is most likely to suit any given set of external conditions or existing plant. The technologist who studies this book with the attention it deserves should find himself not only well-equipped to put what he has learned to practical use, but highly appreciative of the way in which its author has presented the groundwork of a difficult subject.

Der Ingenieur im Chemiebetrieb.

By F. Jähne. Verlag Chemie, G.m.b.H., Hauptstrasse 127, Weinheim a.d. Bergstrasse. [Price 14·80 DM. net.]

"THE Engineer in the Chemical Works," referred to in the title, and to whom this book is addressed, is the mechanical engineer; the chemical engineer, who (at least, in his own opinion) is both chemist and engineer, will likewise benefit from the experience which the author has gathered in chemical works. The book is not a text-book, and presumes that the engineer who has chosen to work in the chemical industry will acquire his knowledge of general processes and of those particular to his special branch elsewhere. The author warns those engineers who are unable to play only the second fiddle to keep away from chemical works, as it is the chemist who decides what is to be produced and how it is to be produced. The engineer is his most important and indispensable assistant, and he can find ample compensation for what he may sacrifice in status; though he is liable to become a specialist in a small section of the highly developed mechanical engineering field, chemical works afford a far-reaching insight into the huge field of technical physics and chemical engineering.

After having discussed the requirements demanded from the personality of the engineer, the author turns to those for providing the proper working conditions. One chapter gives hints for the selection of the geographical situation and for the size of works newly to be erected. Besides the buildings for the actual production, consideration is given to repair and electricians' shops and the department for the maintenance of refractories, as well as to printing shops, technical departments and drawing offices, sanitary installations and first-aid stations; further, there is guidance for the layout of roads, canalisation, and pipelines. Particulars of buildings are discussed by way of examples taken from the manufacture of dyestuffs, pharmaceutical preparations, serums and vaccines, from tablet-making and the packing of pharmaceutical products, laboratories, and from the manufacture of chlorine by electrolysis. The manufactures of solvents and plastics are chosen as examples for buildings which must be separated from others because of risks of fire and explosion.

The most interesting and rewarding task of the engineer is to create a full-size working plant for a process which has been developed in the laboratory, and the advantages and disadvantages of continuous and discontinuous manufacture are discussed in that connection. A chapter is devoted to a concise analysis of the fundamental processes employed in chemical engineering, such as crushing, pulverising, filtration, centrifuging, drying, dust extraction, distillation, rectification, extraction, crystallisation, briquetting, sintering, and mixing. Another chapter recapitulates heat transfer, pressure and catalysis, as the means for initiating, maintaining, governing, and accelerating chemical reactions. A further chapter deals with water, heat and cold, electric energy, gas, compressed air and vacuum. Questions of material handling, storing, and the disposal of waste, peculiar to chemical works, are considered, and, to complete the activities with which an engineer may be confronted, the book concludes with the basic features of costing, wages, the protection of health and prevention of accidents, of standardisation and works organisation.

C. T. R. Wilson and the Cloud Chamber.

By S. L. BARRON. Cambridge Monograph No. 4. Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1.

THE fourth of a series of monographs being issued by the Cambridge Instrument Company, dealing with the association of the company with prominent men of science, mainly in the development of various scientific instruments, has been published recently. This monograph, written by Mr. S. L. Barron, relates to the well-known Wilson cloud chamber, devised by Mr. C. T. R. Wilson in 1911 in order to enable the tracks of alpha-rays and other ionising particles to be seen and photographed. Mr. Wilson, now Emeritus Jacksonian Professor of Natural Philosophy, Cambridge, was then working in the Cavendish Laboratory and the cloud chamber he constructed consisted of a glass cylinder, with a plate-glass top cover and a carefully-fitted metal piston. The space below the piston was connected through a stop cock to a large evacuated glass flask, so that, on opening the stop cock, the piston was drawn down on to a rubber stop, causing moist air in the space above the piston to expand rapidly and thus producing in it a state of super-saturation. Ionising particles, such as the alpha rays from a speck of radium, introduced into the chamber, cause condensation along the paths they follow and the resulting minute water droplets left along the tracks of the particles produce continuous hair-like lines which remain in position long enough to be seen and photographed.

This apparatus, which created great interest, not to say excitement, throughout the scientific world, was used by Wilson for numerous researches, and many other atomic physicists naturally wished to obtain similar apparatus. To meet this demand the Cambridge Instrument Company sought and obtained permission to construct it and did so in 1913 with Wilson's help. A few of these instruments were made and used successfully, but further progress was impeded by the outbreak of war in 1914. Soon after the war, Shimidzu, in the Cavendish Laboratory, devised apparatus in which expansions were produced in quick succession by the reciprocating movement of a piston instead of singly as in the original Wilson apparatus. With this apparatus, which was constructed by the Cambridge Instrument Company in 1921, expansions could be obtained at from 50 to 200 times per minute and it was possible to study thousands of serial expansions and thus to determine the frequency of collisons between the ionising particles and the atomic nuclei of the gas in the chamber. Later, a special camera was made to take stereoscopic photographs of successive expansions and this was used extensively in research work by Shimidzu and Blackett.

The apparatus previously mentioned, being intended for research work, was relatively costly, since high precision in manufacture was necessary. A need was felt, therefore, for a simple and inexpensive instrument which could be used to demonstrate the effects to students in schools and technical colleges. A students' demonstration cloud chamber, which was essentially a simplified form of the Shimidzu apparatus and could be operated by hand, was therefore produced by the Cambridge Company in 1927. It may be mentioned that two instruments of this type were in constant use by visitors to the Atomic Science Section of the Festival of Britain Exhibition throughout the five months of last year for which the Exhibition was open. Thus many thousands of the general public were able to see for themselves what the late Lord Rutherford once described as "the most wonderful experiment in the world," and many very ordinary mortals must have been thrilled as he was when seeing it for the first time. In a foreword to the monograph, written by Sir W. Lawrence Bragg, Cavendish Professor of Experimental Physics, University of Cambridge, it is mentioned that the original Wilson cloud chamber, which was the only one he made, is now "one of the most prized treasures of the Cavendish Museum."

Telford Clarence Batchelor (1857-1947).

By T. H. DAVIES. Published by the author at Stokes Hayes, Church Knowle, Wareham, Dorset. [Price 10s. net, including postage.]

THE author's sub-title to this excellently produced biography of the late T. C. Batchelor indicates that it is "A Memoir describing his Invention and Development of Locked-Coil and Flattened-Strand Wire Ropes"; and the foreword, by the late Dr. H. W. Dickinson, past President of the Newcomen Society, shows how its preparation came about. Dr. Dickinson, in making a survey of the history of rope-making, found that little information was available about locked-coil and flattened-strand ropes, and so applied to Mr. Davies, then a director of the firm of Latch and Batchelor, Limited, Birmingham, who introduced him to Mr. Batchelor, the inventor, then in his 86th year. The immediate outcome was a paper which Mr. Davies presented to the Newcomen Society in 1948, and the delegation to him by Mr. Batchelor of the task of preparing the present memoir, the desirability of which had been urged upon him by Dr. Dickinson. Both as a biography of the patentee and as a description of the evolution and commercial development of types of rope which have been of great economic significance, this book is one to be commended, especially to readers who still believe in the virtues of private enterprise. Mr. Davies has performed his task exceedingly well, including in the book not only fully illustrated descriptions of the ropes, but the sources both of the biographical and the technical material.

MECHANISMS FOR INTERMITTENT MOTION.

By O. Lichtwitz, M.I.Mech.E.

In transmitting rotary motion, the common case is uniform motion of both the driving and driven shafts. Machines for many purposes, however, require a regular cycle consisting of periods of motion alternating with standstills. Various mechanisms for imparting intermittent motion have been devised and, although several of them are ingenious, their design reveals the lack of a systematic treatment of the problems involved. In many cases, designers spend time in inventing mechanisms where satisfactory routine solutions already exist. It is, therefore, not the author's aim to compile a selection of mechanisms, but rather to concentrate on a few types which are of wide general application.

Although graphical methods can be used in laying out the gears in question, and in investigating their kinematic properties, they do not offer the same possibilities as a mathematical analysis. However, the mathematical treatment is not always simple; the functions involved are in many cases transcendental, and some of the formulæ are unattractive from the standpoint of numerical evaluation. Tables of discreet values have been prepared, therefore, in which the steps are sufficiently small for intermediate values to be interpolated without appreciable error. Not only is time saved by the use of the tables, but the reduction in the amount of detailed calculation lessens the danger of failing to see the wood for the trees, and so furthers the understanding of the essential features of the problem.

The literature on gears for intermittent motion is scanty, and scattered throughout many technical periodicals. As a result, such theoretical analyses as have been given lack uniformity and leave many problems unsolved; their existence is little known, and they are not readily accessible. It is hoped that the information contained in this article will help to fill a gap in the literature on gearing, and contribute to a wider field of application of the mechanisms concerned.

One of the simplest means for converting continuous into intermittent motion is a ratchet gear. The motion of ratchet gears is usually derived from a crank or eccentric, and is thus a modified harmonic motion, with favourable accelerations and retardations. If the motion is derived from cams, even more favourable kinematic properties can be achieved.

As the pawl and wheel of a ratchet are not connected positively, the pawl strikes the teeth of the wheel abruptly and, if the driven shaft is not efficiently braked, the ratchet wheel looses contact with the pawl during the period of intended retardation. The former deficiency inevitably makes the ratchet mechanism noisy, and the latter results in the amount of rotation being imprecise. Apart, therefore, from their employment in hoisting machinery, where they serve as detents for preventing undesired rotation of the winding drum in the reverse direction, ratchet gears should be restricted to purposes where a slight inaccuracy of the movement is permissible. If the motion of ratchet gears is derived from cranks or eccentrics, the periods of motion and standstill occupy approximately equal parts of one cycle, which results in a further restriction of their range of application. Friction ratchets are quieter than the others, but the absence of a positive connection may result in even greater inaccuracy in the movement.

Positively working gears for intermittent motion involve problems unknown in gears for transmitting uniform motion. Although, in the case of uniform motion, the gear ratio is specified by the angle through which the driven shaft rotates during one revolution of the driving shaft, the designer of a gear for intermittent motion requires, in addition, a knowledge of the distribution of motion and standstill. The actual shape of the teeth of gears for uniform motion does not, as a rule, need to be ascertained by the designer, as it is determined by pitch, number of teeth, helix angle, and similar data; in designing gears for intermittent motion, however, the main task is the determination of the tooth shape. Another peculiarity which is not encountered in designing gears for uniform motion

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 1.

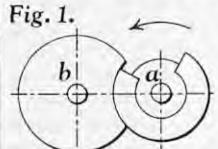


Fig. 2.

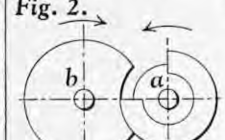


Fig. 3.

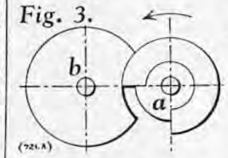


Fig. 4.

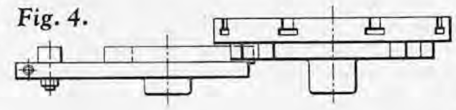


Fig. 5.

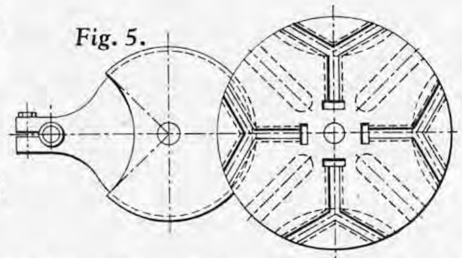


Fig. 6.

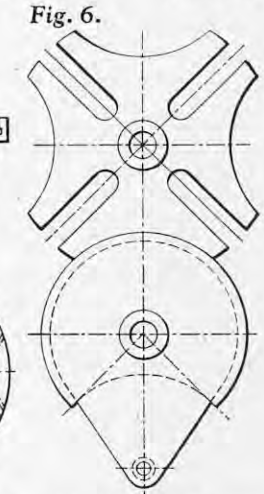


Fig. 7.

is that, in addition to the moving parts, those for locking the driven gear in the periods of standstill must also be designed. The circumferential velocity of uniformly moving gears has little significance at slow speeds and, at higher speeds, involves no more than certain additional considerations of the rating; the varying velocities, accelerations and retardations of intermittent gears, however, must be investigated with care, and impose an additional task on the designer.

A well-known means for obtaining positive intermittent motion is the Geneva mechanism. The positive motion of the driven member makes it suitable for exact mechanisms, for instance, for presses with dial feed. The best known application is in cinematographic projectors, where it provides the intermittent motion for the film. The relation between the periods of motion and standstill is not a very flexible one. The star wheel is a kindred mechanism which differs from the Geneva mechanism by the fact that the distribution of motion and standstill can be chosen almost at will.

The driving member of intermittent gears is usually rotating with constant angular velocity ω, and the angle α through which the driving gear rotates in time t is ωt. For simplicity, it will be assumed in the following that $\omega = 1$. The time t and the angle α are, in that case, numerically equal so that the time can be replaced by the angle covered by the driving gear. The angular velocity $\omega = 1$ radian per second corresponds to $\frac{30}{\pi}$ ($\simeq 9{\cdot}55$) revolutions per minute. If the number of revolutions per minute is N, the angular velocities quoted in later articles in this series must be multiplied by $\frac{\pi N}{30}$. If the rotary motion is converted into a rectilinear one by means of rollers or sprocket wheels of diameter d, the linear velocity is obtained by multiplying the angular velocity by $\frac{d}{2}$.

The acceleration or retardation of a rotating mass has a tangential and radial component. The former component is of more interest as the torque is proportional to it, and as it alone remains if the motion is transformed into a rectilinear one. In what follows, the acceleration is always to be understood as the tangential component, for $\omega = 1$. If the number of revolutions per minute is N, the values obtained for the acceleration must be multiplied by $\left(\frac{\pi N}{30}\right)^2$. The linear acceleration is then obtained by multiplying the result by the radius $\frac{d}{2}$ of the intermittently rotating roller. Table I, herewith, contains values of $\left(\frac{\pi N}{30}\right)$ and $\left(\frac{\pi N}{30}\right)^2$. Since the acceleration increases with the square of the number of revolutions per minute, kinematic considerations are important in the design of high-speed machines. Designers of the latter should also endeavour to reduce as much as possible the moments of inertia of the driven parts, or of the masses to be accelerated and retarded.

There are several ways in which the driven shaft may be locked during periods of standstill; one is shown in Figs. 1 to 3, on this page. The locating disc on the driving shaft a is a part of a cylinder which fits snugly into a concave recess of a disc on the driven shaft b. In the position shown in Fig. 1, the disc on the driven shaft is locked as its concave recess is prevented by the locking disc from rotation in either direction. When the locating disc reaches the position shown in Fig. 2, the driven shaft is free to rotate clockwise, until the position shown in Fig. 3 is reached. If the driven shaft has been rotating clockwise it must then come to a standstill, because, immediately afterwards, it is again prevented from rotating in either direction. The rotating disc, shown in Figs. 1 to 3, extends over 270 degrees, and the driven shaft is locked during three quarters of one revolution of the driving shaft. In general, the rim of the locating disc occupies the same fraction of 360 degrees as the period of standstill expressed as a fraction of one cycle.

Table I.—*Angular Velocities and their Squares.*

N.	$\frac{\pi}{30}$ N.	$\left(\frac{\pi}{30} N\right)^2$.	N.	$\frac{\pi}{30}$ N.	$\left(\frac{\pi}{30} N\right)^2$.
1	0·1047	0·0110	8	0·8378	0·7018
2	0·2094	0·0439	9	0·9425	0·8883
3	0·3142	0·0987	10	1·0472	1·0964
4	0·4189	0·1755	20	2·0944	4·3865
5	0·5236	0·2742	30	3·1416	9·8696
6	0·6283	0·3948	40	4·1888	17·5460
7	0·7330	0·5373	50	5·2360	27·4156

In practice, the means for locating are integral with or connected to the driving and driven gears. If the driven shaft is rotated—or indexed—a fraction of one revolution during one revolution of the driving shaft, the locating disc connected to the driven gear has several concave recesses.

During periods of retardation, the driven shaft, by resisting deceleration, tries to drive the driving shaft. If there is backlash in the intermittent gears, or in a preceding or following pair of common gears, chatter may result. As a counter-measure, backlash should be reduced as far as possible. It is also advisable to provide a brake on the driven shaft. Anti-friction bearings are unsuitable for the driven shaft.

External Geneva Mechanism.

In its usual form, the Geneva wheel, illustrated in Figs. 4 to 7, herewith, has four arms and its resemblance to the ensign of the Order of the Knights of Malta accounts for its alternative name of Maltese Cross. A mechanism with five stations is shown in Figs. 8 and 9, opposite, in two different positions. The driving gear comprises a driving roller and a locking drum. In the position shown in Fig. 8, the roller is about to enter one of the slots of the driven gear. At this instant, the locking drum has reached a position in which the driven gear can be rotated in the direction indicated, and the motion of the driven gear lasts until the driving roller leaves the slot. The locking drum then prevents movement of the driven gear until the roller enters the next slot.

Geometry.—In the Geneva wheels illustrated in Figs. 4 to 7, the straight radial centre-lines of the slots are tangents to the circular path of the

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 8.

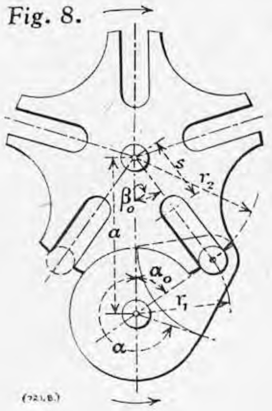


Fig. 9.

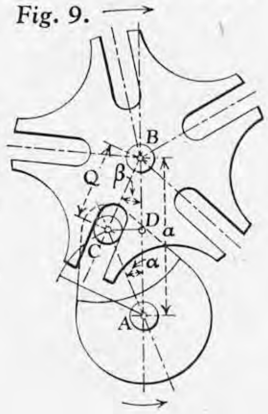


Fig. 10.

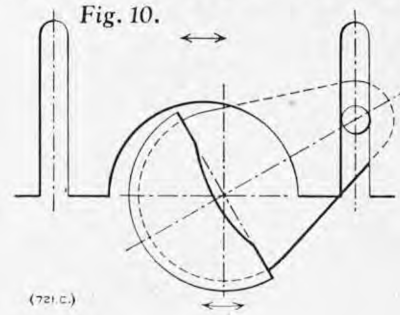


Fig. 11.

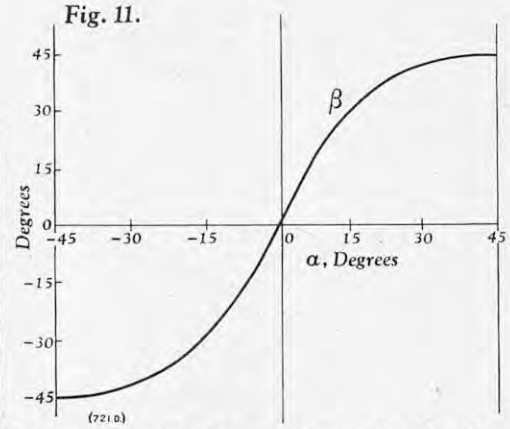
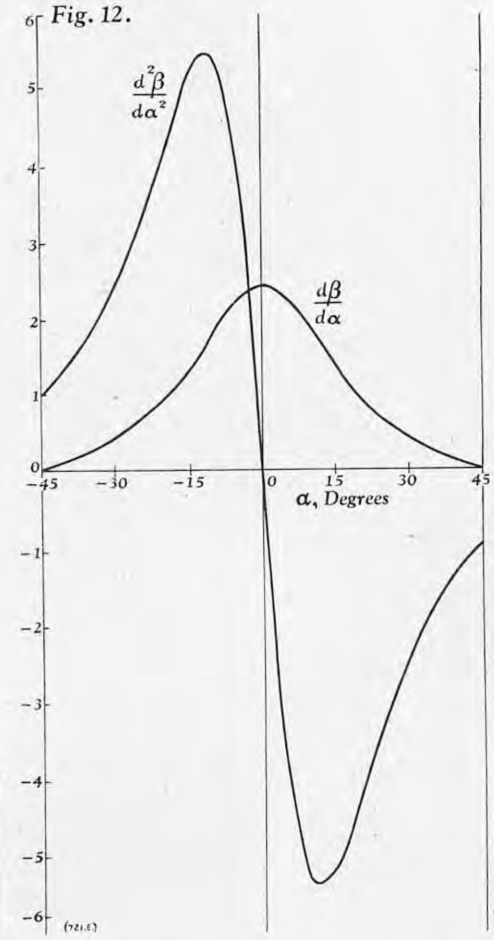


Fig. 12.



centre of the driving roller in the position of standstill. In this case, the driven gear starts and stops without shock. Although this is not absolutely necessary, only gears of this kind will be considered, since they have definite geometrical relations.

The Geneva wheel with five slots, shown in Figs. 8 and 9, may be considered, in the general case, to have n equally-spaced slots. Fig. 8 shows the gears in the position when the driving roller is entering a slot. The angle β_0 between the centre line of the slot and the line connecting the centres of driving and driven gears is, when expressed in radians,

$$\beta_0 = \frac{\pi}{n}. \quad . \quad . \quad . \quad . \quad (1)$$

If this, or any other, angle is to be expressed in degrees, π must be replaced by 180, or the radian measure must be multiplied by $\frac{180}{\pi}$. The corresponding angle α_0 by which the driving roller is short of its central position, is

$$\alpha_0 = \frac{\pi}{2} - \beta_0 = \frac{\pi}{2} - \frac{\pi}{n} = \frac{\pi}{2}\frac{n-2}{n}. \quad . \quad (2)$$

During n revolutions of the driving gear, the driven gear makes one revolution, so that the gear-ratio is, in a sense, n. It is, however, more expedient to consider only a period of continuous motion, and to relate the angles α_0 and β_0 by calling $\epsilon = \frac{\alpha_0}{\beta_0}$ the gear ratio. Thus, by equations (1) and (2),

$$\epsilon = \frac{n-2}{2}. \quad . \quad . \quad . \quad . \quad (3)$$

locking action, but the weaker are the tips of the wheel. A limit is reached when the concave recess of the locking drum reaches the contours of the slots. With decreasing radius, the locking becomes less reliable, and there is an obvious limit where locking ceases altogether.

The duration of each period of motion, expressed as a fraction of the time for one revolution of the driving shaft, is

$$\nu = \frac{2\alpha_0}{2\pi} = \frac{n-2}{2n} = \frac{\epsilon}{n}. \quad . \quad . \quad . \quad (9)$$

If 1 or 2 is substituted for n, the previous formulae yield values which are useless from a practical point of view. The smallest possible whole number for n is, therefore, 3.

Table II, herewith, contains the quantities considered above, for the most usual numbers of stations. The proportion ν of the motion in one cycle increases with the increase in the number of stations and, at $n = \infty$ (see Fig. 10, herewith),

Since

$$C\,D = r_1 \sin\alpha = \rho \sin\beta,$$

$$\sin\beta = \frac{r_1}{\rho}\sin\alpha = \frac{\sin\beta_0 \sin\alpha}{\sqrt{1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha}},$$

or

$$\beta = \sin^{-1}\frac{\sin\beta_0\sin\alpha}{\sqrt{1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha}}. \quad (10)$$

If the driving gear is rotating with unit angular velocity (so that the time t can be replaced by the angle α), the angular velocity of the driven gear is

TABLE II.—EXTERNAL GENEVA MECHANISMS.

n	β_0 Deg.	min.	α_0 Deg.	min.	ϵ	$\frac{r_1}{a}$	$\frac{r_2}{a}$	μ	$\frac{s}{a}$	γ Deg.	min.	ν	$\left(\frac{d\beta}{d\alpha}\right)_0$	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0}$	$\alpha_{max.}$ Deg.	min.	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{max.}$	$\left(\frac{d^3\beta}{d\alpha^3}\right)_0$	m_{max}
3	60	0	30	0	0·5	0·8660	0·5000	0·5774	0·13397	300	0	0·16667	6·46	1·732	4	46	31·44	—672·0	6
4	45	0	45	0	1·0	0·7071	0·7071	1·0000	0·2929	270	0	0·2500	2·41	1·000	11	24	5·409	— 48·04	4
5	36	0	54	0	1·5	0·5878	0·8090	1·3764	0·4122	252	0	0·3000	1·43	0·7265	17	34	2·299	— 13·32	3
6	30	0	60	0	2·0	0·5000	0·8660	1·7320	0·5000	240	0	0·3333	1·00	0·5774	22	54	1·350	— 6·00	3
7	25	43	64	17	2·5	0·4339	0·9009	2·0765	0·5661	231	26	0·3571	0·766	0·4816	27	33	0·9284	— 3·429	2
8	22	30	67	30	3·0	0·3827	0·9239	2·4142	0·6173	225	0	0·3750	0·620	0·4142	31	38	0·6998	— 2·249	2
9	20	0	70	0	3·5	0·3420	0·9397	2·7475	0·6580	220	0	0·3889	0·520	0·3640	35	16	0·5591	— 1·611	2
10	18	0	72	0	4·0	0·3090	0·9511	3·0777	0·6910	216	0	0·4000	0·447	0·3249	38	30	0·4648	— 1·236	2
∞	0	0	90	0	∞	0	1·0	∞	1·0	180	0	0·5000	0	0	90	0	0	0	2

If the distance between the centres of the driving and driven gears is a, the radii of the driving and driven gears are

$$r_1 = a\sin\beta_0 \quad . \quad . \quad . \quad (4)$$

$$r_2 = a\cos\beta_0 \quad . \quad . \quad . \quad (5)$$

respectively, and their ratio is

$$\mu = \frac{r_2}{r_1} = \cot\beta_0. \quad . \quad . \quad . \quad (6)$$

Formulae (3) and (6) show that, in contrast with the case of ordinary gearing, ϵ and μ are not identical except when $n = 4$.

If the distance of the inner end of the slot from the centre of the driven gear is s

$$s \leqslant a - r_1 = a(1 - \sin\beta_0). \quad . \quad (7)$$

The angle over which the locking drum extends is

$$\gamma = 2(\pi - \alpha_0) = \frac{\pi}{n}(n+2). \quad . \quad (8)$$

The radius of the locking drum can be chosen arbitrarily within certain limits. The larger the radius of the locking drum, the more perfect is the

attains the value 0·5; motion and rest then each occupy half a cycle. At the same time, the angle β_0 decreases and, at $n = \infty$, reaches the value 0. Even without further investigation of the kinematics, this fact warrants the deduction that Geneva mechanisms work quieter the larger the number of their stations. It is, therefore, advantageous to make that number higher even than is necessary. Some presses with dial feed have more stations than the process actually requires, in spite of higher tooling costs. It must, however, be ascertained in such cases whether a reduction of the period of standstill is feasible.

Kinematics.—In Fig. 9, the gear of Fig. 8 is shown in a position where the driving gear is at an angle α, and the driven gear at an angle β beyond the central position. The distance of the driving roller from the centre of the driving gear is A C $= r_1 = a\sin\beta_0$ (Formula 4). The distance B C $= \rho$ of the roller from the centre of the driven gear is

$$\rho = \sqrt{a^2 + r_1^2 - 2\,a\,r_1\cos\alpha}$$
$$= a\sqrt{1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha}.$$

obtained by differentiating β with regard to α.

$$\frac{d\beta}{d\alpha} = \frac{\sin\beta_0(\cos\alpha - \sin\beta_0)}{1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha}. \quad . \quad (11)$$

Fig. 9 makes it obvious that ρ is least when $\alpha = 0$, and that the angular velocity is then a maximum, namely

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{\sin\beta_0}{1-\sin\beta_0} = \frac{\sin\beta_0}{2\sin^2\left(\frac{\pi}{4} - \frac{\beta_0}{2}\right)}. \quad (12)$$

The first expression in Formula (12) can readily be found directly from Fig. 9; the second expression is more convenient for logarithmic evaluation.

On differentiating equation (11) with respect to α, the angular acceleration of the driven gear is obtained, namely,

$$\frac{d^2\beta}{d\alpha^2} = -\frac{\sin\beta_0\cos^2\beta_0\sin\alpha}{(1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^2}. \quad (13)$$

Before the central position is reached (i.e., when $\alpha < 0$), $\frac{d^2\beta}{d\alpha^2} > 0$, or the driven gear is accelerated.

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Fig. 13.

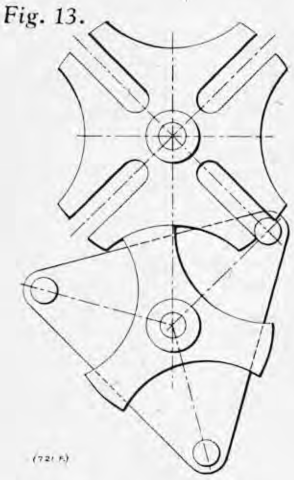


Fig. 14.

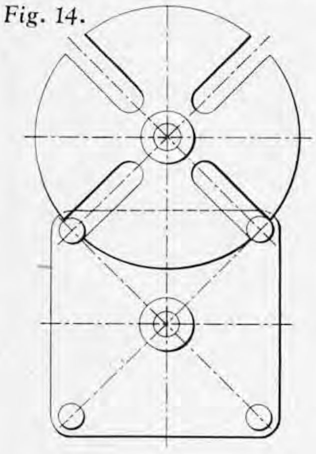


Fig. 15.

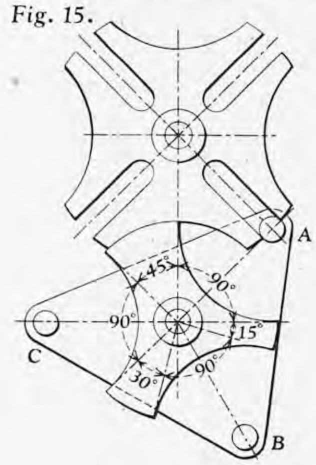


Fig. 16.

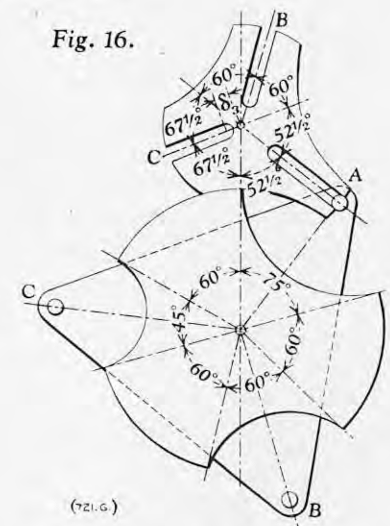
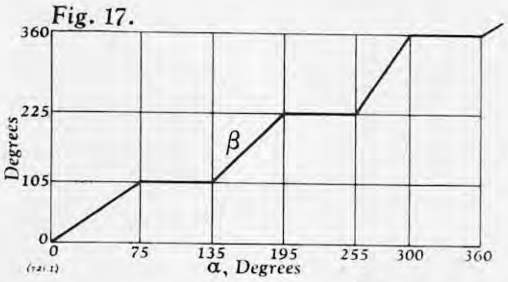


Fig. 17.



In the central position ($\alpha = 0$), $\frac{d^2\beta}{d\alpha^2} = 0$. After the central position has been passed (i.e., when $\alpha > 0$), $\frac{d^2\beta}{d\alpha^2} < 0$, or the driven gear is retarded. The acceleration at the start of motion is obtained by substituting $\alpha = -\alpha_0 = \beta_0 - \frac{\pi}{2}$ in equation (13).

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0} = \tan \beta_0. \quad . \quad . \quad (14)$$

Because of the symmetry of the mechanism, the same value will be found for the retardation at the end of motion. The third differential coefficient of β with regard to α is

$$\frac{d^3\beta}{d\alpha^3} = -\sin\beta_0 \cos^2\beta_0$$
$$\times \frac{2\sin\beta_0\cos^2\alpha + (1+\sin^2\beta_0)\cos\alpha - 4\sin\beta_0}{(1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^3}. \quad (15)$$

The angular acceleration is a maximum when $\frac{d^3\beta}{d\alpha^3} = 0$, or when

$$2\sin\beta_0\cos^2\alpha + (1+\sin^2\beta_0)\cos\alpha - 4\sin\beta_0 = 0.$$

The solution of this equation is

$$\cos\alpha = -\frac{1+\sin^2\beta_0}{4\sin\beta_0} \pm \sqrt{\left(\frac{1+\sin^2\beta_0}{4\sin\beta_0}\right)^2 + 2}.$$

As the value under the square root is larger than 1, only the plus sign is admissible, so that

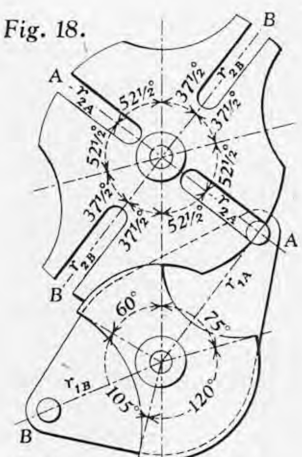
$$\alpha_{\text{max.}} = \cos^{-1}\left[-\frac{1+\sin^2\beta_0}{4\sin\beta_0} + \sqrt{\left(\frac{1+\sin^2\beta_0}{4\sin\beta_0}\right) + 2}\right]. \quad . \quad . \quad . \quad (16)$$

By substituting $\alpha = \alpha_{\text{max.}}$ in (13), the maximum angular acceleration is obtained

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{\text{max.}} = -\frac{\sin\beta_0\cos^2\beta_0\sin\alpha_{\text{max.}}}{(1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha_{\text{max.}})^2}. \quad . \quad . \quad . \quad (17)$$

Figs. 11 and 12, for the Maltese Cross with four stations, show β, $\frac{d\beta}{d\alpha}$, and $\frac{d^2\beta}{d\alpha^2}$ plotted against α, of which $\frac{d^2\beta}{d\alpha^2}$ is the most interesting. The acceleration begins at -45 deg. with a non-zero value, rises to a maximum at $\alpha = -11$ deg. 24 min., and falls rather steeply to zero at $\alpha = 0$. The right-hand side of the graph shows the analogous course of the retardation. The steepness of the curve of $\frac{d^2\beta}{d\alpha^2}$ at $\alpha = 0$, or the rate at which the acceleration

Fig. 18.



changes into retardation, is obtained by substituting $\alpha = 0$ in (15).

$$\left(\frac{d^3\beta}{d\alpha^3}\right)_0 = -\frac{\sin\beta_0\cos^2\beta_0}{(1-\sin\beta_0)^4} = -\frac{\sin\beta_0\cos^2\beta_0}{16\sin^8\left(\frac{\pi}{4} - \frac{\beta_0}{2}\right)}. \quad (18)$$

The minus-sign denotes that the acceleration is decreasing with increasing angle α, and only the absolute value is of interest. Table II contains, in addition to the values discussed in the previous part of this chapter, the values $\left(\frac{d\beta}{d\alpha}\right)_0$, $\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0}$, $\alpha_{\text{max.}}$, $\left(\frac{d^2\beta}{d\alpha^2}\right)_{\text{max.}}$, and $\left(\frac{d^3\beta}{d\alpha^3}\right)$.

As an example, the kinematic properties of a Geneva mechanism with four stations which is driving a feed roller of 5·093 in. diameter (to obtain per revolution the amount of feed $\frac{5\cdot093\,\pi}{4} = 4$ in.) at N = 50 r.p.m., will be investigated.

For $\omega = 1$, the maximum angular velocity is, according to Table II, 2·41 radians per second. For N = 50, it is (using Table I) 5·2360 × 2·41 = 12·62 radians per second, and the maximum linear velocity is $\frac{5\cdot093}{2} \times 12\cdot62 = 32\cdot14$ in. per second.

For $\omega = 1$, the angular acceleration at the start of motion is 1; at $\alpha_{\text{max.}} = -11$ deg. 24 min., it is 5·41 radians per second² (Table II). For N = 50, these values must be multiplied by 27·416 (Table I), so that they are 27·416, and 148·32 radians per second², respectively. The linear acceleration is obtained by subsequent multiplication by $\frac{5\cdot093}{2}$. At the start, it is 69·815 in. per sec.², and at its maximum, it is 377·697 in. per sec.² The latter amount, equal to 31·475 ft. per sec.², is slightly less than the gravitational acceleration.

Table II shows that the kinematic properties are better the larger the number of stations. To assess the influence of n, it may be assumed that, in the example above, n is reduced to 3. As the driven shaft makes one third, instead of one quarter, revolution per cycle, the diameter of the feed roller is reduced to $\frac{3}{4} \times 5\cdot093 = 3\cdot820$ in., to obtain the same amount of feed.

The maximum angular velocity is increased in the ratio $\frac{6\cdot46}{2\cdot41} = 2\cdot68$. The maximum linear velocity is more than doubled, since $\frac{6\cdot46}{2\cdot41} \times \frac{3}{4} = 2\cdot01$. The angular acceleration at the start of motion is increased 1·732-fold, and the initial linear acceleration $1\cdot732 \times \frac{3}{4} = 1\cdot30$-fold. The maximum angular acceleration is increased by the factor $\frac{31\cdot44}{5\cdot410} = 5\cdot81$, and the maximum linear acceleration by $\frac{31\cdot44}{5\cdot410} \times \frac{3}{4} = 4\cdot36$.

The rate of change of angular acceleration to retardation is increased by $\frac{672\cdot0}{48\cdot04} = 13\cdot99$, and of linear acceleration to retardation by $\frac{672\cdot0}{48\cdot04} \times \frac{3}{4} = 10\cdot49$.

Thus, a change from four to three stations is accompanied by a considerable deterioration of the kinematic properties. As even the Geneva mechanism with four stations is not to be regarded as particularly good kinematically, mechanisms with three stations are best avoided.

Modifications.—The course of the motion of a Geneva mechanism is determined by the number of stations, or by the partial movement of the driven gear. Several modifications are possible, however, which make the mechanisms more flexible. Fig. 13, herewith, shows a normal type of driven gear with four slots. The driving gear, however, is equipped with three equally-spaced rollers and three locking segments. In each third of a revolution of the driving gear, the driven gear makes a quarter revolution, and the cycle is repeated after an additional one-third revolution of the driving gear. The proportion, ν, of motion in one cycle is, therefore, trebled. If that increase in ν is permissible, the gear shown in Fig. 13 can replace those shown in Figs. 4 to 7; the speed of the driving shaft can be reduced to a third, with correspondingly reduced velocities and accelerations of the driven parts.

If the number of equally-distributed driving rollers is m, the ratio ν has m times the value for a normal mechanism. Since it cannot exceed 1, $m\frac{n-2}{2n} \leqslant 1$, or

$$m \leqslant \frac{2n}{n-2} = 2 + \frac{4}{n-2}. \quad . \quad (19)$$

The number m must be an integer. Its maximum value in any particular case is indicated in Table II as $m_{\text{max.}}$; more than two rollers are possible only if the driven gear has six or less stations.

If there are four stations, $m_{\text{max.}} = 4$, which is exactly the value of the right-hand side of (19). In this case, illustrated in Fig. 14, herewith, there are no standstills. At the moment when a roller is leaving one slot, another roller is entering the next slot. The driven gear is regularly brought to zero velocity, without, however, remaining at rest, and no locking devices are required.

The rollers of the driving gear need not be equally spaced. In the case shown in Fig. 15, herewith, there are three rollers in the driving gear, and four slots in the driven gear. Each movement occupies 90 deg. of rotation of the driving gear (determined by $n = 4$), and the driven gear is always indexed by 90 deg. There is a standstill of 15 deg. between the action of rollers A and B, a standstill of 30 deg. between the action of rollers B and C, and a standstill of 45 deg. between the action of rollers C and A. The duration of the individual standstills can be chosen arbitrarily (including the value zero), as long as their sum is, in the case under consideration, 360 deg. $-$ (3 $\times$ 90 deg.) $=$ 90 deg. For n stations, and m driving rollers, the sum is $180 \left(2 - m\frac{n-2}{n}\right)$ deg. The number of irregularly-distributed rollers cannot exceed that determined from (19) for regularly distributed ones. The application of Geneva mechanisms having regular driven gears, but irregularly arranged driving rollers, is restricted.

In the case of three slots in the driven gear, (19) indicates $m \leqslant 6$ equally-spaced rollers. When $m = 1$, the case is that of the normal Geneva mechanism. At the other extreme, a driving gear with six rollers does not permit of irregularity in the arrangement of the rollers, as it leaves no standstills. Driving gears with two, three, four or five irregularly-spaced rollers are possible. It should be borne in mind, however, that the kinematic properties of mechanisms with three slots have been shown by the example to be unfavourable. For mechanisms with four or five slots, the number of irregularly-spaced rollers is two or three, obtained by considerations analogous to those above. If there are six or more slots, the driving gear can have only two unequally-spaced rollers.

As a further modification, Geneva mechanisms can be designed to give unequal periods of motion, in which case the partial movements of the driven member also vary. The pitch radii of the driving and driven gears must be varied within the same gear, as shown in Fig. 16, opposite. Roller and slot A correspond to $n_A = \frac{180}{\beta_0} = \frac{180}{52\frac{1}{2}} = \frac{24}{7} = 3\frac{3}{7}$ stations; roller and slot B correspond to $n_B = \frac{180}{60} = 3$ stations; roller and slot C correspond to $n_C = \frac{180}{67\frac{1}{2}} = \frac{8}{3} = 2\frac{2}{3}$ stations. Thus n need not be integral and, in the case of roller and slot C, n is even smaller than 3. The angular velocity and acceleration near the central position, therefore, are rather high. During one revolution of the driving gear, the driven gear makes one revolution in three stages. Fig. 17, opposite, shows the course of one cycle, but schematically only, as the lines of motion actually are not straight.

Fig. 18, opposite, shows an irregular Geneva mechanism with four slots and two rollers. During two revolutions of the driving gear, the driven gear makes one revolution in four stages. Although the slots include equal angles of 90 deg., the partial movements of the driven gear are alternately $2 \times 37\frac{1}{2}$ deg. $= 75$ deg., and $2 \times 52\frac{1}{2}$ deg. $= 105$ deg. The corresponding angles of the driving gear are 105 deg. and 75 deg., respectively, separated by standstills of 120 deg. and 60 deg. Geneva mechanisms with varying partial movements, like those with irregularly spaced driving rollers, are of limited application.

In the case of three slots in the driven gear, only 1, 3, 6, etc., rollers are to be considered. With one roller the case is that of the normal Geneva mechanism. If there are three rollers, the angle of $2\,\beta_0$ of the driven gear corresponds, for any partial movement, to the angle $2\,\alpha_0 = 180$ deg. $- 2\,\beta_0$ (formula 2) of the driving gear. Whatever the values of the individual three angles β_0, the sum of the values of $2\,\beta_0$ is 360 deg., and the sum of the three angles $2\,\alpha_0$ is (3 $\times$ 180 $-$ 360) deg. $=$ 180 deg. The standstills occupy the remaining 180 deg., which need not necessarily be divided into three equal parts, although, in Fig. 16, they are equal. If there are six rollers, the driven gear makes two revolutions per revolution of the driving gear. The sum of the six angles $2\,\beta_0$ is 720 deg.; the sum of the six angles $2\,\alpha_0$ is (6 $\times$ 180 $-$ 720) deg. $=$ 360 deg., so that there cannot be standstills. If more than six rollers were envisaged, the sum of the angles $2\,\alpha_0$ would exceed 360 deg. Thus only three and six rollers need be considered.

In the case of four slots, 2, 4, etc., rollers may be considered. One revolution of the driving gear with two rollers corresponds to half a revolution of the driven gear. The sum of two angles $2\,\beta_0$, corresponding to one revolution of the driving gear, is 180 deg.; the sum of the two angles $2\,\alpha_0$ is (2 $\times$ 180 $-$ 180) deg. $=$ 180 deg., and the remaining 180 deg. can be divided into two standstills. If a driving gear with four rollers is considered, the sum of the four angles $2\,\beta_0$ is 360 deg., and the sum of the four angles $2\,\alpha_0$ is (4 $\times$ 180 $-$ 360) deg. $=$ 360 deg. A mechanism of this kind, therefore, can only be used if there are no standstills. More than four rollers are not possible.

In the case of five slots, the sum of five angles $2\,\alpha_0$ is (5 $\times$ 180 $-$ 360) deg. $=$ 540 deg. As the prime number 5 does not permit of less than five rollers, irregular mechanisms are not possible. The same applies to any higher uneven number, whether it is prime or not. In the case of six slots, the sum of six angles $2\,\alpha_0$ is (6 $\times$ 180 $-$ 360) deg. $=$ 720 deg. If there are no standstills, one cycle comprises two revolutions of a driving gear with three rollers. If standstills are required, there remains only the possibility of two rollers. It will be found by similar considerations that, for higher even numbers of slots, Geneva mechanisms with unequal durations of the partial movements of the driven gear are possible only if there are two rollers.

In designing Geneva mechanisms of the types shown in Figs. 16 and 18, Table II is not sufficient if n is not an integer. The relevant dimensions can be found graphically, or by means of calculations. For example, the design of a mechanism similar to that shown in Fig. 18, with a centre distance $a = 10$ in. may be considered. The roller A and the two slots A correspond to $n_A = \frac{180}{\beta_0} = \frac{180}{52\frac{1}{2}} = \frac{24}{7} = 3\frac{3}{7}$ stations, an entry not included in Table II. The radii of the driving and driven gears are

$$r_{1A} = a \sin \beta_0 = 10 \sin 52\tfrac{1}{2} \text{ deg.} = 7{\cdot}934 \text{ in.},$$
$$r_{2A} = a \cos \beta_0 = 10 \cos 52\tfrac{1}{2} \text{ deg.} = 6{\cdot}088 \text{ in.},$$

and the distance between the centre of the driven gear and the inner end of slot A must be smaller than

$$s_A = a\,(1 - \sin \beta_0) = 10\,(1 - \sin 52\tfrac{1}{2} \text{ deg.}) = 2{\cdot}066 \text{ in.}$$

Similarly, for the roller B and the two slots B corresponding, $n_B = \frac{180}{37\frac{1}{2}} = \frac{24}{5} = 4\frac{4}{5}$ stations.

$$r_{1B} = 10 \sin 37\tfrac{1}{2} \text{ deg.} = 6{\cdot}088 \text{ in.},$$
$$r_{2B} = 10 \cos 37\tfrac{1}{2} \text{ deg.} = 7{\cdot}934 \text{ in.},$$
$$s_B = 10\,(1 - \sin 37\tfrac{1}{2} \text{ deg.}) = 3{\cdot}912 \text{ in.}$$

A certain freedom of choice is available in designing irregular Geneva mechanisms but, as a rule, the partial movements of the driven gears should not differ greatly, otherwise the means for locking the gears assume unfavourable shapes, and locking may even become impossible.

Design and Machining.—The pins for the driving rollers may be secured at one end (Figs. 4 and 5) or at both ends (Figs. 6 and 7) to the body of the driving gear. The rollers should preferably be made of hardened steel. To reduce friction between the locking drum and the locking shoes, it is advisable to make one member of steel and one of cast iron. In the case of a large driven gear, the latter is preferably the cast-iron one. This case will arise, for instance, on dial-feed presses having a vertical shaft (as in Figs. 4 and 5), where the lower side of the casting forms the Geneva wheel and the upper surface is provided with T-slots for clamping down the tools. The angle during which the locking drum is inoperative, or the angle over which the locking drum is recessed, is (360 deg. $- \gamma$). The shape of the recess must be designed in such a way that it does not impede the motion of the driven gear. Machining of a Geneva wheel is not difficult as the contours are formed by circles and straight lines. The backlash between the rollers and slots should be kept to a minimum.

(*To be continued.*)

"DRI-POR" METHOD OF REPAIRING CONCRETE PILES: ERRATUM.—In the article on this subject which appeared in our issue of February 22 we regret that the name of the firm was incorrectly given in the illustration headings on pages 237 and 240. It should have been the Masonry Resurfacing and Construction Company, as stated in the text of the article.

THE INSTITUTE OF METALS.

(*Continued from page 424.*)

CONTINUING our report of the annual general meeting of the Institute of Metals, we now deal with the proceedings that took place on Wednesday, March 26, when two scientific and technical sessions were held in the Park Lane Hotel, Piccadilly, London. The first of these, designated programme "A," took the form of an all-day general discussion of a symposium on "Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys." There were seven papers in the symposium, and they were presented by Mr. W. A. Baker, of the British Non-Ferrous Metals Research Association, as *rapporteur*.

EQUIPMENT FOR THERMAL TREATMENT OF METALS AND ALLOYS.

The seven papers contained in the symposium were as follows: "Electric Furnaces for the Thermal Treatment of Non-Ferrous Metals and Alloys," by Mr. C. J. Evans, Mr. P. F. Hancock, Dr. F. W. Haywood, and Mr. J. McMullen, all of whom are members of the technical staffs of leading firms of electric-furnace manufacturers; "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," by Mr. J. F. Waight, of the West Midlands Gas Board; "Batch and Continuous Annealing of Copper and Copper Alloys," by Mr. Edwin Davis and Mr. S. G. Temple, of Imperial Chemical Industries, Limited, Metals Division; "Bright Annealing of Nickel and its Alloys," by Mr. H. J. Hartley, of Messrs. Henry Wiggin and Company, Limited, and Mr. E. J. Bradbury, of the Mond Nickel Company, Limited; "Batch Thermal Treatment of Light Alloys," by Mr. C. P. Paton, of the Northern Aluminium Company, Limited; "Flash Annealing of Light Alloys," by Mr. R. T. Staples, of T.I. Aluminium, Limited; and "Continuous Heat-Treatment of Aluminium Alloys of the Duralumin Type," by Mr. Marcel Lamourdedieu, of the Société Centrale des Alliages Légers, Issoire (Puy-de-Dôme) and Paris.

On being called upon by the President, Dr. C. J. Smithells, M.C., the *rapporteur*, Mr. W. A. Baker, said that of the seven papers in the symposium, two were of a general character, describing the use of gas and electricity in the thermal treatment of non-ferrous metals and alloys. The remainder described typical furnaces for particular materials and discussed their advantages and limitations. All the papers overlapped to some extent, in that they naturally all included some account of the conditions which must be specified in annealing or otherwise heat-treating non-ferrous metals. The second paper, by Mr. J. F. Waight, on "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," briefly discussed heat transfer by convection and by radiation. The author gave a short account of the application of heat-transfer data to the design of efficient furnaces. A fairly long section discussed alternative gas-burner systems, describing particularly means of controlling the gas/air ratio and of controlling the rate at which the fuel was burned, both of which were, of course, very important for metallurgical reasons and for reasons of furnace efficiency. The author followed this with an account of furnace structures, dealing with the thermal capacity of the structures and the heat losses through the furnace walls. In this connection, he referred to some modern developments in refractory-based insulating bricks. He then went on to discuss furnace atmospheres and reactions to various non-ferrous metals, and followed this with an account of industrial methods for the purification of partially-burnt town gas, where this was used as a controlled atmosphere for bright or clean annealing. He referred very briefly to methods of removing sulphur from the gas, but that point was discussed more fully by other authors. He then described some modern gas-fired furnaces incorporating various means of mechanically handling a charge into the furnace and out of it, which illustrated the use of the various burners described. These included the radiant-tube type, designed to produce a gas-fired furnace similar in some characteristics to its electrical counterpart.

The first section of the paper by Mr. Evans, Mr. Hancock, Dr. Haywood and Mr. McMullen outlined the heat treatments used commercially for magnesium- and aluminium-base alloys. In describing a typical salt bath for the solution heat-treatment of aluminium-base alloys, they called attention to the hazards associated with this type of equipment and the disadvantages from the adherence of salt to the work, and they emphasised that the main reason for its use was the facility with which the work could be quickly heated and held for short times at closely-controlled temperatures. At the temperatures involved in heat-treatment of light alloys, convection was much more important than radiation, and the authors described various furnaces with forced air circulation, including both batch and continuous types. They also described special types designed for flash annealing, where rapid heating of the work was required. In one furnace, radiant heating was completely eliminated by separating the heating chamber from the working chamber, so that the charge was heated by convection only. From the operational point of view, equipment of this type offered a number of advantages. In this paper and in some of the others, great emphasis was laid on the design of conveyor mechanisms, particularly for light alloys, because of the importance of avoiding damage to the surfaces of these relatively soft materials. A striking statement made was that development work on a completely mark-proof conveyor equipment was now completed.

The second section of the paper described electrically-heated furnaces for copper-base alloys, among them a somewhat unusual type, for annealing copper tubes in controlled atmospheres. It was a batch furnace in which the tube charges were withdrawn from the hot furnace into a cooling chamber through which the controlled atmosphere was circulated as a cooling medium. From the description, it was not clear whether any attempt was made to effect heat transfer from the cooling work to the work awaiting heat-treatment in the adjoining chamber, but a little arithmetic suggested that, if this could be done without detriment to the quality of the controlled atmosphere and without incurring other obvious problems, at least 40 per cent., and probably a good deal more, of the energy supplied to this furnace could be conserved.

In introducing the remaining papers it was convenient to refer first to the older non-ferrous metals, copper-base and nickel-base alloys, on the thermal treatment of which the symposium contained two papers. The first, by Mr. Davis and Mr. Temple, outlined the metallurgical changes which took place when copper-base alloys were annealed or stress-relieved. While the authors referred to solution and precipitation heat-treatment for certain copper-base alloys, they rightly emphasised that, for the bulk of wrought copper-alloy products, the only commercially-important thermal treatments were those designed to soften, or partially to soften, the cold-worked materials. In contrast to what subsequent authors said about light metals, they showed that, for most of these materials, close control of heating rate and heating time was not essential, provided reasonably close temperature control was exercised; and, largely for this reason, batch-annealing equipment was regarded as satisfactory, yielding materials with suitable grain sizes. The authors emphasised that batch equipment was very flexible, and that, while continuous annealing offered certain advantages, these could be realised, in practice, only where large quantities of similar products had to be treated.

The authors discussed at some length the effects of some gases on copper-base alloys, and described the practical application of protective atmospheres, including steam, cracked ammonia and ammonia derivatives and partially-burnt town gas. On the last point they referred briefly to recent developments in which the gas : air ratio was controlled to produce a protective atmosphere which was circulated over the charge for direct heating. They pointed out that the operating conditions were critical, because the requirements of the protective atmosphere might not be those best suited to maintain the required temperature and give good thermal efficiency. Nevertheless, they stated that the thermal efficiency might be considerably higher than for some alternative methods of annealing in bright-annealing atmospheres. The authors discussed the special problem of annealing brass in protective atmospheres, stating that the conditions to be fulfilled for bright annealing included the use of temperatures low enough to prevent undue loss of zinc, and withal the provision of a non-oxidising atmosphere. Apparently these conditions were too onerous to be fulfilled in practice, and the normal procedure was to clean anneal, and then lightly pickle to remove the thin film of zinc oxide.

The next paper, by Messrs. Hartley and Bradbury, covered rather a special field, namely, the development of continuous-annealing furnaces for the bright and clean annealing of nickel-base alloys and of certain copper alloys containing substantial amounts of nickel. The nickel-chromium alloys were of special interest, and the authors described the development of special equipment for the bright strand-annealing of wire and strip in hydrogen or cracked-ammonia atmospheres and clean annealing in atmosphere derived from burnt town gas, and, in considerable detail, the elaborate treatment necessary to remove sulphur from annealing atmospheres used for nickel-chromium alloys. The use of a light-weight resistor tube as the heating element and cooling chamber in the furnace described for these nickel-chromium alloys entailed the use of a high-speed temperature controller actuated by a photo-electric pyrometer. In commenting on the shortcomings of existing equipment, and especially of ancillary gear for atmosphere generation, Messrs. Hartley and Bradbury indicated that they would welcome improvements in conveyor belts, but the temperatures involved were high and the service conditions were very onerous. Incidentally, the authors offered some very sound, commonsense advice on the location of furnaces in which controlled atmospheres were used.

The remaining three papers all dealt with equipment for the heat-treatment of light alloys. The first of these, by Mr. Paton, was concerned with the conventional types of batch furnace. He described the effects of annealing, solution-treatment, precipitation-treatment and stabilising treatment on light alloys, and went on to discuss the technical considerations affecting the selection of the detailed design of batch furnaces for various heat treatments. For a number of reasons electricity was preferred to gas heating, though gas- or oil-fired furnaces were used for some of the less exacting operations, such as pre-heating prior to working. The author discussed the effect of furnace atmosphere and the fact that some alloys tended to blister in moist atmospheres at high temperatures, and he said that this hazard arose even in electrically-heated furnaces. At lower temperatures, where the hazard was less serious, direct gas-fired furnaces could be used, but care must be taken to avoid condensation difficulties and stains. He also discussed the disadvantages of salt-bath and air furnaces. Mr. Paton described a number of industrial batch furnaces, including direct and indirect gas-fired furnaces and an electric furnace, all for annealing slab and sheet, and the common factor in his criticism of these furnaces was that the rate of heating was unduly slow for certain materials, the grain size of which, in annealing, was very sensitive to heating rate. This consideration obviously had a major influence on the selection of furnaces for light-alloy heat-treatment, and the advantage of batch-type furnaces, namely, their flexibility, was likely to be outweighed by the disadvantage of slow heating.

The paper by Mr. Staples dealt exclusively with equipment designed to ensure rapid heating in the annealing of light alloys. The author described at considerable length the metallurgical changes involved when cold-worked light metals were heated, and, as he explained in his paper, some of the alloys were very sensitive to the rate of heating, and rapid heating to the annealing temperature markedly affected the grain size of the annealed product. With other alloys, rapid heating was desirable for other reasons; it might minimise the solution of hardening constituents and facilitate the inter-stage softening of the material thereby. In other cases it was desirable to use rapid heating and to heat-treat for a short time to minimise diffusion between the core and cladding in clad alloys. Mr. Staples discussed the factors involved in the design of an air furnace to produce this desired rapid heating, and showed how such considerations were applied in the design of a flash-annealing furnace for light-alloy sheet. The use of superheated air to increase the rate of heating entailed special consideration to the circulation of the air over the charge and close control of conveyor speed and other variables.

The paper by Mr. Lamourdedieu was in an even more special category. He described a furnace still under development for the continuous solution heat-treatment of Duralumin-type alloys. The sheet was fed into a furnace and first heated rapidly by induction to a temperature near to the solution heat-treatment temperature, and it was then passed, by suitable rollers, to a furnace chamber in which it remained at the desired temperature for a few minutes, before emerging directly into a quenching tank. The author described the equipment in some detail, including the modifications in design necessary to avoid preferential heating of the edges of the strip, and showed the temperature distribution across a strip under suitable conditions of operation. His paper included data for the properties of Duralumin-alloy strip heat-treated in this furnace.

Discussion.

Mr. W. A. Fowler, who opened the discussion, said that the progress which had been made in the development of light alloys, and also in the knowledge of the importance of the various forms of heat-treatment, was evident. There was a growing call for such exacting performance from the furnaces as to tax the ingenuity of the furnace builders. The advance of the furnaces must keep pace, however, with the advance in the rolling mills. There seemed to be two distinct schools of thought on the heat-treatment of extruded sections, the one which proclaimed the virtues of the vertical furnace and the other which advocated the horizontal furnace. The vertical furnace was largely standard practice in America and was becoming increasingly popular in this country. In many instances it had superseded the horizontal batch type. The horizontal continuous furnace had such protagonists as the Issoire works of the Société Centrale des Alliages Légers. Mr. Paton claimed that the vertical furnace gave a product free from kinks imparted by the supports in the horizontal furnace, but there was a certain amount of distortion when quenching sections of unequal dimensions. He stated that the loading and unloading of the furnace were more laborious than for a horizontal furnace, and from knowledge acquired from other sources there was also a doubt as to the temperature control. It seemed that the vertical furnace was not all that could be desired in this respect. On the other hand, it had been said that the quenching associated with the horizontal furnace, whether by sprays or by tank immersion, resulted in such distortion as to make it extremely difficult, if not impossible, to straighten the section by any subsequent treatment. The capital costs involved in the installation of a vertical furnace were very formidable indeed, and the method of loading and unloading was both cumbersome and costly, whereas, with a horizontal furnace of the continuous type, it was possible to charge direct from the extrusion press as well as to have a direct discharge of the section either into a spray box or a quenching tank. The capital cost, and the operational costs, were lower than for the vertical furnace. It might be that each system was superior in its own field of application.

The need for the flash-annealing of light alloy sheet was well brought out in the paper by Mr. Staples. There were now a number of continuous flash-annealing furnaces for single sheets in operation in this country. The economic disadvantages, compared with batch annealing were well recognised and, were it not for the fact that a rapid rate of heating in certain materials for metallurgical reasons was essential, it was doubtful whether these furnaces, for the light-metal industry at least, would ever have been developed at all. For the same metallurgical reasons as obtained for sheet, it was desirable to apply a flash-anneal to strip in coil form, and no doubt a continuous furnace for this purpose would be available before long. There was some difference of view, however, as to whether, if elec-

DIESEL-DRIVEN SHOT-FIRER'S CARRIAGE.

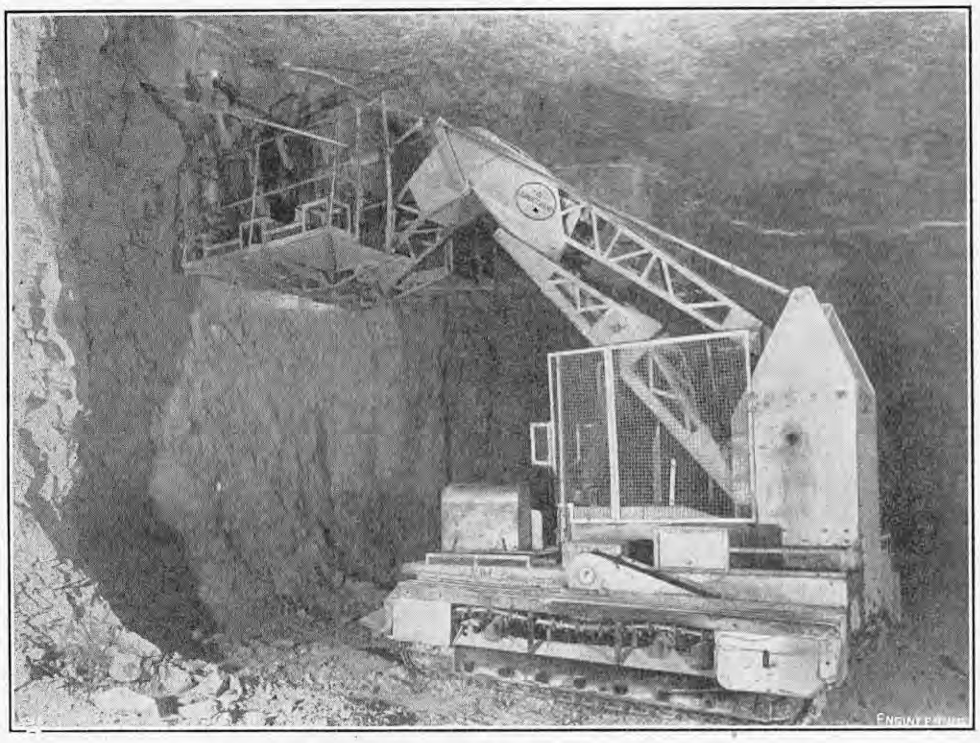


FIG. 1. CARRIAGE AT WORKING FACE.

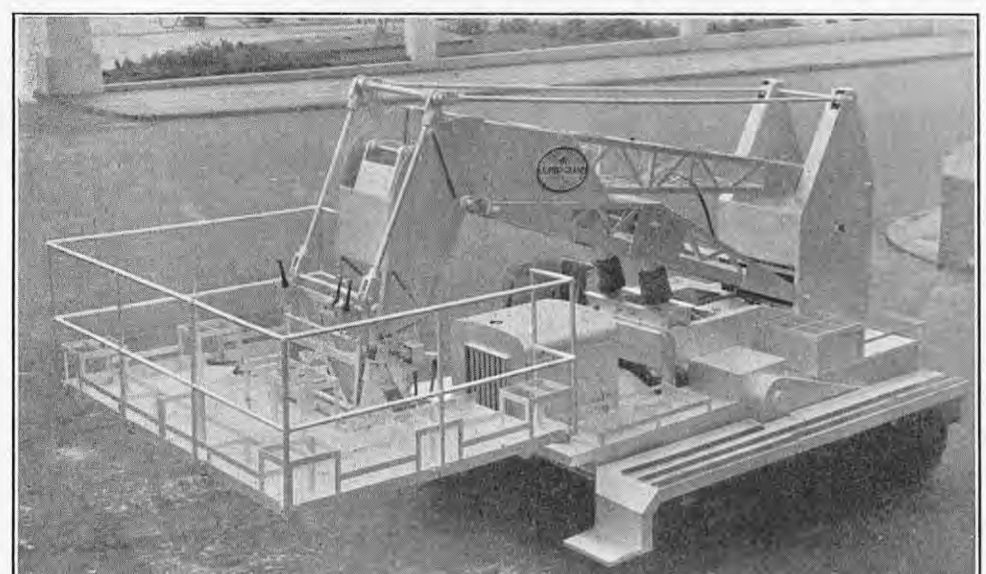


FIG. 2. CARRIAGE ON SURFACE PRIOR TO DISMANTLING.

tricity were used, the heating should be by radiation from electric-resistance elements, perhaps assisted by convection, or by induction heating. There were certain metallurgical advantages in the rapid heating achieved in the salt bath, and no doubt for this reason their retention was more or less assured, but it was a particularly striking fact that the vertical forced-air furnace had been installed in recent years at important centres, among which were the Issoire works. His firm (The British Aluminium Company, Limited) had had experience of both types of furnace and had a fairly good idea of the limitations of both. It was realised that the salt bath had fairly high operating costs, but they had not found that the forced-air circulation furnace was by any means a cheap unit.

(*To be continued.*)

INCREASE IN COPPER PRICES.—An Order made by the Minister of Supply—The Copper, Zinc, etc., Prices Order, 1952, S.I. 1952 No. 729—increases the maximum controlled prices of secondary unwrought copper by 4*l*. per ton; copper scrap, gilding metal, and gun-metal by 3*l*. per ton; and cupro-nickel and brass by 2*l*. per ton. It also consolidates and revokes the earlier Non-Ferrous Metals Prices Orders. It came into effect on April 8, and is on sale at H.M. Stationery Office. [Price 4*d*.]

DIESEL-DRIVEN SHOT-FIRER'S CARRIAGE FOR ANHYDRITE MINE.

THE Billingham works of Imperial Chemical Industries, Limited, claimed to be the largest chemical factory in the British Empire, and the second largest in the world, were founded during the 1914-1918 war by the Government of the day, for the purpose of making synthetic ammonia for use in connection with munitions. By the time the war ended, however, little progress had been made with the development of the plant and, as there was no further need for munitions, the site was put up for sale. It was taken over by Brunner, Mond and Company, one of the original constituent companies of Imperial Chemical Industries, who developed it for the production of synthetic nitrogenous fertilisers. Sulphate of ammonia, formed by the reaction of ammonia with anhydrite, was the first fertiliser to be produced, a process for which the factory is particularly suitable as there are extensive deposits of anhydrite below the factory areas.

Small-scale production started early in 1924, but at first the anhydrite was obtained elsewhere. Development of the plant was rapid and, in 1926, mining operations were started on the Billingham site with the sinking of two 13-ft. diameter shafts. Development of the mine was equally rapid, the production of anhydrite rising steadily over the years, but towards the end of the Second World War it became apparent that, if the increasing demands were to be met, mining techniques would have to be overhauled and special equipment installed. Accordingly, a programme of modernisation was worked out and this envisaged the use of 150-h.p. self-tipping Diesel trucks in place of rail haulage; the introduction of the largest and heaviest types of Joy loaders; the installation of an underground primary-crushing plant; the provision of mobile carriages for the shot-firers and roof-scalers; and the employment of a new type of mobile drilling carriage fitted with electric rotary drills. Inception of this programme was held up to a certain extent by the shortage of materials; even so, remarkable progress has been made, the Diesel trucks and Joy loaders being at work and the pre-crushing plant installed, the latter undertaking involving excavating underground to a depth of almost 90 ft.

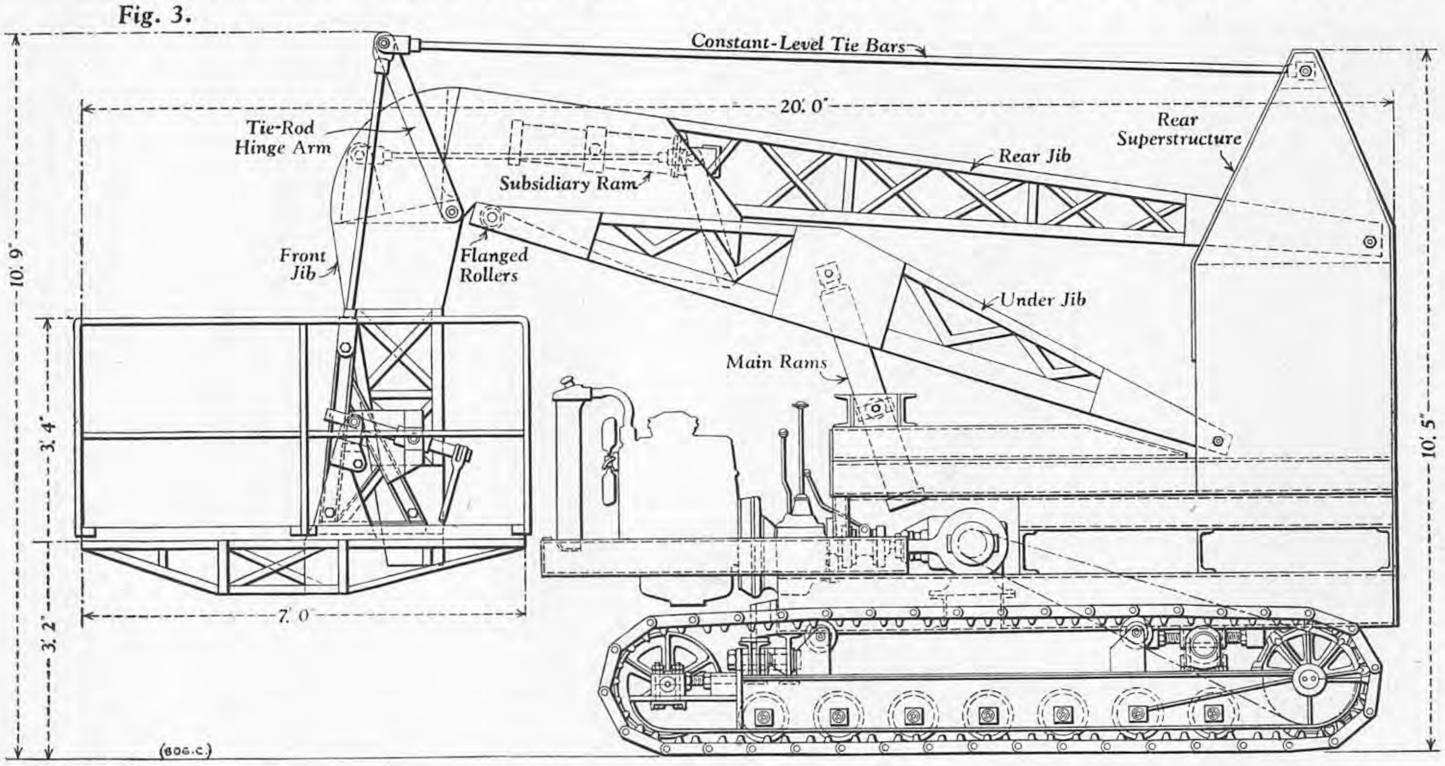
Recently, the work of modernisation was taken a step further with the introduction of the mobile shot-firer's carriage. Its use has been necessitated by the introduction of vertical-face mining in place of the top-heading and bench method, the latter having proved unsatisfactory for efficient use to be made of the Joy loaders. Vertical-face mining necessitates blasting a face 24 ft. wide and, on an average, 18 ft. high; this requires the drilling of approximately 60 holes which subsequently have to be charged with electric detonators, explosive and stemming prior to blasting, and it is for the latter purpose that the shot-firer's carriage has been designed. It is illustrated in Figs. 1 and 2 on this page and in Figs. 3 and 4, on page 458, Fig. 1 showing the unit at the working face, Fig. 2 a general view of the machine above ground, Fig. 3 a side-elevation drawing, and Fig. 4 details of the platform and platform-control gear. It consists basically of a self-propelled mobile platform for lifting men and materials to the various positions required for charging the drilled holes with detonators, explosives and stemming. In particular, it has been designed to reduce the manual effort involved in shot-firing operations and to increase the safety of the men engaged in this work. To facilitate maintenance work, the design incorporates as many as possible of those components used in the Diesel-driven drillers and scalers still in the course of development.

As will be seen from the illustrations, the unit is mounted on full-track equipment. At first, difficulties were experienced in obtaining a suitable chassis, but eventually Messrs. Ruston-Bucyrus, Limited, came to their aid by supplying the tracks, axles, steering clutches, cross-shaft and cross-shaft bearings of their type 27T blast-hole drill equipment. The tracks for this equipment have an overall length of 11 ft. 9 in., with an overall width over tracks of 9 ft. 10 in. Standard 10-in. treads are fitted and the track frames are tied together by a solid circular axle at one end and by a pivoting axle at the other. The chassis frame consists of four 10-in. by 3-in. channels, which at one end are joined to the solid rear axle through adjustable axle blocks but are tied together by a 10-in. by 5-in. joist at the other end, the centre of the joist being fitted with a 2-in. diameter pin which forms the pivot point for the front axle. Thus the suspension allows relative vertical displacement of the tracks without the full effect being transferred to the chassis.

Unfortunately, the power unit and transmission assembly fitted to the Ruston-Bucyrus 27T could not be incorporated conveniently in the general design. The carriage is fitted, therefore, with a Perkins P4 Diesel engine and a Ford type-7V four-speed and reverse gearbox. The engine is a four-cylinder unit developing 34 brake horse-power at 1,500 r.p.m., the maximum governed speed. Only first and reverse ratios are used in the gearbox, second, third and fourth speeds being rendered inoperative. The drive from the gearbox is taken to the steering clutches through a bevel-reduction gearbox designed by Messrs. Hardypick, Limited, which takes the place of the centre cross-shaft

DIESEL-DRIVEN SHOT-FIRER'S CARRIAGE FOR ANHYDRITE MINE.

Fig. 3.



originally incorporated in the Ruston-Bucyrus transmission. Standard Ruston-Bucyrus steering clutches and brakes are used, as fitted to the 27T blast-hole drill equipment. Each consists of a separate brake drum and a 4-to-1 reduction gearbox of the epicyclic type, the braked annulus acting as the steering clutch. Final drive to the track sprockets is by roller chains. To provide simultaneous disengagement of the clutch and application of the brake, the clutch and brake linkages are connected.

During the design stage, it had been hoped to employ the constant-level platform mechanism used by Messrs. F. Taylor and Sons (Manchester), Limited, on their "Jumbo" crane, for elevating the shot-firing platform. This, however, was found impracticable as, at the time the design was under review, movement of the front jib of this crane was tied to that of the rear jib. Accordingly, a design was prepared which consists of a modified Jumbo crane-jib assembly arranged so that it incorporates constant-level tie bars and a shortened front jib actuated separately by a hydraulic ram. This arrangement will be clear from Fig. 3, from which it will be seen that the front jib is hinged to a rear jib and can be moved about its hinge by a hydraulic ram located inside the rear jib. The rear jib, in turn, is pivoted to a superstructure at the rear of the chassis frame and rests upon flanged rollers fitted to the top of a further jib known as the under jib, which pivots about a point located at the base of the superstructure. It will be appreciated that, with this arrangement, movement of the under jib causes corresponding movement of the main, or rear, jib. The under jib is raised by two hydraulic rams, the cylinders of which are connected through trunnions to the chassis frame and the rams to the centre of the jib.

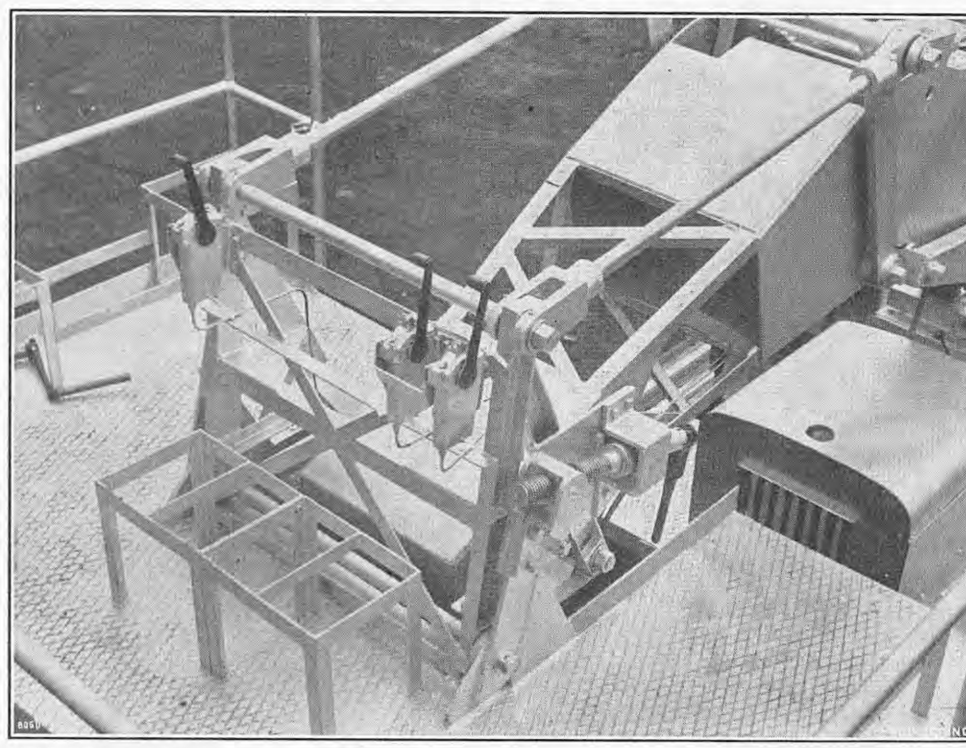


FIG. 4. PLATFORM AND REMOTE-CONTROL GEAR.

To obtain constant platform level regardless of the working height, the platform has integral with it a triangulated structure. A point at the top of this structure is joined to the end of the constant-level tie-rod system, and a further point at its base acts as a pivot point for the front jib, the design being such that the distance between these two points is equal to the distance between the pivots which join the rear-jib and tie-rod system to the rear superstructure and also equal to the distance between the pivot points of the tie-rod hinge-arm at the joint between the front and rear jibs. Furthermore, the pivots are so disposed that a line projected between those which join the front jib and tie rod to the platform is parallel to a line projected between those which join the rear jib and tie rod to the rear superstructure. Both these projected lines are, in turn, parallel to the axis of the tie-rod hinge arm; the tie rods and their respective jibs, therefore, always lying parallel to each other regardless of their elevation, and the platform, as a consequence, maintained at a constant level relative to the chassis. To permit the platform attitude to be changed, it is hinged to the front of the triangulated structure and secured thereto by a nut and screw mechanism; by turning the screw, the attitude of the platform may be adjusted relative to the front jib.

The rear superstructure and under jib are supported by a sub-frame, both the jib and sub-frame being substantially similar to those installed in the "Jumbo" crane. The base of the sub-frame is built up from 6 in. by 3 in. and 7 in. by 3 in. channels, and the complete unit is bolted to the main chassis frame so that it can be dismantled easily when the machine is broken down for lowering into the mine. For the same reason, the rear superstructure, which forms the hinge attachment for the rear jib and tie-rod assembly, is bolted to the sub-frame. This structure is of welded construction, being built up from 2-in. by 2-in. by $\frac{5}{16}$-in. angles and $\frac{1}{4}$-in. plate, the design being such that it can incorporate ballast weights and a 10-gallon fuel tank. In general, the rear jib is similar in construction to that fitted to the "Jumbo" crane, but it is modified at the leading end to accept the ram which actuates the front jib. The front jib was designed by Messrs. Taylor and Sons for the shot-firer's carriage, the design allowing an extension piece to be fitted so that it can be converted to a scaling jib identical with that fitted to the scaler's carriage. The platform is 9 ft. wide and 7 ft. long and, in plan view, is U-shaped. Handrails and toe-boards are provided and a series of racks is disposed round the edges of the platform to hold the explosives and clay containers. Storage racks are also provided on the chassis.

The hydraulic system is fed by a Keelavite type GH.104.C gear pump driven through a Martin-Harper power take-off from the gearbox. The pump is rated for a maximum pressure of 2,000 lb. per square inch and is arranged to deliver fluid to

MELTING CAST-IRON BORINGS IN CUPOLAS.

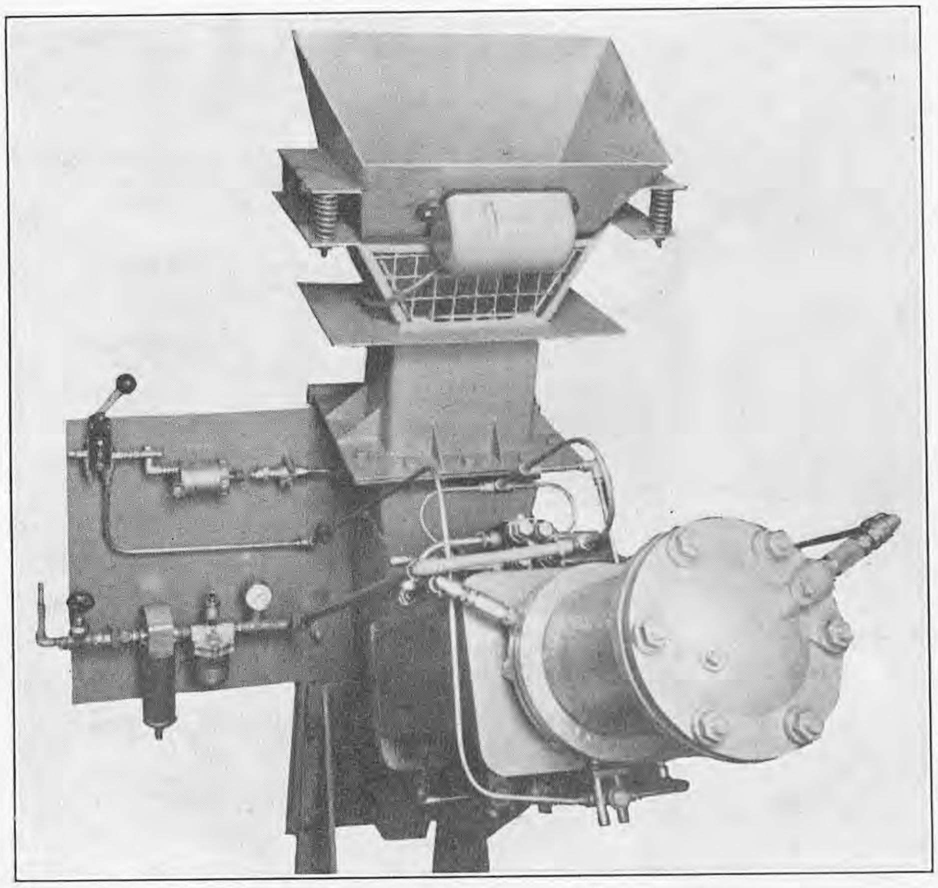


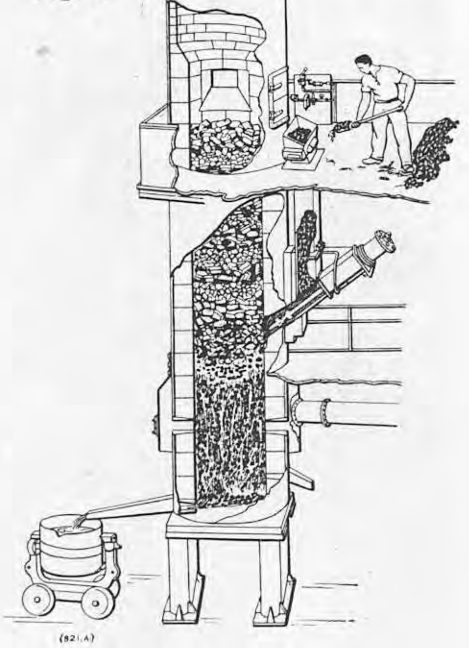
Fig. 1. Swarf-Feeding Device and Control Panel.

Fig. 2. Feeding Swarf into Vibratory Hopper.

two Keelavite type-1007 selector valves, one valve serving the front-jib ram and the other valve the two main rams which work the under jib. Restrictors are fitted to the inlet to each ram and set so that, in the event of a pipe failure, the platform descends at a rate slow enough to safeguard the men and explosives. When the selector valves are closed, the pump delivers back into the supply tank, which is installed at a sufficient height to maintain a small static head at the pump inlet. With a 1-ton load distributed along the front edge of the platform, the maximum pressures required to operate the front and under-jib rams are 920 lb. per square inch and 600 lb. per square inch, respectively; the relief valve, therefore, is set to lift at 1,000 lb. per square inch. The rams, which were supplied by Messrs. Taylor and Sons, have a diameter of 5 in., with strokes of 33 in. and 23¼ in. for the front jib and under jib, respectively. The front-jib and under-jib selectors and engine accelerator and stop controls may be operated remotely from the platform. Three Exactor type-SL controls are used for this purpose, one for each jib selector and one for the combined engine-accelerator and stop control. They consist of transmitters and receivers coupled together by hydraulic tubing so that movement of the transmitter produces an identical response at the receiver. The platform controls can be seen in Fig. 4.

With the jibs in the travelling position, the height of the complete unit is 10 ft. 9 in. and the length 20 ft. The overall width is 9 ft. 9 in., and, on a flat smooth surface, the turning-circle diameter is 25 ft. The platform can be raised from 3 ft. 2 in. above ground level to 18 ft. above ground level, the average speed of lift being 9 ft. per minute. Forward maximum travelling speed is 1·25 miles an hour, and the carriage is ballasted to give travelling stability on gradients up to 1 in 3. With a 1-ton load on the platform, the unit can be operated at the face on gradients up to 1 in 4. During a demonstration, the carriage proved remarkably easy to operate and positive in its action, the platform being elevated to the required height by means of the twin main rams below the rear jib and kept close to the working face by manipulation of the subsidiary ram installed in the jib assembly. The carriage was produced as a result of close co-operation between the suppliers of the various components and Imperial Chemical Industries, Limited, who did much of the design work. The machine was constructed at the works of Messrs. F. Taylor and Sons (Manchester), Limited.

Fig. 3.



MELTING CAST-IRON BORINGS IN FOUNDRY CUPOLAS.

On an average, about 15 per cent. of the initial weight of an iron casting is removed during machining operations and, very often, a high proportion of the borings or swarf produced is lost to the foundry industry owing to the difficulty of melting this material economically and satisfactorily in the foundry cupola. The swarf cannot, of course, be charged directly into the cupola in the normal manner as the particles would be blown out again immediately by the upward flow of the blast and gases. At present, borings are dealt with by one of three methods, the most common, perhaps, being briquetting, in which some form of binding agent is usually employed. Another method is to put the swarf in cylindrical containers for charging into the cupola, a process usually referred to as "canistering." The third process is to remelt the swarf in an electric furnace. The first two methods are not always satisfactory, as briquettes are sometimes liable to break up and canisters to burst prematurely by the crushing action of the pig, scrap, coke and limestone constituting the remainder of the charge. The capital and maintenance costs of an electric furnace place the third method rather out of the reach of the smaller firms, which for many years past, and more particularly latterly, as a result of the mounting costs of raw materials and the shrinkage of supplies, have felt the need for a simple method of consuming, in their own foundries, the cast-iron borings produced in their machine shops.

A process has been devised by Messrs. Crofts (Engineers), Limited, Empire Works, Thornbury, Bradford, in which the swarf is fed directly into the cupola at a point well below the normal charging level and just above the melting zone, where the downcoming coke, limestone and solid metal of the charge prevent the borings from being ejected from the cupola. On a recent visit, we saw the apparatus in service. It is claimed that the equipment can be fitted to any cupola in 24 hours at a cost of 400*l*. The process is shown diagrammatically in Fig. 3, and the apparatus itself in Fig. 1, on this page. It consists essentially of an electrically-driven vibratory hopper on

OIL-WELL DRILLING EQUIPMENT FOR TUNISIA.

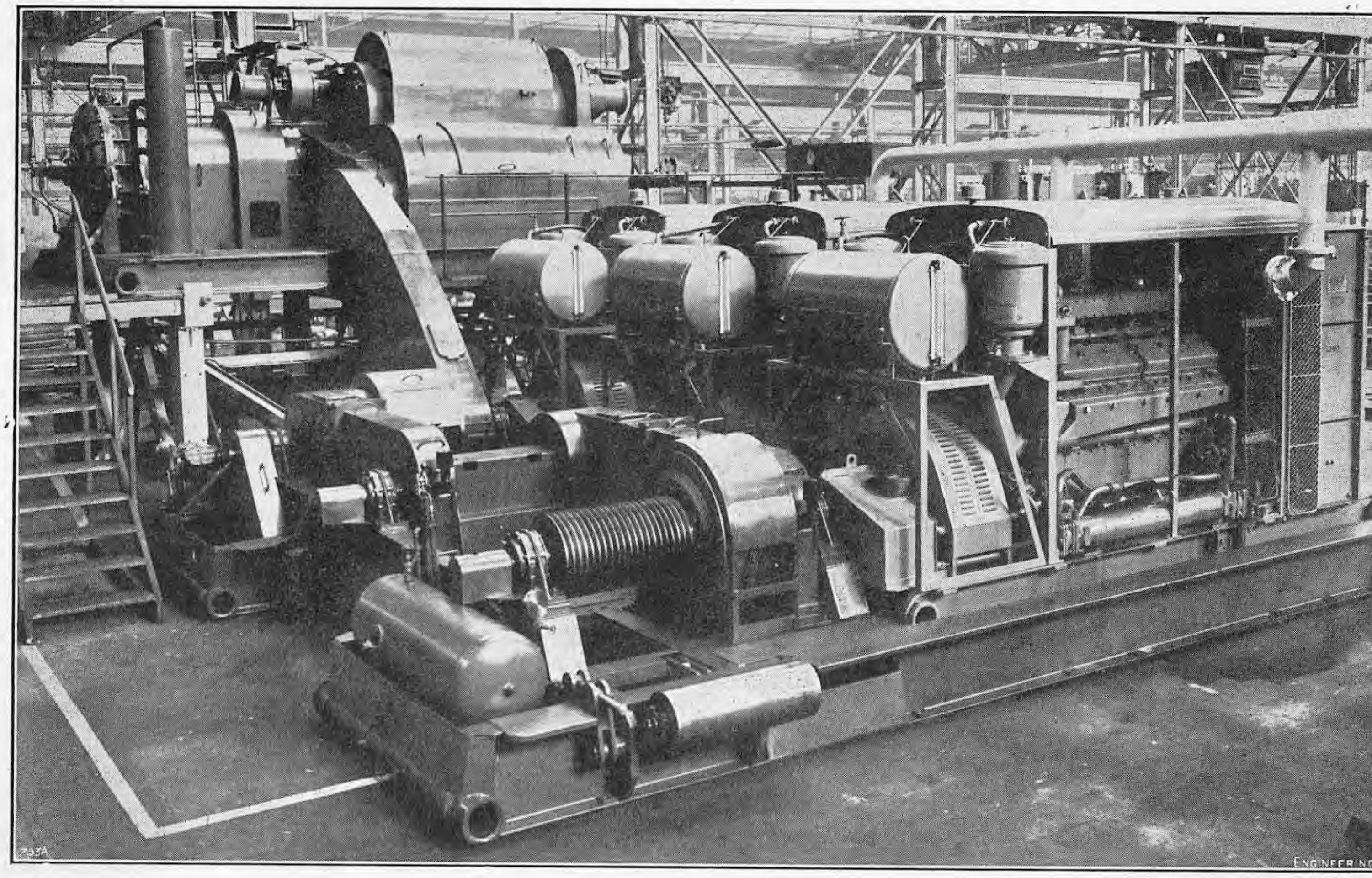
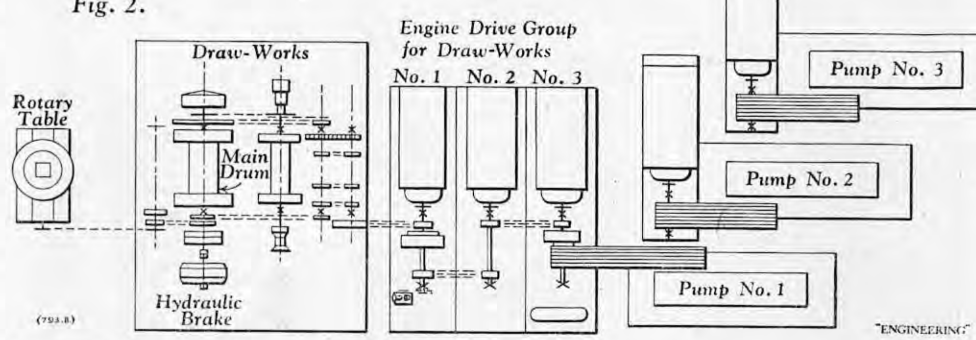


FIG. 1. DRAW-WORKS AND DRIVING GROUP IN THE MAKERS' WORKS.

the cupola stage and a pneumatic feed chamber situated at an angle of 40 deg. to the vertical wall of the cupola. Swarf is fed, by hand, into the hopper, as is seen in Fig. 2, and a vertical chute, normally some 5 ft. or 6 ft. in length, takes the material into the feed chamber below. It may be noted, in passing, that the apparatus shown in Fig. 2 has been set up for demonstration purposes only and this explains why its chute is only about 1 ft. long. A reciprocating ram in the feed chamber, as may be seen in Fig. 3, pushes the swarf into the cupola and into the spaces between the metal, coke and other descending solids. The borings immediately enter the melting zone and are rapidly heated to their melting temperature, thereafter merging with the molten metal and slag produced from the charge. The feed ram is a mild-steel rod having fin-like projections welded on to it, and the speed of its reciprocating motion can be adjusted to between 5 and 35 strokes per minute. The operation of the ram is regulated by means of a dwell valve on the control panel, which is seen on the left in Fig. 1. The ram is operated by compressed air taken from an 80 lb. per square inch pressure line in the foundry.

The chute and feeding chamber are never allowed to become empty and if, for any reason, the operation of the cupola is stopped, the resistance encountered by the ram automatically arrests the reciprocating motion and the ram is protected from possible damage by the swarf lying in front of, and around, it. When the machine is restarted it appears that any crust of partially-molten borings which may have formed on the inner side of the orifice bricks is easily dislodged by the operation of the ram. The orifice bricks are renewed every month and the operation may be accomplished in a few hours. The ram lasts about three months, on an average, after which the worn fins have to be replaced. The workshops of Messrs. Crofts produce about 40 tons of cast-iron borings a week and the whole of these are now returned to the cupolas for remelting; it is stated that the addition of swarf may be adjusted so as to constitute from 5 to 25 per cent. of the total metal charge. The wastage in the melting process is similar to that incurred in the normal cupola melting of pig iron, steel and scrap, namely, about 3 per cent. Experiments conducted by the firm, at Bradford, indicate that the savings realised when remelting iron borings at the rate of 40 tons a week represent an economy of 33⅓ per cent. in the consumption of pig-iron, purchased cast-iron scrap and steel scrap, on a total weekly melt of 200 tons.

Fig. 2.



OIL-WELL DRILLING EQUIPMENT FOR TUNISIA.

THE Royal Dutch Shell Group, in association with the Société de Recherche et d'Exploitation des Petroles en Tunisie, have been operating a "wild-cat" drilling plant close to Zeramedine, a small Arab village in Tunisia, some 45 km. south of Sousse. Known as Zeramedine No. 1, the drilling rig consists of an Ideal unit of type 100, made by the Oil Well Engineering Company, Limited, Cheadle Heath, Stockport, driven by three 100-h.p. Davey, Paxman Diesel engines. The hoisting winch, or "draw-works," as it is more commonly termed, which handles the drill pipe, casing and tubing, is conservatively rated for a power input of 800 h.p. and a drilling depth of 12,000 ft. In addition to handling the weight of the drilling string, the draw-works also transmits the drive to the rotary table, which turns the drill pipe and drilling bit. The unit is illustrated in Fig. 1, above, where it is shown erected in the works of the Oil Well Engineering Company, with the drive group lined up. The main hoisting drum is 26 in. in diameter and 46 in. between flanges, and has two water-cooled alloy-steel brake drums, 54 in. in diameter and 10 in. wide. A hydraulic brake controls the rate of fall of the drilling string when it is being lowered into the well, thus reducing the wear of the friction brakes.

Transmission of power through the draw-works is by precision chains running on sprockets having machined and hardened teeth. There are three forward speeds and one reverse speed and, as the drum is also provided with high and low gears, there are six hoisting speeds. The drive to the rotary table is through a friction clutch and a chain and sprocket assembly, so that the three speeds in the main transmission can be used to provide three drilling speeds. The friction clutches for the two drum speeds and the drive to the rotary table are operated by compressed air and controlled by simple levers at the driller's position. The sand-reel shaft, which is situated above the main shaft, carries a reel 14 in. in diameter and 46 in. between flanges for spooling the wire line on which instruments are lowered into the hole. Like the main drum, this reel is provided with two brake rims, the diameter in this case being 38 in. and the width 7 in. The sand-reel shaft is also fitted at one end with a break-out cathead and at the other end with a spinning and make-up cathead. In principle, the catheads consist of small spools or capstan heads, the break-out cathead being used for pulling on the end of the large pipe wrenches employed when unscrewing the drill pipe as it is hoisted from the hole, and the spinning and make-up cathead for a similar purpose when assembling the pipes as they are returned into the hole. Both catheads are engaged by compressed air, the controls being placed within easy reach of the driller.

The hoisting winch and associated equipment is mounted on a platform of welded construction, which is built up from steel plates and standard sections. The

OIL-WELL DRILLING EQUIPMENT FOR TUNISIA.

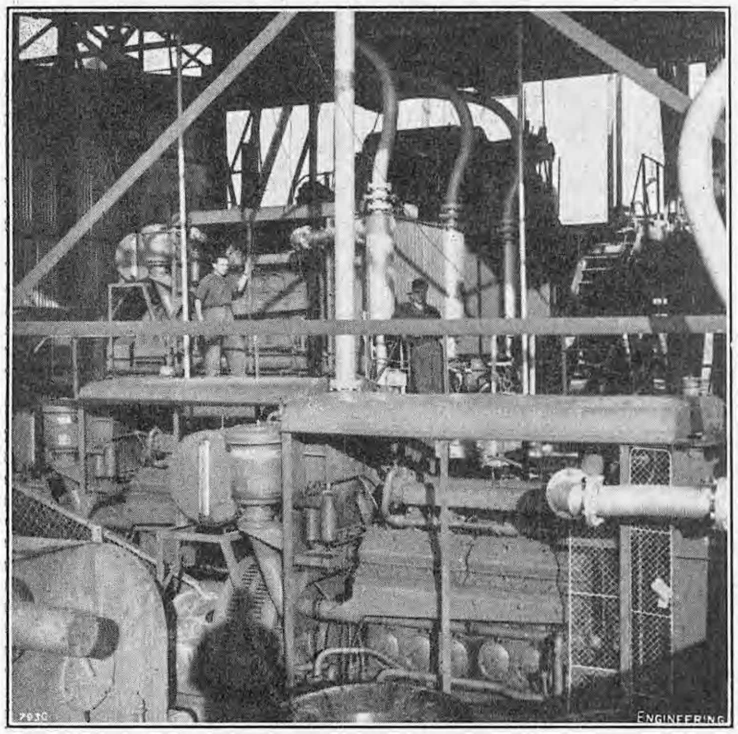


Fig. 3. General View of Plant Erected in Tunisia.

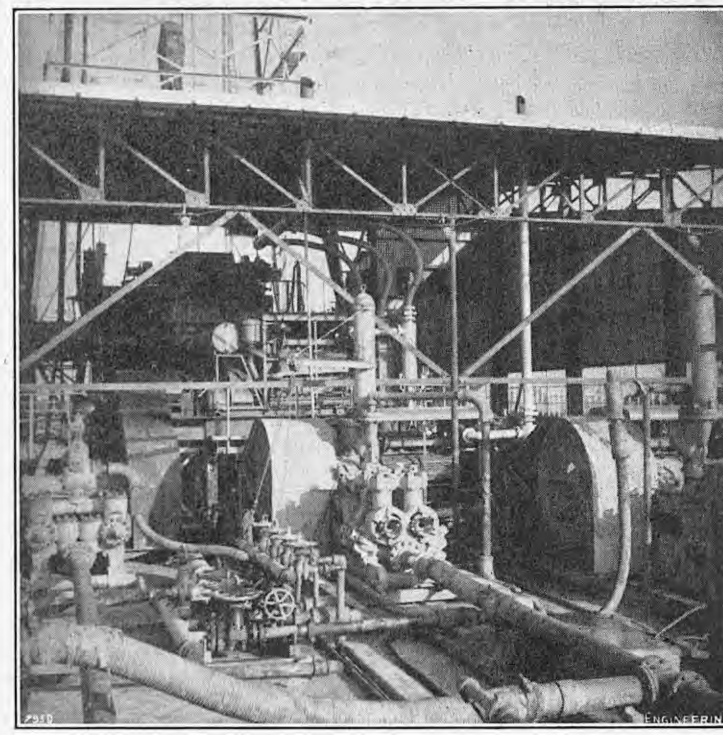


Fig. 4. Slush Pumps and Associated Engines.

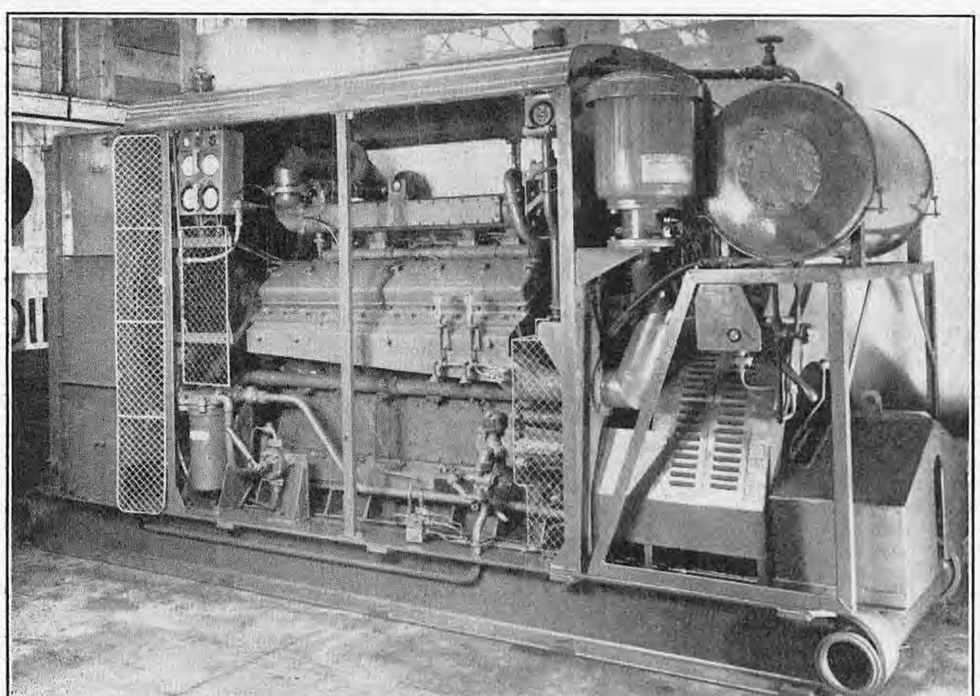


Fig. 5. Paxman 400 H.P. "Package" Set.

unit has a weight of approximately 60,000 lb., and can be broken down into two sections for transport purposes. The three-engine drive group is arranged so that each engine output extension shaft can operate independently, with any two compounded together, or with all three compounded. To cater for this, the engine controls, which are operated pneumatically, are arranged so that the engines can be controlled individually, together in pairs, or all three together by a single lever. The layout of the engines in relation to the draw-works will be clear from Fig. 2, opposite, which shows the layout of the complete plant in diagrammatic form. The compounding drives consist of $1\frac{1}{2}$-in. triplex chains, engagement of the different engines being effected through splined positive clutches. A $1\frac{1}{2}$-in. pitch quadruple chain transmits the main drive from No. 1 engine shaft to the draw-works, the pneumatically-operated master clutch being controlled by the driller from the drilling position. As will be seen from Fig. 2, the No. 3 engine is also arranged so that it can drive a slush pump; multiple V-belts are employed for this purpose and the drive is engaged by a pneumatically-operated clutch. During normal drilling operations, No. 1 engine is used to drive the draw-works and No. 3 engine to drive No. 1 slush pump, but Nos. 2 and 3 engines may be connected into the pump drive if required. When pulling the drilling string out of the hole, Nos. 1 and 2 engines are used together for driving the draw-works, and, if necessary, No. 3 engine can also be used. Each engine is fitted with a scoop-controlled fluid coupling and, if necessary, can be isolated from the extension shaft, thus the power distribution is completely flexible.

As previously indicated, the three engines used to drive the draw-works were supplied by Messrs. Davey, Paxman and Company, Limited, Colchester. They are twelve-cylinder V-type units, each with its own radiator, oil cooler, fuel system, air cleaner, etc. The complete assembly is mounted on a fabricated skid-type base for easy transport. This arrangement, referred to by the manufacturers as a "package" set, will be clear from Fig. 5, on this page, which shows one of the units in their works. A special feature of these engines is the provision made to avoid damage should the lubricating-oil pressure drop to a dangerous value or the cooling-water temperature become too high. In such an event, the scoop in the hydraulic coupling is withdrawn automatically, thus isolating the engine from the drive group; at the same time, the working oil-circuit of the governor is drained, causing the fuel racks to return to their closed positions, thereby shutting the engine down. As a further safety precaution, a butterfly flap valve is fitted in each air-intake manifold. These are closed when a large quantity of natural gas is struck, to ensure that none enters the induction system; otherwise, the engines would operate without control from the governor. Although unlikely to be needed at present, electrical heating elements are provided for pre-warming the lubricating oil and cooling water to facilitate starting.

In all, six 400-h.p. Paxman 12-r.p.m. "package" sets are used in connection with the drilling rig, as, apart from those used to drive the draw-works, three further engines are arranged to drive slush pumps so that a high circulation of mud can be achieved. Some of these engines and their associated pumps can be seen in Figs. 3 and 4 above, while their position in relation to the rest of the plant is shown diagrammatically in Fig. 2. The size of engine used is governed largely by transport arrangements, as the complete drilling rig has to be moved to remote areas, often without the benefit of roads. Furthermore, reliability has to be considered and, even if it were practicable to use a single large engine, this would be inadvisable as, in the event of a breakdown, the complete rig would be shut down whereas the failure of a single engine of a group is not serious. Reliability is, undoubtedly, the most important factor, as drilling proceeds 24 hours a day. As a consequence, routine maintenance is adhered to rigidly and, considering the adverse conditions in which they operate, the engines are kept in remarkably good order. A comprehensive log is kept for each engine, with notes of any adjustments made, and these are carefully analysed as an aid to proper maintenance. Overhauls are carried out on a progressive basis so that an engine is only out of commission for a short period. The use of "package"-type units greatly facilitates this work as it permits an engine to be removed from the drive group and replaced without breaking and remaking a large number of pipe joints. To make this task easier, the mains from the fuel-oil, lubricating-oil and cooling-water make-up tanks are connected to the individual engines through flexible pipes and the corresponding branches on the mains are provided with stop cocks.

Institution of Civil Engineers.—Bayliss prizes of 15*l*. each have been awarded to Mr. Kenneth George Aubrey, Australia, and Mr. Lance Dynes Bedford, New Zealand, who tied for first place at the associate-membership examination (sections A and B) of the Institution of Civil Engineers, held in October, 1951. Mr. D. B. Cook, Bury, Lancashire, obtained third place and was awarded an honourable mention. Results at British and overseas centres were taken into account.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

MEMORIAL TO SIR EDWARD MACCOLL.—A plaque to the memory of Sir Edward MacColl, deputy chairman and chief executive officer of the North of Scotland Hydro-Electric Board from its inception in 1943 to his death on June 15, 1951, was unveiled by the Lord Justice General (Lord Cooper) at Pitlochry power station, on Friday, April 4. Lord Cooper was the chairman of the Committee appointed in 1941 to investigate the harnessing of Highland water power, whose recommendations led to the establishment of the Board.

SHIPBUILDING ACTIVITIES.—Contracts placed with Scottish shipbuilders, announced during the first quarter of the present year, cover the construction of 62 ships, aggregating 385,000 tons gross. Of these, 38 vessels, making together 290,000 tons, have been ordered from Clyde shipyards, while firms on the East Coast have shared in orders for 24 ships, totalling 95,000 tons gross. The figures include ten tankers, totalling 130,000 tons.

EXPORTS OF COAL FROM GLASGOW.—Shipments of cargo and bunker coal from the port of Glasgow, for the year to February 29 last, totalled 345,270 tons, according to the minutes of the Traffic Committee of the Clyde Navigation Trust. This compares with 389,600 tons in the year to February 28, 1951, and 1,708,761 tons in the year to June 30, 1939.

QUESTIONS ON INCREASED CHARGES FOR ELECTRICITY.—Glasgow Chamber of Commerce, on March 31, decided to address the following questions to the South-West Scotland Electricity Board: (1) Why do the British Electricity Authority charge the South-West Scotland Electricity Board 0·75*d.* a unit for electricity which they obtain from the North of Scotland Hydro-Electric Board for 0·7*d.* a unit? (2) What is the reason for the "threatened further increase" in electricity charges? (3) What is the explanation for the high cost of the administration of the electricity services since the industry was nationalised, and for the increased costs due to the standardisation of bulk-supply tariffs, amounting to about 1,000,000*l.*?

NEW TOWN OF GLENROTHES, FIFE.—Expenditure to date in connection with constructional work at Glenrothes, the new Fife town, is about 565,000*l.*, it was stated on April 2 by Sir Hector M'Neill, chairman of Glenrothes Development Corporation. Referring to the Corporation's efforts to attract light industries to form an additional outlet for labour, apart from the major local industries of coal and papermaking, he said that, at the Corporation's display at the Civil Engineering and Building Exhibition in the Kelvin Hall, Glasgow, a number of inquiries had been made regarding possible factory sites in the new town.

CALL FOR NEW INDUSTRIES IN LANARKSHIRE.—To counteract increasing unemployment in Lanarkshire, the County Council have urged the Board of Trade to develop new industries in the County. The Board also received a request on behalf of the East Kilbride Development Corporation for authority to commence work in connection with the John Deere agricultural-machinery factories, Government sanction for which has been withheld because of the steel shortage, and have now agreed that the work may proceed, as soon as a starting date has been given by the Scottish Building Committee.

DELAY TO CAMPBELTOWN WATER SCHEME.—The delivery of the special type of 9-in. cast-iron water pipe wanted by Campbeltown Town Council for their new water scheme may take from two to three years, according to a reply given to Major Duncan McCallum, M.P. for Argyll, by Commander Galbraith, Under-Secretary of State for Scotland. It was pointed out that the scheme, commendable as it was, was not more urgent than many others, and no hope could be held out of advancing the the delivery date already given by the manufacturers.

CLEVELAND AND THE NORTHERN COUNTIES.

UNITED STATES STEEL.—Imports of steel from the United States have been arranged for earlier dates than originally promised. The first consignment is for a cargo of about 290 tons of steel sheets and 1,660 tons of steel ingots. The material is for supply to consuming works on the North-East Coast. Other cargoes are expected to reach Tees ports in the very near future.

THE TASK OF MANAGEMENT.—Mr. A. G. Grant, director and general manager of Whessoe, Ltd., engineers, Darlington, addressing the Teeside Group of the Institute of Industrial Administration, called for less uninformed criticism of industry from outsiders. It had been said he stated, that managements were weak and employees did not work hard enough. Industry agreed that it had much to do to improve productivity, but it should be allowed to put its own house in order, which it could do more effectively and quickly if there were less criticism from outside. The task of management was a complex one because of the times, and, because industry had to be subject to some measure of Government control. Management needed men of high ability, supported by modern administrative methods and technique. These techniques could be taught, but, he maintained, management could not.

WEAR COAL AND IRON-ORE IMPORTS.—Returns recently issued by the River Wear Commissioners show that, during February, 258,286 tons of coal and coke were shipped from the Wear, against 264,777 tons last year and 380,168 tons in 1938. The figures for the first two months of the present year were 501,990 tons, against 514,860 tons in 1951 and 763,722 tons in 1938. Of this year's shipments 102,665 tons were exported abroad, as compared with 64,630 tons last year and 328,280 tons in 1938. In the first two months of 1952 18,956 tons of iron ore were imported into the river.

PROPOSED CLASSES FOR BOILERMEN.—The Tees-side Smoke Abatement Society has decided to ask local industrialists to co-operate in promoting greater fuel efficiency by helping to arrange classes for boilermen and furnacemen. It is suggested that these men should be allowed to attend classes in their employers' time.

WORLD'S LARGEST TANKER.—The S.S. World Unity, 31,745 tons deadweight, which went into service on April 6, is the largest tanker yet to join the world's oil-carrying fleets. She was handed over to her owners, World Tankers Corporation of Liberia, by the builders, Vickers-Armstrongs Ltd., Barrow-in-Furness, after successfully completing her trials.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL ALLOCATIONS.—It is officially pointed out that the main difficulty in regard to the supply of steel to the cutlery industry is that allocations are not being granted far enough ahead. It is stated that, unless authorisations are awarded quickly, there may be a serious shortage later on, because steelmakers deliveries are made nine months after the receipt of an order.

SHEFFIELD CHANGE FROM TRAMS TO 'BUSES DEFERRED.—The Sheffield scheme for the change-over from tramways to omnibuses, in progressive stages, has been deferred at the instance of the Minister of Transport, who states that the substantially increased expenditure involved in the next few years cannot be justified in the country's present financial state. The Sheffield Transport Committee accordingly have decided to defer the conversion for a year.

DEARTH OF SKILLED MEN.—The engineering trades of Sheffield and district report an acute shortage of skilled employees which is restricting the demand for unskilled persons who could otherwise be absorbed. The demand for women employees, both semi-skilled and unskilled, in the lighter industries has declined, but women are in good demand generally in Sheffield.

INTENSIFICATION OF OPENCAST MINING.—The drive for opencast coal is being intensified as a result of the appointment of a five-man national executive by the National Coal Board, which has taken over opencast mining from the Ministry of Fuel and Power. Twenty-four sites are now being worked in the Sheffield and West Riding region and others are planned to begin operations at the rate of about one a fortnight. The region is expected to yield more than 2,000,000 tons of coal this year from opencast sites. Four new sites have been put out to contractors.

THE MIDLANDS.

PROPOSAL TO RE-OPEN UNDERGROUND FACTORY.—It has been suggested that part of a large underground factory, built during the war about four miles from Kidderminster, should be re-opened. The question arose as a result of a proposed requisitioning of the Kidderminster carpet factory of Woodward, Grosvenor & Co., Ltd., by the Ministry of Supply for the manufacture of aircraft parts. Mr. Gerald Nabarro, M.P. for Kidderminster, put forward the alternative plan for using the underground factory, which was closed in 1946 and has since been on a care and maintenance basis. This factory, it is claimed, could meet the Ministry of Supply's requirements for aircraft component production without the necessity for interfering with work at the carpet factory, which is operating two shifts a day, mainly on export orders.

DEFENCE ORDERS IN THE MIDLANDS.—Mr. S. A. Davis, regional controller for the Ministry of Supply in the Midlands, announced in Birmingham on March 27 that more than 12,000 contracts for defence equipment had been placed in the Midlands since January 1. Most of these orders have gone to the engineering centres, Coventry, Birmingham, Wolverhampton, and the Black Country. Many more contracts remain to be placed in the Midland region, and these will include sub-contracts, some of which will come under the Ministry of Supply's super-priority plan.

SIXTY-SEATER OMNIBUS.—A single-deck Daimler omnibus which will carry 60 passengers, 30 seated and 30 standing, is being run experimentally by Birmingham City Transport Department. The vehicle has a rear entrance and a front exit, the doors being power-operated under the control of the driver. It will run between Station-street, in the city, and the Kingstanding municipal housing estate on the outskirts, and its operation over a period of two months is to be studied by the Transport Department to see if it is suitable for use during peak traffic periods.

USE OF MINE WATER FOR INDUSTRY.—Bilston town council are considering a plan for pumping water from the disused coal mine workings under the town to meet an expected increase in industrial water consumption. Developments at the Bilston Steelworks of Stewarts and Lloyds Ltd. will require greater supplies of water by 1954. A certain amount of mine water is being pumped at present to feed the local canals, and the Bilston council plan envisages increasing the quantity raised daily from the underground source, which is very large. The plan requires the approval of the Ministry of Housing and Local Government, who have undertaken to give it favourable consideration. Details are now being prepared for submission to the Ministry, and, at the same time, the possible effect of the water on industrial plant is being investigated.

BEWDLEY GASWORKS.—Bewdley gasworks, one of the oldest and smallest in the Midlands, closed down on March 27, after supplying gas to the town for 114 years. The 1,500 consumers in the Bewdley area are now supplied from the gasworks at Kidderminster through a four-mile main which has been laid for the purpose.

B.I.F. AIR SERVICE.—During the period of the British Industries Fair (May 5 to 16) a special air service between London and Birmingham will be operated by Olley Air Services, Ltd. Aircraft will fly between Croydon Airport and Castle Bromwich, where the landing will be made within 100 yards of the entrance to the Fair buildings. There will be a 'bus-train connection between Croydon Airport, Earl's Court, and Olympia in conjunction with the air service. One morning flight, with an evening return flight, will be made daily in each direction.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SATURDAY VOLUNTARY SHIFT AT COLLIERIES.—It has been announced during the past week that there has been an overwhelming majority in the recent ballot among Welsh miners in favour of resuming the Saturday voluntary shift in September after the usual summer stoppage. Although final figures have not been received, it has become clear that the majority will be in the region of 12 to one. Normal week-end work has now been resumed in the coalfield following the recent boycott.

INCREASED COAL EXPORTS TO FRANCE.—South Wales will benefit considerably as a result of a decision to increase coal shipments to France. It was announced during the past week that, following the decision to export an extra 2,000,000 tons of coal this year, exports to France would be stepped up from the United Kingdom, during the remainder of the year, by about 100,000 tons a quarter. Of this quantity 75,000 tons will be supplied by South Wales.

DEVELOPMENTS AT CAERPHILLY.—The South Western Divisional Coal Board have asked Caerphilly Urban Council to approve plans for the development of 120 acres at Nelson, involving the sinking of two shafts, the erection of colliery buildings, plant, sidings and transmission lines.

STEEL SHIPMENTS FROM SWANSEA.—Liners trading with South and East Africa will make Swansea a regular port of call in future. The news is contained in a letter received by the Mayor, Alderman D. Jones, from Mr. J. Gurney Braithwaite, Parliamentary Secretary to the Ministry of Transport, who wrote that, in the past, Newport had been the only port in the Bristol Channel for the loading of steel and similar cargo for Africa, but, with the new works of the Steel Company of Wales now operating, Swansea obviously had become more suitable than Newport for certain materials.

NOTICES OF MEETINGS.

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

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Liverpool Branch*: Tuesday, April 15, 6.30 p.m., Radiant House, Bold-street, Liverpool. "Embedded Panel Warming: Some Practical Applications," by Mr. H. H. Bruce. *Manchester Branch*: Friday, April 25, 6.30 p.m., Engineers' Club, Albert-square, Manchester. "Ventilation and Heating of Laboratories," by Mr. H. Coase. *Scottish Branch*: Tuesday, April 29, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. "A Review of Current Research in Heating and Ventilating," by Mr. N. S. Billington.

INCORPORATED PLANT ENGINEERS.—*Glasgow Branch*: Tuesday, April 15, 7 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow. "Development of the New Mechanical Engineering Research Laboratory at East Kilbride," by Mr. T. C. Crawhall. *Western Branch*: Wednesday, April 16, 7.15 p.m., Grand Hotel, Bristol. "Industrial Fire Protection," by Mr. C. Gotsell. *Liverpool and North Wales Branch*: Thursday, April 17, 7.15 p.m., Radiant House, Bold-street, Liverpool. Address by the Branch chairman, Mr. W. H. Price. *South Yorkshire Branch*: Thursday, April 24, 7.30 p.m., Grand Hotel, Sheffield. Film on "The Manufacture of Wire Ropes."

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Anglian Section*: Tuesday, April 15, 7 p.m., Public Library, Ipswich. Annual Meeting. *Coventry Students' Section*: Tuesday, April 22, 7.15 p.m., Technical College, Coventry. Annual Meeting. Film on "How Steel is Made." *Birmingham Branch*: Wednesday, April 23, 7.15 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting and "Symposium of Defects." *West Riding of Yorkshire Branch*: Saturday, April 26, 6.30 p.m., Technical College, Bradford. Annual Meeting. *London Branch*: Wednesday, April 30, 7 p.m., Waldorf Hotel, Aldwych, W.C.2. Annual Meeting. "Surface Finish and Design Sands," by Mr. F. Roy Pell.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre*: Tuesday, April 15, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Chassis-Frame Construction and Repair," by Mr. C. F. Cunningham. *East Midlands Centre*: Wednesday, April 16, 7.30 p.m., Mechanics Institute, Nottingham. "The Care and Maintenance of Diesel Engines," by Mr. S. Parrish. *North-West Centre*: Wednesday, April 16, 7.30 p.m., Adelphi Hotel, Liverpool. Annual Meeting. *Institute*: Thursday, April 17, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," by Mr. M. Towle. *North-East Centre*: Thursday, April 17, 7.30 p.m., Hotel Metropole, Leeds. Annual Meeting.

INSTITUTE OF FUEL.—*North-Western Section*: Wednesday, April 16, 2 p.m., Engineers' Club, Albert-square, Manchester. Annual Meeting. "Thermal Factors in Furnace Design," by Professor R. J. Sarjant and Mr. W. Hulse (Preceded by luncheon at 1 p.m.). *East Midland Section*: Thursday, April 17, 6.15 p.m., East Midland Gas Board's Showrooms, Nottingham. "Developments in Gas Manufacture in the Area of the East Midland Gas Board," by Dr. M. Barash and Mr. A. W. Elliott. *Scottish Section*: Friday, April 18, 7 p.m., Royal Technical College, Glasgow. Annual Meeting. *Institute*: Tuesday, April 22, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Recent Developments in Instruments," by Mr. E. C. Klepp. Wednesday, April 23, Institution of Mechanical Engineers, S.W.1. 4.30 p.m., Annual Meeting (for Corporate Members only). 5.30 p.m., Presidential Address on "Fuel Technology and Civilisation," by Dr. G. E. Foxwell.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, April 16, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "The Fell Diesel Mechanical Locomotive," by Lieut.-Col. L. F. R. Fell.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Southern Centre*: Wednesday, April 16, 6.30 p.m., Technical College, Weymouth. "Computing Machines," by Mr. J. Bell. Wednesday, April 23, 6.30 p.m., Royal Beach Hotel, Portsmouth. Discussion on "The Place of Electricity in a National Fuel Policy," opened by Mr. D. P. Sayers. *Utilization Section*: Thursday, April 17, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "Equipment of Battery-Electric Vehicles," by Mr. W. D. Sheers. (ii) "The Economic Basis of Battery-Electric Road-Vehicle Operation and Manufacture," by Mr. H. W. Heyman. *London Students' Section*: Monday, April 21, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. Address by the President of the Institution, Sir John Hacking.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section*: Wednesday, April 16, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Current Radio Interference Problems," by Mr. E. M. Lee. *South Midlands Section*: Thursday, April 17, 7.15 p.m., Public Library, Rugby. "Acoustics and the Radio Engineer," by Dr. E. G. Richardson. *North-Western Section*: Wednesday, April 30, 7.15 p.m., College of Technology, Manchester. "Very High-Frequency Broadcasting: The Case for Amplitude Modulation," by Mr. J. R. Brinkley.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Section*: Wednesday, April 16, 7 p.m., James Watt Memorial Institute, Birmingham. Discussion on "Standard Costing and the Production Engineer." *Western Section*: Friday, April 18, 7.30 p.m., University College of the South West, Exeter. "The Production Engineer," by Mr. T. B. Worth. *Derby Section*: Monday, April 21, 7 p.m., School of Art, Green-lane, Derby. "Production in Foundries," by Mr. J. Hill. *Manchester Section*: Monday, April 21, 7.15 p.m., College of Technology, Sackville-street, Manchester. "Research in Relation to Production Engineering," by Dr. D. F. Galloway.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Manchester Branch*: Wednesday, April 16, 7.30 p.m., Engineers' Club, Albert-square, Manchester. Open Discussion Meeting. *Kent Branch*: Thursday, April 17, 8 p.m., County Hotel, Canterbury. "Electrical Precautions in Operating Theatres," by Mr. A. A. Mansell.

INSTITUTION OF WATER ENGINEERS and INSTITUTE OF SEWAGE PURIFICATION.—Thursday, April 17, 3 p.m., Chamber of Commerce, 95, New-street, Birmingham. "The Rivers (Prevention of Pollution) Act, 1951: A Commentary," by Mr. Ll. Jones and Mr. D. H. A. Price.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Branch*: Thursday, April 17, 6 p.m., James Watt Memorial Institute, Birmingham. Discussion on the Report of the Anglo-American Productivity Team on "Welding." *North-Western Branch*: Thursday, April 17, 6.45 p.m., Engineers' Club, Albert-square, Manchester. "Steam Piping for High Pressures and High Temperatures," by Dr. R. W. Bailey, F.R.S. *Institution*: Friday, April 18, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. James Clayton Lecture on "Some Aspects of the Mechanics of the Cavitation Process," by Professor R. T. Knapp. Friday, April 25, 5.30 p.m., Storey's-gate, S.W.1. Meeting in conjunction with the *Internal-Combustion Engine Group* and the *Steam Group*. "Explosions in Enclosed Crankcases of Steam and Internal-Combustion Engines, Their Cause, Effect and Possible Remedy," by Mr. John Lamb.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Scottish Branch*: Thursday, April 17, 6 p.m., Ca'doro Restaurant, Union-street, Glasgow. Annual Meeting. *Institution*: Thursday, April 24, 6 p.m., 11, Upper Belgrave-street, S.W.1. "An Investigation of the Behaviour of a Riveted Plate Girder Under Load," by Drs. S. Mackey and D. M. Brotton.

INSTITUTE OF MARINE ENGINEERS.—Thursday, April 17, 7 p.m., 85, The Minories, E.C.3. Junior Section Discussion on "The Value of Technical Qualifications to the Marine Engineer Apprentice."

INSTITUTION OF CHEMICAL ENGINEERS.—*North West Graduates' and Students' Section*: Thursday, April 17, 7 p.m., Shell Refining and Marketing Co., Ltd., Research Centre, Thornton, Lancashire. Film Evening. *London Graduates' and Students' Section*: Friday, April 18, 6.30 p.m., Caxton Hall, Westminster, S.W.1. "The Fluid Catalytic Cracking Process," by Mr. J. G. Lucas.

INSTITUTE OF WELDING.—*North London Branch*: Thursday, April 17, 7.30 p.m., Polytechnic, Regent-street, W.1. Annual Meeting and Film Evening.

ILLUMINATING ENGINEERING SOCIETY.—*Birmingham Centre*: Friday, April 18, 6 p.m., Imperial Hotel, Temple-street, Birmingham. "Light from Space," by Mr. W. Wilson.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 18, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "A Study of the Cause of Rudder Failures," by Mr. T. W. Bunyan.

INSTITUTE OF METALS.—*Sheffield Local Section*: Friday, April 18, 6.30 p.m., The University, St. George's-square, Sheffield. "Corrosion of Iron and Its Prevention by Deposits of Non-Ferrous Metals," by Dr. U. R. Evans, F.R.S.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 18, 6.30 p.m., 39, Victoria-street, S.W.1. "Some Modern Submersible Pumping Applications," by Mr. W. L. Gardiner. Friday, April 25, 6.30 p.m., 39, Victoria-street, S.W.1. "Condensed Steam Collection: A New System," by Mr. A. J. Simpson.

LIVERPOOL METALLURGICAL SOCIETY.—Friday, April 18, 7 p.m., Electricity Service Centre, Whitechapel, Liverpool. Annual Meeting and presentation of prize-winning students' papers.

PERSONAL.

A ROYAL ORDNANCE FACTORIES BOARD has been established to advise the Minister of Supply on matters of policy in relation to these Factories. The chairman of the Board is Lieut.-General SIR KENNETH N. CRAWFORD, K.C.B., M.C., his deputy is MR. C. K. F. HAGUE. Two other non-official members, who will serve in an honorary capacity, are MR. HENRY A. BENSON, C.B.E., F.C.A., and DR. JAMES TAYLOR. The official members of the Board, in addition to the chairman, are SIR LEWIS B. HUTCHINSON, K.B.E., C.B., MR. A. G. E. BRIGGS, MR. N. BALIOL SCOTT and MR. T. E. HARRIS, C.B., C.B.E.

MR. J. A. HUNT, M.B.E., general manager, the Hymatic Engineering Co., Ltd., has been elected President of the British Compressed Air Society for the ensuing year. MR. H. G. HARWOOD, a director of Hugh Wood & Co., Ltd., has been elected vice-president.

MR. H. S. GIBSON, C.B.E., M.A., managing director of the Iraq Petroleum Co., Ltd., has been elected President of the Institute of Petroleum, 26, Portland-place, London, W.1, in succession to MR. C. A. P. SOUTHWELL, M.C., B.Sc.

As the control of Henry Meadows Ltd., Wolverhampton, has now been acquired by Associated British Engineering Ltd., MAJOR-GENERAL W. S. TOPE, C.B., C.B.E., has relinquished the chairmanship and MR. ALAN P. GOOD has become chairman in his place. Major-General Tope is taking up other important duties in the Brush-ABOE Group.

MR. J. F. COALES has resigned his position as research director of Elliott Brothers (London) Ltd., Century Works, Lewisham, S.E.13.

MR. W. M. BOND, assistant, permanent-way (maintenance) to the civil engineer, British Railways, London Midland Region, is to retire on Saturday, April 19.

DR. WILLIAM REID, chairman of the Scottish division of the National Coal Board, has been nominated President of the Mining Institute of Scotland for the session 1952-53. Mr. G. W. Kirkwood, general manager, Lothians Area, and Mr. W. Smith, general manager, Central East Area, of the Board, have been nominated vice-presidents.

MR. W. T. P. PERKINS, general manager of the Transport and Harbours Department, British Guiana, has been made chief engineer, Nigerian Railways. He will be succeeded in British Guiana by MR. A. J. F. BUNNING, C.M.G., formerly adviser on inland transport to the Secretary of State for the Colonies.

MR. REX BATE, Loughborough sales director of the Brush Electrical Engineering Co. Ltd., is transferring his headquarters to the offices of the Brush-ABOE Group at Dukes-court, London, S.W.1.

MR. R. J. WOODHAMS, after several years as sales and service manager of the aircraft division of Air Service Training Ltd., is taking up an appointment with another member of the Hawker Siddeley Group, namely Armstrong-Whitworth Aircraft Ltd.

MR. H. C. BUTCHER has retired from the position of secretary of Samuel Fox and Co. Ltd., Stocksbridge, a branch of the United Steel Companies Ltd., Sheffield, after 52 years of service with the firm. His successor is MR. F. STONES, A.C.I.S., who has been on the staff of the United Steel Companies for 26 years.

MR. J. E. RIGBY, a nominee of the British Transport Commission, has been appointed to be a member of the Transport Users' Consultative Committee for the North-Western Area in succession to MR. H. P. AGGLETON, who has resigned.

MR. GEORGE WOODCOCK, M.A., assistant general secretary of the Trades Union Congress, has been appointed a vice-chairman of the National Savings Committee on which he will represent the trades-union movement.

BRITISH INSULATED CALLENDER'S CABLES LTD. state that the telephone number of their Ipswich branch will change to Ipswich 51265-6, with effect from April 15.

PROGRESS WITH THE KIRKUK-BANIAS PIPELINE.—The Iraq Petroleum Company have announced that crude oil from their oilfield at Kirkuk, North Iraq, has now reached Banias, in Syria, the newly-constructed Mediterranean terminal of the 30-in. oil pipeline. Although some 115 miles of 30-in. pipeline still have to be laid before the new system reaches Kirkuk, it proved possible to bring it into operation by connecting the system to existing 12-in. and 16-in. pipes of the southern fork of the pipeline terminating at Haifa, at present inoperative. Meanwhile, construction of the 30-in. line continues and is expected to reach Kirkuk by the end of April. First shipments of oil from Banias are scheduled for mid-April; at present the oil is being pumped into storage tanks having a capacity of 550,000 tons, which have already been installed at Banias. When in full operation, the 30-in. pipeline will convey an additional 14,000,000 tons of Kirkuk crude oil to the Mediterranean each year.

90,000-TON REINFORCED-CONCRETE SILO FOR AMMONIUM SULPHATE AT SINDRI, INDIA.

(*For Description, see Page* 449.)

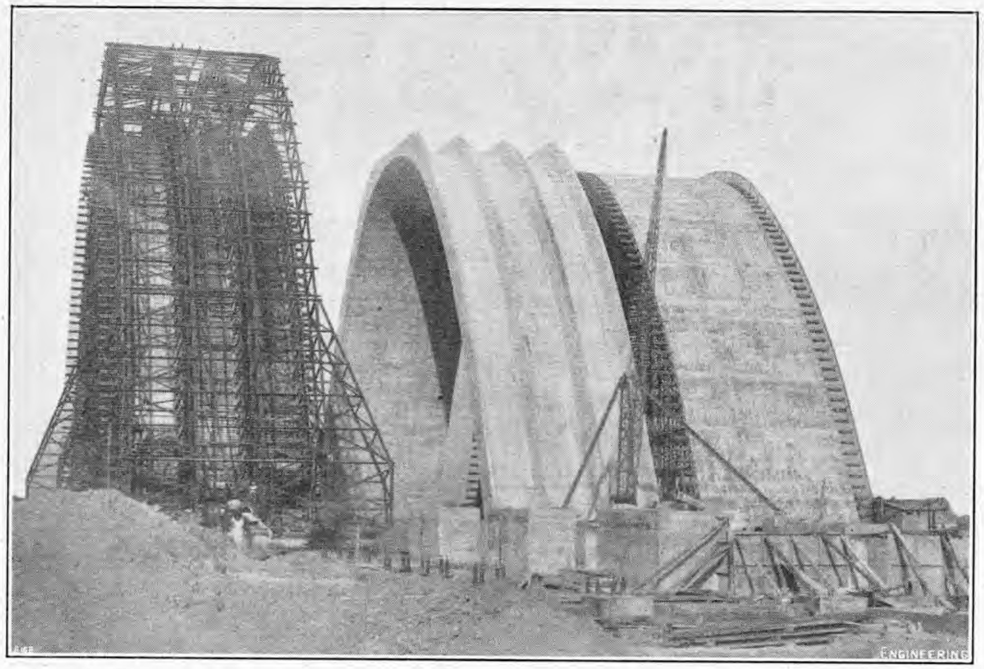


Fig. 6. Completed Arch: External Shuttering to Left, Internal Shuttering to Right.

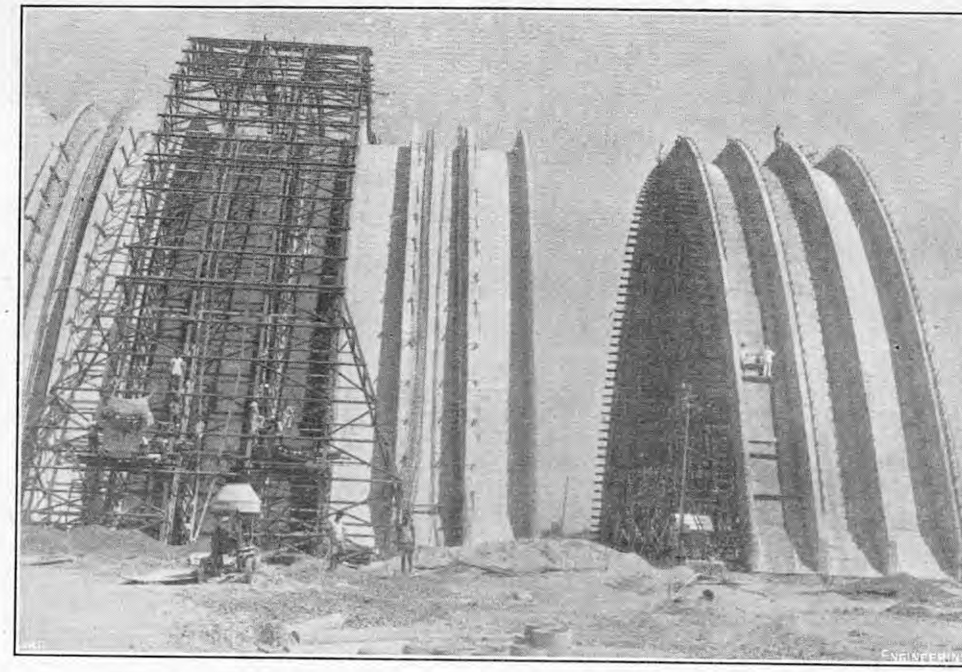


Fig. 7. External Shuttering in Position for Concreting.

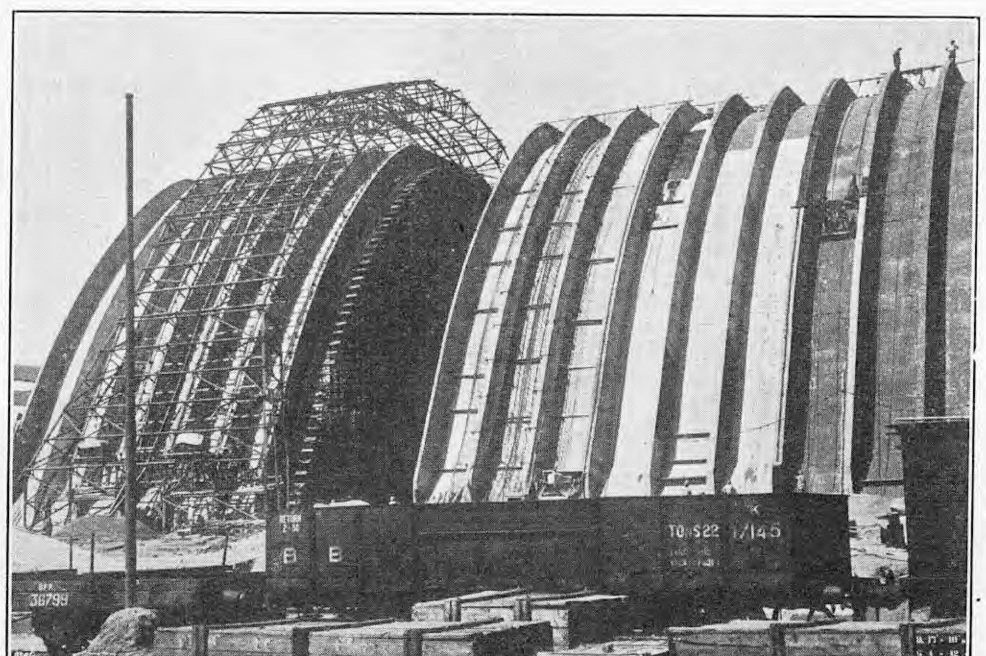


Fig. 8. Silo Arches under Construction.

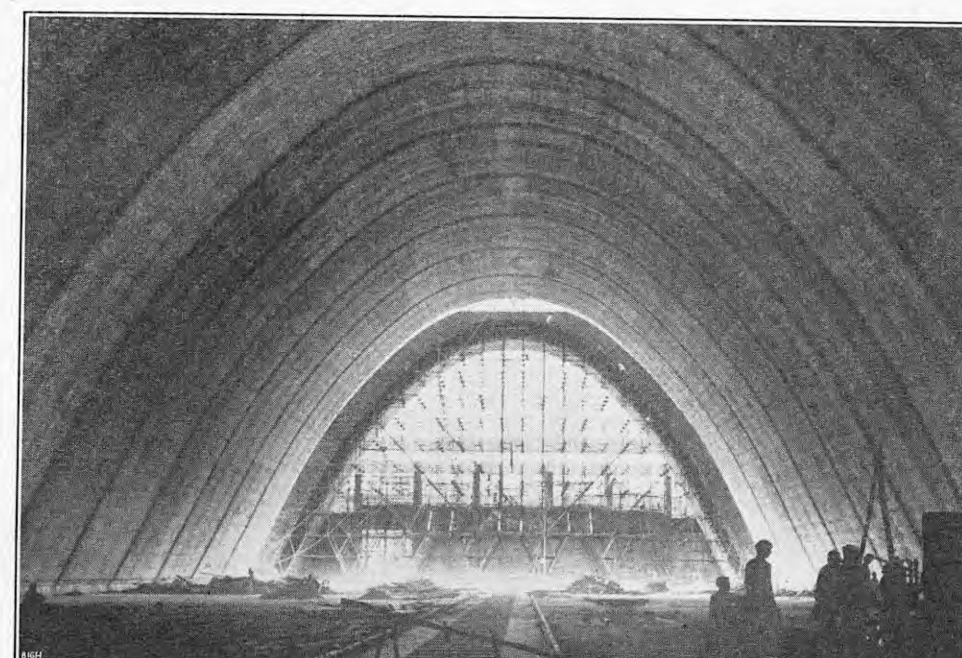


Fig. 9. Interior of Silo.

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ENGINEERING

FRIDAY, APRIL 11, 1952.

VOL. 173. No. 4498.

LEONARDO DA VINCI AND HIS TIMES.

In the long list of eminent Italian men of science, which includes the names of Galileo, Torricelli, Malpighi, Galvani, Volta, Avogadro, Marconi and many others, there is only one, Leonardo da Vinci, the 500th anniversary of whose birth falls in the coming week, who also occupies a place among the great artists. "He is the only man," said *The Times*, "who has achieved the first eminence both in art and science." The dual nature of his genius and of his achievements has never been so clearly recognised as it is to-day, but, even now, little is said about him in the histories of science. His splendid work as a painter, sculptor and designer brought him fame at an early age, but his work as a scientist, accumulated slowly, set up no notable landmarks, and, for the greater part, lay hidden from the public view in his voluminous manuscripts, written in a peculiar manner with baffling abbreviations. By his methods he secured secrecy, if that was what he desired, but his notes suffered a prolonged obscurity in consequence, as did Pepys's diary, and had to await a translator and interpreter. There are over 5,000 sheets of these manuscripts preserved in various Royal, public and private libraries, and though there have been exhibitions of his work before, the celebrations of the quincentenary of his birth, now being held in various Italian cities and at the Royal Academy, London, will lead to a fuller appreciation of his work than has been possible up to the present.

Lecturing on Leonardo at the Royal Institution in March, 1920, Mr. Edward McCurdy, after reviewing his great contributions to art, said that "his researches in natural and applied science cover so wide a field and specialisation in these days has so divided knowledge into water-tight compartments, that properly to gauge the value of his contributions to scientific research would require a combination of many trained intelligences." A glance at the list of lecturers and their subjects for 1952, as given in the catalogue of the exhibition at the Royal Academy, shows how right Mr. McCurdy was in his judgment.

An illegitimate son of a Florentine notary, and born on April 14, 1452 (Old Style) at the small Tuscan village of Vinci, Leonardo was well brought up by his father in Florence when that city was the centre of Italian fashion, art, learning and commerce. After serving an apprenticeship to an artist and goldsmith, he soon made a mark with his composition and found his first patron in the ruler of Florence, one of the Medici family, Lorenzo the Magnificent. When about 29, he moved to Milan, finding employment under Lodovico Sforza, the son of Francesco Sforza. Like most Italian rulers, Sforza was glad to have in his service a man who could not only arrange masques and festivals, and decorate his palaces and galleries, but who also had in his portfolio a remarkable collection of designs for war-like instruments and machines; for the Fifteenth Century was every whit as war-minded as the Twentieth. Lodovico proved a good patron, paying Leonardo a salary of 2,000 ducats per annum, displaying commendable patience as regards the execution of the great equestrian statue of his father, Francesco, and leaving Leonardo ample time to follow his own bent.

It was in 1496, when Leonardo had been in Milan 15 years, that he wrote about his needle-polishing machines, "Early tomorrow, Jan. 2, 1496, I shall make the leather belt and proceed to a trial . . . One hundred times in each hour 400 needles will be finished, making 40,000 in an hour and 480,000 in 12 hours. Suppose we say 4,000 thousands (implying 10 machines) which at 5 solidi per thousand, gives 20,000 solidi : 1,000 lira per working day, and if one works 20 days in the month, 60,000 ducats the year." His dream of wealth came to nothing, and his service under Lodovico came to an end when, faced with the hostility of France, Rome and Venice, Lodovico had to leave Milan and take refuge in Germany. Leonardo, then 47, found his next patron in the despicable Caesar Borgia, who sought his assistance in fortifying the Romagna; but the co-operation of the master painter, engineer and architect, and one of the greatest monsters of all times, fortunately lasted only a short time. After this, Leonardo led a somewhat unsettled life. At one time he was again in Florence or Milan; he also spent some time at Rome, where, however, his younger rivals, Michael Angelo and Raphael were at the zenith of their powers; and, in 1515, he willingly became the pensioner of the youthful Francis I of France, who gave him for residence the chateau at Blois, near Amboise. There Leonardo died on May 2, 1519, at the age of 67.

He never married, and so, with no family calls on his time, divided his life between the demands of his successive masters, and his own personal investigations which are recorded in those manuscripts that might so easily have been destroyed. To some extent, the contents of these were known to and used by contemporaries and his immediate successors; but, for nearly two and a half centuries a large section lay completely neglected. When the French invaded Italy in 1796, that arch-plunderer Napoleon, whom little escaped, caused many of the manuscripts to be sent from Milan to Paris. With them went the Italian physicist Giovanni Battista Venturi, who, in 1797, published his *Essai sur les ouvrages physico-mathematiques de Leonardo da Vinci, avec des fragments tires de ses manuscrits.* Venturi had followed

Leonardo as an investigator of the phenomena of flowing water and his name is familiar to engineers through the Venturi meter, invented by the American hydraulic engineer, Clemens Herschel.

Leonardo's life covered a period of intense interest in European history, and of momentous changes in men's outlook, after long years of comparative stagnation. Before Leonardo's day, the Italian cities had become famous as centres of the new learning, and Florence had been the first to have a professor of Greek. Other notable Greek teachers were Bessarion, Argyropulos, Trapezuntius and Bracciolini Poggio. A year after Leonardo's birth occurred the sack of Constantinople by the Turks, which sent scores of monks and scholars flying northward and westward, carrying their precious Greek and Arabic manuscripts with them. With this scattering of the libraries of Constantinople came the setting up of innumerable printing presses, the books and editions produced in Italy in Leonardo's time far exceeding in number those published in the rest of Europe. John Richard Green, in his *Short History of the English People*, tells how Thomas Linacre, the founder of the Royal College of Physicians, William Grocyn, of New College, Oxford, and John Colet, Dean of St. Paul's and founder of St. Paul's School, were among those who crossed the Alps to listen to the teachers of Greek. Leonardo was affected by the Renaissance of literature equally with the Renaissance of art and in his manuscripts mentions more than 70 writers. He had a special regard for the works of Archimedes, Vitruvius and Hero, whose books had been entirely neglected by the medieval churchmen. He could not have been affected less by the wealth which accrued from the trade, manufacturing and commerce of the Italian cities. Here again, however, Italy led the way, for it was the Florentine traders and writers who, adopting the Arabic numerals instead of the Roman numerals, developed a mercantile system of arithmetic and also introduced to accountancy the method of book-keeping by the introduction of double entry.

Another important feature of the age was the widening of men's horizons by the exploration of the coasts of Africa, Asia and America, for Leonardo's contemporaries included not only Gutenberg, Caxton, Erasmus and Luther, but also of Vasco da Gama, Magellan, Cabot and Columbus. History presents many facets to the reader and, viewing the political instability of Italy in the Fifteenth Century, it may seem, perhaps, a little remarkable that it proved so wonderful a forcing ground for the new learning. The country was divided into a number of petty states and republics, all ready to further their own aggrandisement at the expense of their neighbours; while at Rome the Papal throne was occupied in turn by a succession of political Popes who had lost all sense of their duty to their high office. Signs of the corruption which was to lead to the Reformation were everywhere, and in Leonardo's countryman, Savonarola, it found one of its first martyrs. Another fellow citizen of Florence, somewhat younger than Leonardo, was Niccolo Macchiavelli, who brooded long over the ills of his unhappy country, which he hoped to see united, even if this meant unity under a single tyrant. Italy at that time, declared Macchiavelli, "was more enslaved than the Hebrews, more servile than the Persians, more dispersed than the Athenians, without a head, without order, beaten, despoiled, ravaged, over-run, and enduring every kind of evil." As though the Italians were not suffering enough from their own political incompetence, foreign Powers stepped in again and again, the unhappy story of disunity continuing down to the days of Victor Emmanuel, Garibaldi, Mazzini and Cavour. Throughout these troublous centuries, however, the torch of science was kept burning in one or another of the Italian universities, several of which are taking part in the Leonardo celebrations.

PLANT MAINTENANCE IN THE UNITED STATES.

MORE attention than usual is being paid this year to plant maintenance. The report of a productivity team on the subject, which visited the United States in January, is awaited with interest, and at a meeting of the Institution of Mechanical Engineers last week there was a large attendance of members and visitors to hear and discuss Mr. Max Bentham's paper on "Some Considerations Regarding a Factory Maintenance Engineering Department" (a brief notice of which is given on the opposite page). It may, therefore, be useful to review the papers which were presented at the Plant Maintenance Conference in Philadelphia, U.S.A., from January 14 to 16 this year. If there are any lessons to be learnt from the conference, they are of even greater significance in this country than in America, since here the restrictions on plant renewal must be offset by more thorough maintenance.

The papers presented at the conference covered a wide field, including the maintenance of buildings, transport, machinery and electrical equipment, also lubrication and personnel training, most of these aspects of the subject being dealt with by authors from large, medium and small factories. Considerations of costs, planning, and systems of preventive maintenance predominated. The papers on preventive maintenance emphasised the importance of building up an organisation suited to the needs of the factory, so that breakdowns are prevented by planned maintenance and inspection.

To organise a maintenance scheme the first requirement is a full knowledge of the factory and its equipment. Complete specifications and records must be maintained of every structure and machine, and a manual of standard maintenance procedure must be compiled. The manual shows what is to be inspected, how it is to be inspected and how often it is to be inspected, and, by its aid, the precise duties of the maintenance staff are worked out, the times and routes to be followed are specified, and the work is allocated to the staff according to their abilities. Standard instructions are issued to the men, who submit written reports on their inspections. The records kept should facilitate the analysis of maintenance costs and should give the history of every piece of equipment. Such an organisation, of course, adds to overhead charges, but these should be more than recovered by the greater effectiveness with which labour is employed and by the decrease in lost production time due to the avoidance of breakdowns. Some authors suggested that the planning of maintenance and the compilation of material lists could be undertaken by foremen, but others were in favour of a maintenance planning engineer doing this work, thereby leaving the foremen free to attend to their main duties. The routine maintenance hands service the plant, carry out minor repairs, and report any faults or failures, potential or actual. Such reports often enable the planning engineer to see that the necessary repairs are carried out at the convenience of the production department, and also help him to order any replacement parts that have to be made in the machine shop without upsetting that shop's programme.

The activities of the planning engineer are not limited to the organisation of routine maintenance, but extend to the planning of overhauls of equipment at predetermined intervals. Prior to the overhaul of a machine, the engineer compiles a schedule of parts known to need replacement; instructions can then be issued to purchase or manufacture the parts in advance. Then, when the machine is dismantled, any other necessary replacements are ordered. Whether or not all these duties are performed by one man or by several depends mainly on the size of the factory, but even in the smallest plant they should all be carried out, and should preferably be the responsibility of a person able to devote all his time to them. The usefulness of a maintenance planning engineer is also apparent, particularly in large or medium-size factories, when a substantial production capacity is devoted to rebuilding or modifying machines, manufacturing tools or making machines of special design, for such activities can easily starve the maintenance services. A planning engineer can preserve a proper balance. In large factories this difficulty does not arise, since there are separate departments for maintenance and new equipment.

The papers dealing with maintenance costs all stressed the close connection between planning and accounting. It was difficult to deal with the accounting of maintenance costs in detail because, just as maintenance practices vary, so also do accounting systems. Indeed, one author, who had attempted to compare maintenance costs in a group of firms in the same industry, had found it impossible, although the firms were all about the same size, they were producing the same kind of products and they were using similar equipment. Before analysing maintenance costs in a particular factory, however, it is necessary first to analyse the maintenance policy. For example, the policy may be one of high maintenance or of high replacement; some firms run their machines to destruction and then replace them, others endeavour to maintain their machines in as nearly new condition as possible. In the use of labour, too, some employ men exclusively according to their special skills; others prefer men who are reasonably proficient in several classes of work. Maintenance is also affected by at least one aspect of production policy, namely, the ratio of machines to operators; in some factories, there is an excess of machines, to ensure the maximum utilisation of the labour force; whereas in others there is an excess of labour, to ensure the maximum utilisation of machines.

Unreasonably complex systems of maintenance accounting must be avoided; but however small the plant there should be a system, and simplicity should be the keynote. It is probable, however, that in most firms simplicity in this respect is overdone. The efficiency of maintenance can only be revealed by breaking down the costs into significant categories, distinguishing, for example, between routine maintenance and major repairs and overhauls. The allocation of maintenance costs to individual machines focuses attention on inefficient plant; the cost of repairs to roofs, floors, paintwork, drains, and other building features will enable an inquiry to be made into the relative economics of different materials and methods of construction; and periodical reports on maintenance costs to heads of departments will help them in organising and administering their shops, and will assist the management in apportioning overheads.

For the maximum value to be extracted from such accounts, an investigation should be carried out periodically to determine how and why the money is being spent. It would be a very well-run factory indeed where some useful information would not be revealed in this way; where, for example, the cost of overhauling a machine was practically the same as the cost of buying a new machine; where expensive lubricating oils were being used on plant that would run just as well on cheaper grades; where poor-quality paint was being used for work that would be more economically preserved by a better paint; or where, on a job previously done by outside contractors, it would be cheaper to employ the works staff. An intelligent analysis on these lines may well show what maintenance should cost as well as what it actually costs.

Such was the gist of the papers. It would be easy for a cynic to scoff at the ideals expressed, but it is a fact that in many works, where every effort is otherwise made to increase production efficiency, time and money are wasted by badly maintained machines.

NOTES.

THE BRITISH ASSOCIATION MEETING AT BELFAST.

THE next annual meeting of the British Association for the Advancement of Science will be held in Belfast from Wednesday, September 3, to Wednesday, September 10, 1952, under the presidency of Professor A. V. Hill, C.H., O.B.E., F.R.S. The preliminary programme for the meeting has just been published and has been forwarded to members; others interested can obtain copies from the secretary, whose address is given below. The inaugural meeting, on Wednesday, September 3, will be held in the Whitla Hall, Queen's University, and the subject of Professor Hill's address is "The Ethical Dilemma of Science." Most of the Sections will be accommodated in Queen's University, but Section G (Engineering) is one of the exceptions, as it will meet in the Methodist College, Malone-road. Sir Ben Lockspeiser, K.C.B., F.R.S., is President of Section G this year and his address, which will be delivered on Friday, September 5, will deal with "Progress in Aeronautical Science and Engineering." Other subjects for discussion in Section G, in which, as in recent years, two sessions will be held simultaneously, are vibrated concrete, transmission-line constants, ships and shipbuilding in Belfast, aircraft, chemical engineering and servo-mechanisms. In addition, several papers by young engineers will be taken on Tuesday, September 9. Professor W. Fisher Cassie, King's College, Newcastle-upon-Tyne, 1, is the Recorder of the Section. The meeting will include the usual number of social functions and an excellent programme of general and sectional excursions has been arranged. Information may be obtained from the secretary, Mr. D. N. Lowe, O.B.E., Burlington House, Piccadilly, London, W.1.

THE MELCHETT MEDAL.

The Council of the Institute of Fuel have awarded the Melchett Medal for 1952 to Dr. D. T. A. Townend, D.I.C., Hon.M.Inst.GasE., F.Inst.F., in recognition of his contributions to the science of combustion, particularly in the field of the higher hydrocarbons. Since the early part of 1945, Dr. Townend has occupied the position of director-general of the British Coal Utilisation Research Association. During the war of 1914-18, he served in the Royal Naval Air Service, afterwards proceeding to the Imperial College of Science and Technology, London, where he collaborated with the late Professor W. A. Bone, F.R.S., and Professor D. M. Newitt, F.R.S., in researches upon gaseous combustion at high pressures. In 1938, he was appointed Livesey Professor of Coal, Gas and Fuel Industries, with Metallurgy, in the University of Leeds, and during the subsequent years, he achieved a reputation as an administrator, rapidly widening the scope of the teaching and research activities of his department. Dr. Townend has written many papers on combustion and related fields, and served as President of the Institute of Fuel from 1948 to 1950.

THE INSTITUTION OF MECHANICAL ENGINEERS.

At a meeting of the Institution of Mechanical Engineers held on Friday, April 4, Mr. Max Bentham's paper on "Some Considerations Regarding a Factory Maintenance Engineering Department" drew an unusually large audience. The meeting was arranged in conjunction with the industrial Administration and Production Engineering Group, and before the presentation of the paper the retiring chairman of the Group, Mr. J. M. Newton, B.Sc., inducted the new chairman, Mr. Oscar Rendell. The subject of Mr. Bentham's paper—the American approach to which is reviewed in a leading article on the opposite page—suffers from the disadvantage that much of what is said about it borders on the trite; which is perhaps why it is so often neglected. Mr. Bentham remarked that many production managers had hoped to replace old machinery in 1949, when the sellers' market passed and the machinery makers could supply more to the home market, but with the turn of world events at the end of 1950 this hope had considerably diminished. By planned maintenance, therefore, old machines had to be kept going at full capacity. In many factories, he said, there were no proper records of machine breakdowns. In organising a maintenance system, information and experience relating to the machines should be recorded, so that the period of production to be allowed between general and major overhauls of each machine could be determined. It was essential for a definite programme to be laid down and followed from the moment a new machine was installed. The maintenance engineer's or the millwright's shop should be centrally situated in relation to the major producing units; it should have easy access by road, and possibly by rail; and it should, as far as possible, be self-contained. A stores for plant spares should be run under the maintenance engineer, who could also have (the author recommended) a large tool section under his control for reconditioning the tools of the production department as well as the tools of the maintenance department. Mr. Bentham also described, in some detail, a costs system and a method of controlling the work of the maintenance staff.

LLOYD'S REGISTER OF SHIPPING.

The annual report of Lloyd's Register of Shipping does not usually present comparisons with the past, otherwise than in the statistical tables. The report for 1951, recently issued, is an exception, however, as the opportunity has been taken to mark the year of the Festival of Britain by including some particulars of British shipping, and of the Society's operations, for the year 1851. The comparison makes interesting reading. In 1851, when the Society's title was "Lloyd's Register of British and Foreign Shipping," its organisation comprised only two committees—the Committee of Management in London, and a branch Committee in Liverpool. To-day there is also a Scottish Committee in Glasgow, and national Committees in America, Australia and New Zealand, Canada, Denmark, France, Holland, Spain and Sweden. In 1851, there were only 21 surveyors exclusively employed by the Society in the whole of Great Britain, with 40 non-exclusive surveyors in the smaller British ports, and in Ireland and the Channel Islands, whereas there are now 701 exclusive surveyors and 36 non-exclusive, covering the whole world. The Register Book for 1851 contained the names of 9,121 ships which were classed with the Society, and of these only 86 were steamships; and the total "classed" tonnage was only 2,202,000—an average of 240 tons. The total number of ships classed was not very much greater in 1951, the actual figure being 9,729; but their tonnage aggregated 36,267,143, an average of nearly 3,730 tons, and of the total 9,493 were either steamships or motorships. The world fleet in 1951 had increased to 87·2 million tons gross, which was 2·6 million tons more than in 1950 and 27 per cent. more than the total immediately before the recent war. The United States possessed the largest fleet, but a large number were laid up in reserve, so that Britain still had the largest fleet actively employed. A notable feature was the large proportion of tankers, this type now representing more than a fifth of the total world tonnage; 105 tankers, totalling 1,061, 429 tons, were built under the Society's survey during 1951. The total number of ships of all types built to the Society's classification during the year was 472, with an aggregate gross tonnage of 2,151,882, this total representing 60·5 per cent. of all ships built in the world in the twelve months to December 31, 1951. Concurrently with this great activity in the marine field, the Society has considerably extended its work in other directions, especially in research and in the inspection of oil-refinery plant, and special equipment such as turbo-alternators, structural steelwork, switchgear, etc., for the Hydro-Electric Commission of Tasmania.

THE ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.

The annual dinner of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, W.C.2, on Friday, April 4. In the absence of the president (Mr. T. G. W. Haldane), the chair was occupied by the immediate past-president (Mr. A. G. Ramsey). The toast of "The Electrical Industry" was proposed by Dr. S. F. Dorey, who said that electricity was now as indispensable at sea as it was on land, and it was being increasingly used in ship construction. It should be possible to increase the electrical demand in this country many times, and when the same process was applied to the other parts of the world some idea could be gained of the potential magnitude of the industry's activities. The questions for them were therefore how could these future demands be dealt with, what type of power was most suitable and where was the necessary fuel to come from? In reply, the President of the Institution of Electrical Engineers (Sir John Hacking) said that, owing to the requirements of industry and to a stationary working population, there was no immediate prospect of any serious curtailment of demand for power; in other words, more electricity would be required. It should be pointed out that the increase in the amount of coal consumed by the electricity supply industry had not led to an increase in the total requirements as it was offset by savings in other directions. The nationalised coal industry had made substantial savings in operation, and, although the public had a right to criticise, he hoped they would also trust those in charge. Replying to the toast of "Our Guests," which was proposed by the chairman, Sir Arthur Fleming said the advance in electrical knowledge since his early days as a junior engineer at the historic Deptford power station had been very rapid. The one lesson to be learnt from these developments was that in every generation the education and training of the young engineer must be kept in the forefront.

ASLIB AERONAUTICAL GROUP CONFERENCE.

In September, 1951, a number of information officers and technical librarians from the aircraft industry formed, under the auspices of Aslib, the Aslib Aeronautical Group, to arouse a wider interest of the aircraft industry in existing information services and to increase the efficiency and scope of those services. The Group held its first week-end conference and annual general meeting from Saturday, April 5, to Monday, April 7, at the College of Aeronautics, Cranfield, Bedfordshire. It was generally agreed that the conference was highly successful; it was attended by 45 delegates representing 30 organisations, of which half were from industry, the other half comprising Government departments and research establishments, one of the national airways corporations, learned societies, educational establishments, and the technical Press. At the conference dinner on Saturday evening, the delegates were welcomed by Air Marshal Sir Victor Goddard, K.C.B., C.B.E., M.A., and Air Chief Marshal Sir Edgar Ludlow-Hewitt, G.C.B., G.B.E., C.M.G. On Saturday afternoon two overseas visitors, Dr. A. C. de Kock and Dr. R. Timman, of the Nationaalluchtvaartlaboratorium (N.L.L.), Amsterdam, discussed the N.L.L. scheme for cataloguing aerodynamic data on cards (in the first place to be restricted to reports of wind-tunnel tests), which they hope to operate on an international basis. The scheme is being considered by a working party of the Aslib Aeronautical Group, consisting mainly of aerodynamicists, who were able to offer some constructive criticism on the Dutch scheme. On Saturday evening, Mr. P. L. Taylor, M.A., gave a lecture on "Electrical Engineering and Aircraft." On Sunday, at the annual general meeting, a vote of thanks was passed to the secretary, Mr. C. W. Clevedon, for his valuable work. After the annual general meeting, Mr. A. H. Holloway spoke about the work of the Technical Information Bureau of the Ministry of Supply, an organisation for collecting and distributing information on all research and development subjects, other than atomic research and electronics. The Central Radio Bureau of the Ministry of Supply, a "joint Service body" providing the Government departments and industry with information on electronic research and development, was the subject of a talk by Mr. J. G. Ogg. On Sunday afternoon, the three working parties presented their reports. The working party on periodicals has completed and issued a preliminary list of holdings in the group, and the work of compiling a union catalogue is in hand. The other two working parties are considering, respectively, the N.L.L. scheme, as already mentioned, and aeronautical abstracting services, but their final recommendations are not yet ready.

LETTERS TO THE EDITOR.

"KNOCK" IN AUTOMOBILE ENGINES.

To the Editor of Engineering.

Sir,—On page 278 of your issue of February 29, 1952, an abstract was given of our paper "The Significance of Octane Numbers in Relation to Road Anti-Knock Performance," in which the impression was given that we recommended the Modified Borderline technique for estimating user-opinion of road anti-knock quality. In fact, we stated that the Modified Uniontown Method should be used for this purpose, and only recommended the Modified Borderline technique when it was desired to obtain the knock-limited spark-advance speed relationship for a particular fuel or in the detailed study of different hydrocarbon types.

The Modified Uniontown Method rating is based on the spark advance setting that gives trace knock regardless of the speed at which the knock occurs. The method thus gives equal weight to both low and high speed knock and is, therefore, the best indication of the road rating as decided by the user. It is also simpler to carry out than other methods and requires less fuel sample. For these reasons it is recommended for all normal road tests of fuel anti-knock quality.

Yours faithfully,
J. G. Withers.
H. J. Eatwell.

Anglo-Iranian Oil Company, Limited,
Sunbury-on-Thames.
April 1, 1952.

MAN-POWER AND PRODUCTIVITY.

To the Editor of Engineering.

Sir,—Your correspondent, Mr. M. S. Forinton, in his letter in your issue of March 21, on page 371, *ante*, referred to your leading article dealing with productivity. This is a subject which has been bandied about in an indiscriminate way between party and party, and economist and economist, and I feel it should be emphasised that productivity is essentially a relative term.

We all want to know how much better the output is, but if we are to have the right answer, we must be able to compare like with like as far as product and output per week is concerned. How far are we able to do this? On comparing a mud-wing from a new car with one from a car of a very late pre-war type, it was found that the former contained only a trifle more than half the material in the latter. Thus a ton of steel now yields nearly twice as many parts; the wear and tear on the press tools is less; the power needed for pressing is less; and a man can handle more of them. Therefore, since equals are not being compared, it is impossible to say that productivity in the pressing shop has increased, particularly if the service life of the article is taken into consideration.

In an ironmonger's shop the other day, the response to the question: "In what way do all the articles you have in your shop differ from those you sold pre-war?" was: "They are shoddier." The reasoning applied to the motor-car mud-wing holds good for anything else which is shoddier, so that productivity computation can easily be completely misleading unless it is related to exactly similar examples of pre-war goods.

There is, too, another factor of no little importance. What of the labour devoted to producing machines which are used to assist in improving output in some other factory? This, in effect, is a charge on the factory's output. In other words, the workers producing the machines are helping in the production of the factory in which they are used. When assessing the man-hour output of a factory in which automatic machines are used exclusively, some allowance should obviously be made for the time spent in building those machines.

On one occasion, the overall output figure was quoted by Sir Stafford Cripps as 138 per cent. of 1938. It is well known that miners, builders, transport workers and many workers in heavy engineering are not producing, in 44 hours, more of the same things than they produced in 48 hours before the war. How, then, has the result quoted above been achieved by the remainder of the country's industries, which, of course, must carry the laggards, too?

The productivity figure may be used by a Government to help them to determine how far they can allow wages to rise, and how much money can be removed from circulation by taxation for Government spending. Both of these actions are of great importance to the population, and it would be better to have no productivity figure than one that leads a Government in the wrong direction.

Yours faithfully,
A. Hoare, M.I.Mech.E.

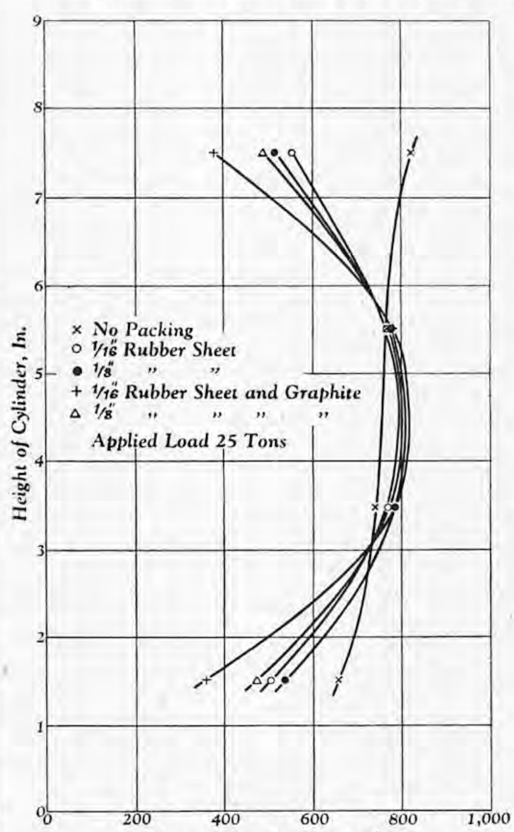
"Overcombe,"
Nodgham-lane, Carisbrooke, I.O.W.
April 1, 1952.

TESTS ON CONCRETE WITH ELECTRICAL-RESISTANCE STRAIN GAUGES.

To the Editor of Engineering.

Sir,—With reference to the article on the above subject by Dr. Grassam and Dr. Fisher on page 356 of your issue of September 21, 1951, and the subsequent correspondence on this subject, I have carried out some further tests.

Two additional concrete cylinders, 9 in. long and



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$4\frac{1}{2}$ in. in diameter, were cast, and electrical-resistance strain gauges were mounted in the positions shown in the graph, herewith, which is similar to that on page 468 of your issue of October 12, 1951. The ends of the cylinders were again capped with plaster of Paris, which was rubbed down until it was smooth and normal to the longitudinal axis of the cylinder. These two specimens were both tested in two different testing machines under various end conditions, the load in each case being applied through ball-seated platens. The end conditions tried were: no packing between cylinders and platens; $\frac{1}{16}$-in. thick soft rubber sheet at each end; $\frac{1}{8}$-in. soft rubber sheet; $\frac{1}{16}$-in. soft rubber sheet lubricated on both sides with graphite; $\frac{1}{8}$-in. soft rubber sheet lubricated with graphite. A selection of the results is shown. The figures are the means of the readings of diametrically-opposite gauges.

It has not been possible to reproduce the variation in strain which was obtained when the previous specimen was tested without end packing. This demonstrates the difficulty of obtaining repetitive end conditions with these specimens, but with the present specimens the introduction of any form of packing has produced a strain variation of the type previously obtained.

Your faithfully,
K. R. Peattie.

University of Nottingham.
March 27, 1952.

STEEL AUTHORISATIONS.

To the Editor of Engineering.

Sir,—The war-time authorisation scheme for steel had two major faults: authorisations were not given far enough ahead to match producers' programmes, and lapsed if delivery was delayed. The new scheme repeats these errors.

On March 5, Mr. Duncan Sandys told the House that the Ministry of Supply had already issued the allocations for the second quarter of this year, but that he would make no forecast of the allocations for the last two quarters. On the other hand, producers of the finished and semi-finished classes of steel listed in the Iron and Steel Distribution Order, 1951 (S.I.2006) tell us that some of our indents placed in 1951 will not be due for delivery until the end of this year. It appears that we shall be able to get delivery of the steel against these old indents when it is ready, but to agree this with our suppliers has already cost at least 5*l.* per ton, as it has been necessary to do a complicated jig-saw puzzle of anticipated delivery dates and authorisation periods, in addition to lengthy trunk calls and many letters.

The present insoluble problem is that of our future indents. We have for years past found it necessary to send them anything up to 18 months ahead of the time when delivery is required, but Clause 1 of the Order states that "No person shall . . . agree to acquire or dispose of any iron or steel . . . except in accordance with the provisions of this Order," so that we cannot send them until we have the authorisations. We fail to appreciate that any harm could result from forward indents placed on the understanding that authorisation particulars would be furnished before delivery of the steel. The second difficulty is that if delivery is delayed more than three months the authorisation lapses, though the reasons for the acquisition of the steel are still as valid as when the authorisation was first issued. Why, for example, should the making of a lathe be deemed no longer necessary because there has been a breakdown at a steelworks?

Yours faithfully,
April 2, 1952. Frustrated.

OBITUARY.

MR. T. A. CROMPTON.

We have learned with much regret of the death, on April 2, of Mr. T. A. Crompton, managing director of Messrs. Blundell and Crompton, Limited, engineers and ship repairers, of West India Dock-road, London, E.14. Mr. Crompton, who was 72 years of age, had been seriously ill for several months.

Thomas Albert Ashton Crompton was born on February 4, 1880, and was the son of Mr. T. Albert Crompton, consulting engineer, and the inventor of the ship's ash hoist which bears his name. He was educated at Woodgrange College, Essex, and at the East London College, and, after serving an apprenticeship, partly in his father's office and partly with A. W. Robertson and Company, spent nine years at sea, rising to be chief engineer. He then returned in 1909 to the family business, subsequently amalgamated with Blundell's London Copper and Brass Works, which began in 1825 as the works of Jonathan Downton, maker of the Downton pump. In the combined firm, he rose from assistant manager to managing director, though latterly, because of advancing years, he had been gradually reducing his personal activities in the business. Mr. Crompton was a member of the Institution of Mechanical Engineers and the Institution of Naval Architects, and a vice-president, and former chairman of Council, of the Institute of Marine Engineers. He was a liveryman of the Worshipful Company of Shipwrights, a member of the Court of Assistants of the Horners' Company, and a former President of the City Livery Club.

THE INSTITUTION OF NAVAL ARCHITECTS.

In last week's issue, on page 434, *ante*, and in a leading article on the preceding page, we recorded and commented upon the proceedings at the opening session of the 1952 Spring Meeting of the Institution of Naval Architects, held in London on board the Wellington, headquarters ship of the Honourable Company of Master Mariners, on Wednesday, April 2, and the following days. We summarised, on page 434, the main items from the Council's report, and gave the names of the recipients of the various Institution awards. These having been presented, following the formal business of announcing election results, etc., the President (Viscount Runciman of Doxford) delivered his address, which we reprint below, slightly abridged.

The President's Address.

This is the first occasion, said Lord Runciman, on which I have had the privilege of addressing the Institution as President. I did undergo a sort of trial trip last summer at the International Conference of Naval Architects and Marine Engineers, which was to me a valuable and enjoyable experience, though we all regretted that the ill health of my distinguished predecessor should have been the cause of it. We are glad to see, in his increasing public activities, evidence that Lord Cunningham is regaining his wonted vigour. The International Conference provided not only very pleasant and useful contacts with those in other lands who pursue similar objects to our own, but was the occasion of papers and discussions of real and lasting value.

In the international field, we have welcomed an invitation from the Associazione Italiana di Tecnica Navale for joint meetings in Genoa, Rome and Naples in late September, details of which are to be made known shortly. The Council feel that this meeting offers a suitable opportunity to elect General G. Rota an honorary member of the Institution. Though he is, perhaps, not so well known to the younger generation, senior members will be aware of the valuable contributions to naval architecture which have been made in the past by this distinguished Italian constructor. It is proposed to make the presentation of the diploma of honorary membership to General Rota in Rome during the autumn meetings.

There are certain domestic matters to which I should refer. The first is our by-laws. Experience has shown that the big revision of the by-laws and regulations which came into force in 1948 left one or two points still in doubt. Accordingly, the Council have set up a small committee to consider them and, we hope, put them beyond the possibility of misinterpretation. It is planned to complete the work during the next few months, and to call a special meeting in the autumn to approve the proposals, so that the amendments can be submitted to the Privy Council and introduced for adoption in 1953.

We have for some time been looking forward to having our own modest lecture hall. I am sorry to say that, so far, we have failed to secure a licence to build. This is probably inevitable at the present time, though our architects say that, so far as steel is concerned, the new building only requires 3½ tons. All the plans are prepared, and the approval of all the London authorities concerned have been received. As soon as permission to build is given, we shall go ahead and provide a proper home for ourselves, with much improved facilities for our members and for holding meetings, both formal and informal, which then might well be held more frequently.

Members of this Institution are naturally familiar in their daily lives with the effect of the re-armament programme on shipbuilding. It gives rise to severe practical difficulties in things like the shortage of steel and of certain sorts of specialised labour, though on the more professional side it stimulates the designer—particularly, of course, of warships—and results in such interesting types as the Eagle aircraft carrier and the Daring class of destroyers. It should, and doubtless does, stimulate also metallurgical and other researches into the possibilities of more economical materials and ways of using them, which could be of benefit far beyond the production of warships. It is recognised, for example, that warships, being required to withstand abnormally high working stresses, including shock stresses imposed by the malice of the Queen's enemies, and to be capable of operating at very low temperatures, call for steel of good notch ductility. There is increasing experimental evidence that British steels vary considerably in this respect, and there is urgent need for a simple test for discriminating between those which are acceptable and those which are not. This is primarily an Admiralty requirement, as is the need for developing a satisfactory technique for welding aluminium alloys, but it does not need much imagination to realise the benefit that could result to merchant-ship design and construction if these problems were once satisfactorily solved.

Of quite a different kind is a research (in which this Institution is taking part) into the most appropriate way of measuring the tonnage of merchant ships. This is a subject which bristles with difficulties far beyond that of arriving at a good simple mathematical answer. The existing terms of gross and net tonnage are enshrined in Acts of Parliament, and, being the basis on which the ship is made to pay for many of the services she needs, are further hallowed in the temples of Mammon. But it has become apparent that, in some respects, notably propelling power allowances, the existing laws are out of date and have begun to militate against good and economical design in certain kinds of ship. As main engines become more compact for any given horse-power, the defects of the existing rules will become more serious, and I am glad that some steps are being taken to amend them. It is particularly satisfactory that, in this country, shipowners, shipbuilders, the technical institutions and Lloyd's Register should be working together on this question, in which all our interests are basically the same; but any reforms, to be effective, require international agreement.

Examples could be multiplied of the work of the Institution, beneficial to its members and to the world at large. The more we are able to develop and co-ordinate our working relationship with the kindred institutions and other bodies concerned with the production of better ships so that each one of us is complementary to the others, the more useful we shall be. We shall never, I suppose, reach the end of our journey towards designing the perfect ship, or even the most efficient compromise (for all ship design is a compromise of one sort and another), but year by year we take a few steps along the road. That, after all, is what justifies our existence.

Deep Sea Liners.

Following the President's address, the technical sessions were opened with the paper by Mr. Basil Sanderson, M.C., entitled "Britain's Deep Sea Liner Trade, 1945-51, and Some Random Thoughts." Some of the main points made by Mr. Sanderson were quoted in the leading article on page 433, *ante*, previously mentioned. He did not read the paper *in extenso*, but summarised its principal features, amending it, in so doing, by stating that the estimate of the Chamber of Shipping, in 1950, that the cost of new construction was about three times the average of the years 1937-39, required to be corrected; "I am sorry to say," he observed, "that this is already out of date—the latest figure is four times, which makes the position even blacker." With regard to the effect of fouling in increasing the fuel consumption at sea, he said: "I would add a further example which came to my notice only last week. A passenger vessel left New Zealand after having spent 42 days in the warm waters of Auckland during the height of the summer, and arrived in London a few days ago. She made the homeward passage at a speed of 14·33 knots, and consumed 87 tons of oil per day. Our superintendent engineer told me that, with her draught and trim, that expenditure of fuel could have been expected to produce a speed of more than 17 knots, which was the schedule laid down. In the clean condition, at 14·33 knots, he estimated the proper consumption at 52·44 tons per day; so here we have an increased fuel consumption, for the speed actually maintained, of 83·2 per cent., which is beyond anything I ever thought possible."

The discussion was opened by Mr. John Baird, who, referring to Mr. Sanderson's suggestion that ships might be designed to be loaded and discharged through side ports, said that there were ships in existence which had in the superstructure the means of horizontal loading. In particular instances, such as a train ferry, it was the obvious thing to do, but, from the point of view of the general cargo carrier, it could only waste the space of the superstructure. Mr. Sanderson had suggested the use of a hangar berth, a question which was tied up to some extent with the loading of the ship. Mr. Baird could not help feeling that cargo-lifting machinery in the ship was wrong. Why not have tiered warehouses alongside, having the hold cargo at the top and 'tween-deck cargo at the bottom, gantry cranes being provided for loading the whole ship? The cargo to be loaded could be lifted to the necessary height when the ship was not there, so that no time was wasted and deck machinery was unnecessary. In the liner trade, there had been a succession of very similar ships, each fitted with some deck machinery at considerable cost, with generators to drive the machinery, the fuel used for that purpose being carried halfway round the world; the machinery was used only intermittently and for very short periods. If there was any possibility of ports being modernised as well as ships, surely that was a way in which the shipowner could make a considerable saving. Mr. Sanderson had also referred to the waste of space due to the installation of refrigerating equipment in a ship, confessing to a personal suspicion that too much attention had been paid in the past to improving the refrigeration plant system and too little to the quality and efficiency of the insulating medium. But, after all, a refrigerating plant was composed of two parts, the refrigerating equipment and the insulation. If a lot of time was devoted to improving the machinery, which was probably more susceptible to improvement than the insulation, the effect was to improve the equipment as a whole. The real problem for the refrigerating engineer was to preserve a balance between the amount of insulation he used and the amount of machinery that he put in.

Mr. J. L. Kent, C.B.E., who was the next speaker, observed that liners used mainly for pleasure cruises needed large expanses of deck area, and perhaps a departure from the conventional ship form might receive consideration for this type of vessel. A proposal, put forward some years previously, contemplated a ship with three or more decks, rectangular in shape, extending from bow to stern, and supported well above the water surface upon two parallel horizontal cylinders with shaped ends, floating on the water and containing the propelling machinery, fuel, stores, etc. On the lower decks were the public rooms and cabins, and the upper were sports and promenade decks. It was shown that such a ship could be made sufficiently stable and strong to withstand all the strains, etc., that it was likely to experience in service, and that it could be driven at the same speed as the equivalent conventional ship with approximately the same expenditure of power. Other improved qualities, e.g., seakindliness in storms and ease in stowing fuel and stores, safety, etc., were claimed for such a design, and incidentally, in case of emergency, the ship could be rapidly converted into an aircraft carrier.

In the penultimate paragraph of his paper, the author noted as a fact that the latest and most efficient hull forms, when new and clean, often gave startlingly good results in speed and fuel consumption, which were lost when the hull became fouled. This statement supported the view which he had held for some years, namely, that laminar flow was present in the friction belts of many modern ships of moderate speed, and that the Reynolds number was not a criterion of its presence or absence. If this was true, turbulence stimulation should not be used in model experiment work, as it masked the possibility of a ship form inducing laminar flow. Such a flow was not an objection, as the shipowner profited, at least, during the first voyage out of dock; but, of course, the margin of power allowed should cover the possibility of the ship becoming foul on the second and subsequent voyages.

(*To be continued.*)

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

Fig. 8.

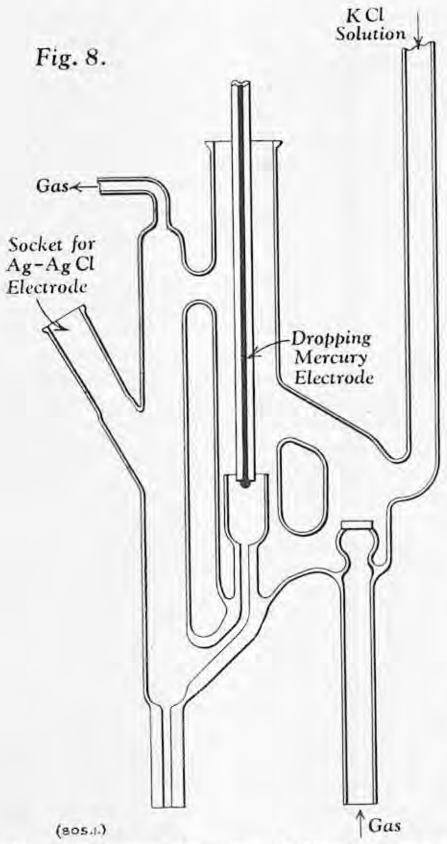


Fig. 8. Potentiometric Oxygen Meter; British Oxygen Company, Limited.

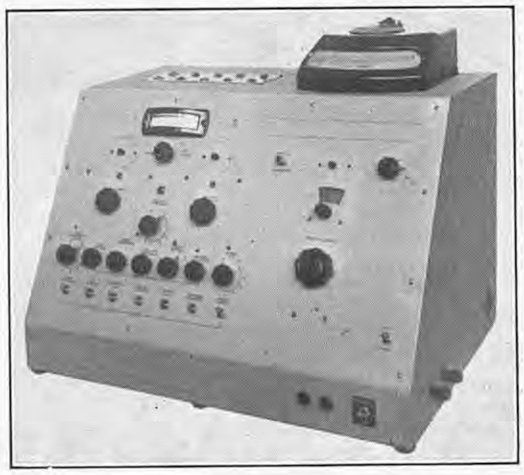


Fig. 9. Polarograph; British Oxygen Company, Limited.

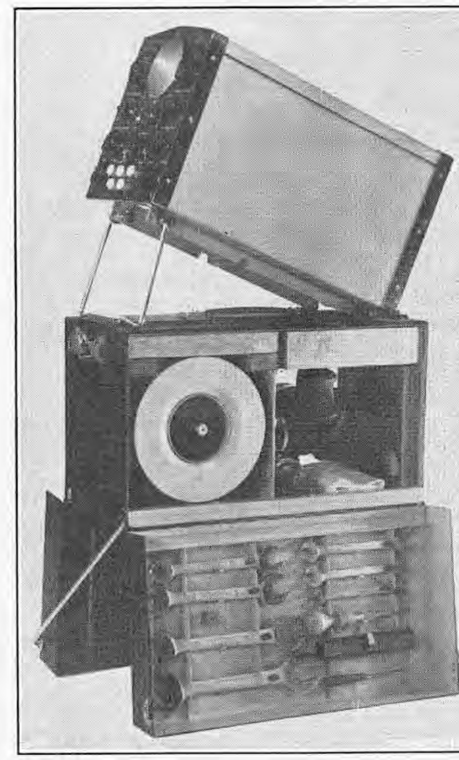


Fig. 10. Portable Engine Indicator; Shell Refining and Marketing Company, Limited.

THE PHYSICAL SOCIETY'S EXHIBITION.

(*Concluded from page 427.*)

Among the apparatus shown by the British Oxygen Company, Limited, Morden-road, London, S.W.19, at the Physical Society's Exhibition, which closed on Tuesday, April 8, was the potentiometric oxygen meter, a diagram of which is given in Fig. 8. The operation of this instrument depends on the fact that the normal potential of a dropping-mercury electrode is changed by the diffusion current of oxygen in solution. The gas to be analysed is passed through a decinormal solution of potassium chloride in which a dropping-mercury electrode is immersed. A silver-silver chloride electrode is used as an anode. The potential between these two electrodes is smoothed by a large capacity and is measured potentiometrically on a *p*H meter. The system is contained in a cell which has been designed to allow drop-formation to take place in a non-turbulent liquid, but at the same time to allow the saturation with the gas mixture to be attained rapidly. The instrument has a range from 0 to 0·5 per cent. of oxygen and differences of 0·005 per cent. can be detected.

In the magnetic oxygen meter, which was exhibited by the same firm, use is made of the fact that oxygen is strongly paramagnetic, in comparison with other gases, to estimate its concentration in mixtures. The instrument is portable and is intended primarily for use in hospitals for measuring the gas concentration in oxygen tents. It consists of a small glass dumb-bell, weighing about 8 milligrams, which is suspended by a quartz fibre 8 μ in diameter in a non-uniform magnetic field. If the surrounding gas contains oxygen its susceptibility is higher than that of the dumb-bell. The latter therefore rotates until the spheres at its ends occupy a region of lower field strength. This rotation is indicated by means of a beam of light, which is reflected from a mirror 1 mm. square cemented to the dumb-bell. The scale can be calibrated in terms of oxygen partial pressure or, if the total pressure can be assumed constant, directly in terms of oxygen concentration in ranges between 0 to 30 and 0 to 100 per cent. including those with a set-up zero.

A polarograph, which is illustrated in Fig. 9, was also being shown by the British Oxygen Company. This instrument has been designed for analytical research work and incorporates refinements not found in most commercial instruments. The applied voltage is measured to within 0·01 volt by a calibrated slide wire, the total potential difference across which is 3·0 volts. This voltage is accurately set by comparison with the electromotive force of a Weston standard cell. The current is measured on a calibrated galvanometer which gives a full-scale deflection with a current of one microampere. Ten sensitivity ranges are provided in accurately-known ratios between 1 and 1/1,000. The range-changing resistances are designed to present a constant total resistance at all settings both to the galvanometer (for damping purposes) and to the remainder of the circuit. The galvanometer is shunted with a large capacity to reduce the oscillations caused by the dropping-mercury electrode. This electrode is of all-glass construction so that contamination of the mercury with rubber or plastic tubing is prevented. Provision is made for the cancellation of both the ohmic and non-ohmic residual currents carried by the base solution and of a large wave in case it is required to measure a small superimposed wave. This enables the full galvanometer sensitivity to be used to determine small concentrations of one substance in the presence of either a large residual current due to the base solution or of a large concentration of another substance reduced at a slightly lower voltage. The main slide wire is supplied from accumulators which can be charged *in situ*. The other circuits are fed from the mains.

The portable engine indicator illustrated in Fig. 10 has been designed by "Shell" Refining and Marketing Company, Limited, Thornton Research Centre, Thornton-le-Moors, Chester, to provide a compact and versatile instrument which can easily be attached to an engine and is simple to operate. It is therefore particularly suitable for use in the field. It consists of a number of electromagnetic transducers which convert the varying pressures in the fuel, induction and exhaust lines of the engine into voltages which are amplified and displayed against a time base on the screen of a cathode-ray oscilloscope. The pressure in the cylinders, as well as the movement of such parts as the fuel-injection valves, can be shown in the same way. The time base recurrence is synchronised with the rotation of the engine crankshaft by voltage pulses which are obtained from a rotary generator. This generator is driven by a rubber pad which is held against the end of the shaft. As the orientation of this coupling is arbitrary, the position of the crankshaft which corresponds with any point on the displayed diagram can be determined stroboscopically. This is achieved by illuminating a scale, marked, for example, on the rim of the flywheel, by a portable stroboscopic lamp. The voltage pulses which synchronise the time base also flash this lamp after an electrical delay, which can be adjusted manually. Simultaneously, the cathode beam is momentarily deflected vertically to identify the instant of flashing on the diagram.

The same firm was showing an apparatus for the rapid and precise ebullioscopic determination of molecular weights. This instrument has been designed to remove the limitations on the outputs of conventional ebullioscopes, which are imposed by the long time-constant of the Beckmann thermometers commonly employed to measure boiling point elevations. This has been done by employing differential electrical resistance thermometers incorporating thermistors as the temperature-sensitive elements. As the time-constant of these is very short the ebullioscope must produce an extremely steady internal temperature; and on the instrument exhibited, an adequately stable reading of boiling point elevation is produced about three minutes after the addition of the solute. The ebullioscopes are used in pairs in order to compensate for the variation in the boiling point of the solvent with the barometric pressure and are enclosed in continuously-heated vapour baths to hasten the equilibrium of fresh charges of solvent. The speed of operation depends upon this point. Rapidity is further increased by providing two pairs of ebullioscopes which are used alternately. Each ebullioscope requires a charge of about 40 ml. of solvent and the standard error of a single determination of boiling point elevation is in the region of 0·0005 deg. C.

The portable magnetic crack detector, shown by Messrs. Solus-Schall, Limited, 18, New Cavendish-street, London, W.1, and illustrated in Fig. 11, opposite, has been designed for detecting the presence of cracks in small specimens or in equipment on site. Magnetisation is effected by passing a current of about 750 amperes from a self-contained transformer into the specimen by a pair of metal electrodes or by wrapping short-circuited connections from the secondary of the transformer round the specimen. A third method is to use a ten-core cable, with the turns series-linked. These can be coiled round the specimen and connected directly to the mains through a fuse. As the short-circuit current is high, adequate ampere-turns are provided for magnetisation and, as direct current is used, no transformer is necessary. The magnetic particles are usually suspended in a light oil which is sprayed on to the surface of the specimen. The magnetised object can also be dipped into a bath of the detector fluid or a dry powder can be used. If the surfaces

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

FIG. 11. PORTABLE MAGNETIC CRACK DETECTOR; SOLUS-SCHALL, LIMITED.

are machined or polished, the normal black magnetic ink gives good results, but on rough or dirty surfaces a quick-drying white paint is applied to give adequate contrast. Alternatively, coloured inks can be used.

When the electrodes are deposited on certain types of crystal vibrators, adjustments must be made for frequency changes. To replace the usual dual process of sputtering an initial conducting film and subsequently electroplating for frequency adjustments, Messrs. W. Edwards and Company (London), Limited, Worsley Bridge-road, Lower Sydenham, London, S.E.26, have designed a crystal frequency control unit. This apparatus, which was shown at the exhibition and is illustrated in Fig. 12, consists of a turret head on which the high-frequency crystals are mounted. This head is arranged inside a vacuum chamber and is fitted with an externally-controlled mechanism so that each crystal can be rotated into the calibrating position. The turret itself consists of a Perspex disc, the circumference of which is drilled and fitted with spring-loaded connections, the connections holding the crystals which are mounted on a standard base. A conical-shaped mask, the aperture of which is parallel to the surface of each crystal, is fitted on the upper surface of the disc. With this arrangement, one face of 16 crystals about ½ in. square can be coated in a single evaporation from a source located at the top of the vacuum chamber about 1 gram of gold being vaporised to deposit a film $0 \cdot 2\ \mu$ thick. To ensure a surface film, the crystal faces are so arranged that the vapour emitted by the evaporation source is normal to the crystal surface and, for this reason, the crystals are inclined to the plane of the jig.

The remaining face of each crystal is then coated individually and the frequency calibration made. To economise in the consumption of metal, such as gold, the vapour must be brought close to the crystal surface, and, in order to do this without raising the crystal temperature, the charge necessary to coat 16 crystals is distributed between four heaters which are arranged on a second turret head. The evaporation source for the gold is a molybdenum foil which is bent to a hairpin shape so that the vapour is emitted in a solid angle. As a result, the gold deposited on the chamber walls is less than that usual with filament-type heaters. To deposit a gold film about $0 \cdot 2\mu$ thick on to one crystal face a charge of 60 milligrams must be vaporised.

The crystal electrode mask consists of a short tubular shield with the required aperture at one end. The evaporation heater is not completely enclosed by the shield tube since the pressure in the tube rises when evaporation begins and the vapour aperture is insufficient to obtain adequate pumping speed. Additional shields are therefore fitted round the vapour source to prevent conducting films being deposited on the Perspex plate. In order to measure the frequency during evaporation each

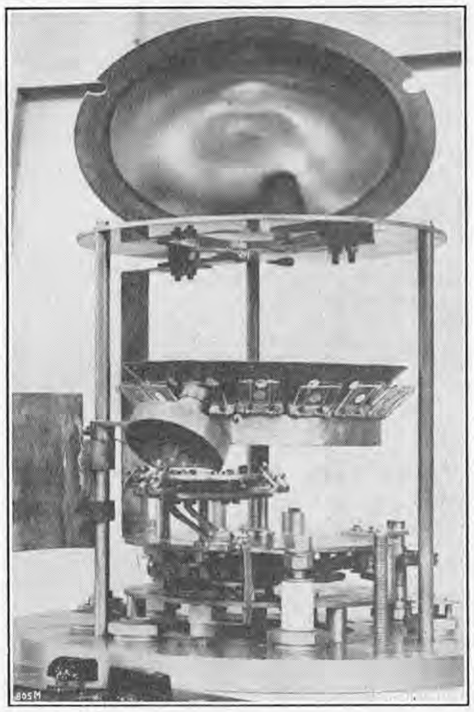


FIG. 12. QUARTZ-CRYSTAL FREQUENCY-CONTROL UNIT; W. EDWARDS AND COMPANY (LONDON), LIMITED.

crystal is connected to a pair of spring loaded contacts under the Perspex holder. These contacts are wired to an external test oscillator, which is mounted in the base plate. The Perspex holder and vapour source turret head are rotated into position by a sprocket and chain, which are connected to a vacuum sealed shaft in the base plate. The sprockets on both the turret head and crystal holder shafts are of the freewheel type and are mounted in opposing positions. Independent movement of both shafts is then obtained by a single handle, the clockwise rotation of which moves a new crystal into the calibration position while turning it anti-clockwise changes the source of evaporation.

Messrs. Kelvin and Hughes, Limited, and associated companies, New North-road, Barkingside, Essex, were exhibiting a number of examples of the equipment and instruments they manufacture for marine, aviation and industrial purposes. Among these mention may be made of the 50-cycle motor-generator, which is illustrated in Fig. 13. This consists of a low-inertia high-torque induction motor which has an induction generator built integrally with it. It has a linear "voltage output against speed characteristic" and is intended for use with servo mechanisms.

The motor is basically of the squirrel-cage induction type, in which special attention is given to the rotor design so as to obtain maximum torque at stall, and low speeds. The stator winding is designed to operate from a two-phase or a single-phase source using a phase-shifting condenser. In either instance the unit may be safely operated continuously at any speed from zero to maximum. The induction generator attached to the motor consists of a two-pole two-phase stator winding and a cup-type rotor carried on the motor shaft. Enclosed within the rotor is a fixed core of magnetic material to ensure maximum flux linkage with the cup. While one phase is energised continuously, a voltage varying linearly with the rotor speed is induced in the second phase. These generators are specially compensated to obtain a low residual voltage, and to ensure that a change in rotor position will give a minimum change in that voltage.

Another exhibit on this stand, of which mention may be made, was the yarn tension pick-up unit and strain recorder illustrated in Fig. 14. This has been designed for use in the textile industries where it is frequently desirable to investigate the rapidly fluctuating tensions in threads and yarns during spinning, spooling and weaving operations.

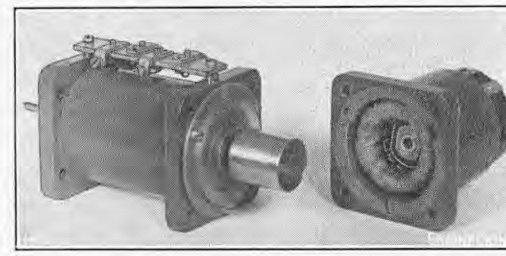


FIG. 13. 50-CYCLE MOTOR-GENERATOR; KELVIN AND HUGHES, LIMITED.

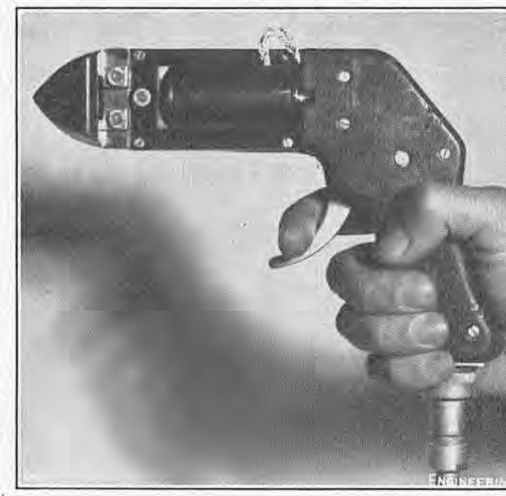


FIG. 14. YARN TENSION PICK-UP UNIT AND STRAIN RECORDER; KELVIN AND HUGHES, LIMITED.

The mean value of the tension can, of course. be readily measured on simple dial instruments, but these take no account of the rapid fluctuations which may cause breakage or structural damage, especially to synthetic yarns. To investigate the behaviour of a machine or to adjust it for optimum performance in respect of tension fluctuations a pick-up unit has been incorporated in the firm's strain recorder. This unit consists of a small cylindrical transducer of the inductance (variable-reluctance) type in which the armature is suspended by spring diaphragms between a pair of coils. A small movement of the armature then causes an increase in the inductance of one coil and a corresponding decrease in the other.

The yarn runs on a miniature ball-bearing pulley which is connected mechanically to the armature and round two guide pulleys which are fixed to the frame, so that the force on the armature is twice the tension in the yarn. The movement of the armature, and hence the change in inductance, is then proportional to the tension. This change of inductance is then converted by the strain-recording amplifier into deflections of a stylus, which draws a dry instantaneous and permanent record of the tension variations in the form of a fine black trace on Teledeltos paper. The cylindrical inductance unit is mounted on a pistol-grip handle with a smooth exterior, which can be used in most inaccessible places in winding and spinning machines, and may be inserted between the warps of a loom.

To load the yarn a trigger is provided which moves the inductance unit forward; the yarn is then laid on a straight run between the pulleys and the trigger is allowed to spring back to the operating position. Only about ¾ in. pullout of yarn is required, and there is no need to stop the machine for loading. In its standard form, the instrument has a maximum sensitivity of about 2 grammes for full-scale deflection, and tensions up to 150 grammes may be accommodated simply by using the sensitivity control on the amplifier. Higher tension ranges are contemplated. The response of the equipment is uniform up to 60 cycles per second (3,600 r.p.m.), but the pick-up has a natural frequency of several times this and is substantially damped, so that transient fluctuations of tension are faithfully recorded. An advantage claimed for this method of tension recording is that the pick-up unit is separate from the remainder of the equipment, though it is connected to it by a cable of any length up to 50 ft. It may thus be made small and light and may be hand held and used in very inaccessible positions.

The recorder may, if desired, be fitted with an additional fixed marker pen energised by a contactor clamped to the machine under investigation. In this way a mark is made on the record for each revolution or oscillation of some component of the machine and correlation may be observed between these movements and the changes in tension. The equipment, in conjunction with some means for applying a constant rate of extension, may also be used for rapidly obtaining load-extension curves for fibres. Without the tension pick-up unit and with the addition of other suitable conversion elements, the instrument can be applied to a wide range of engineering and physical measurements involving rapidly changing loads, strains, etc., or any quantity which can be converted into a ahange of resistance, inductance or capacitance.

HEENAN AND FROUDE, LTD.

A booklet has been issued by Messrs. Heenan and Froude, Limited, Worcester, to mark the 50th anniversary of the incorporation of the company on March 29, 1902. The firm was started in 1880 by Mr. Hammersley Heenan, who purchased the works of Woodhouse and Company, Newton Heath, Manchester. In the following year he took into partnership a former colleague of his in India, Mr. R. Hurrell Froude, the eldest son of William Froude, F.R.S., who had invented the hydraulic dynamometer. The business was partly transferred to Worcester in 1903, and in 1935 the Newton Heath works was disposed of; for a time there was also a works at Birmingham. At first the firm specialised in steel structures, and were responsible for the Blackpool Tower, but the Froude dynamometer soon became the mainstay of the business, water coolers being added in 1906. Products to-day include air filters, closed-circuit air coolers, automatic machines for the wire, strip and chain industries, the Heenan-Dynamatic dynamometer, the Heenan-Dynamatic coupling, oil-coolers for heat-treatment shops, refuse-disposal plants, and special conveying equipment.

The Heenan and Froude Group now includes other firms purchased since 1936, namely, Associated Locomotive Equipment, Limited, Worcester (British-Caprotti poppet-valve gears for locomotives and ships, and Lentz poppet-valve gears for locomotives); Messrs. W. G. Bagnall, Limited, Stafford (locomotive builders); Court Works, Limited, Madeley, Shropshire (malleable-iron and grey-iron founders); Messrs. Fielding and Platt, Limited, Gloucester (hydraulic equipment, particularly presses); Industrial Waste Eliminators, Limited, 27, Albemarle-street, London, W.1 (abattoir equipment, etc.); the Morton Machine Company, Limited, Wishaw (machinery for the bakery industry); the New Destructor Company, Limited, Worcester (incinerators, scrap-baling presses, etc.); and Hyganic Developments, Limited (owners of patents relating to the conversion of town's refuse into fertiliser). A large proportion of present orders for the parent company are for machinery for overseas countries, including the United States, Sweden, Norway, Denmark, Holland, and Switzerland. The booklet opens with a note addressed to shareholders by Mr. Alan P. Good, chairman of the board.

Aviation Films.—A series of interesting and well-produced 16-mm. films dealing with various aspects of the activities of the Hunting Group of Companies was shown recently at a Press and trade preview. The films comprise "The Launch of m.t. Wheatfield," a news film showing the launching of a new addition to Hunting's tanker fleet at Haverton-on-Tees, in December, 1951 (running time, 6 minutes); "Phoenix Works," produced for Field Aircraft Services, Limited, showing various stages in airframe overhaul procedure at Tollerton and engine overhaul at Croydon airport (running time, 17 minutes); "The World from the Air," produced for Hunting Aerosurveys, Ltd., describing the processes involved in producing maps and models from aerial photographs (running time, 13½ minutes); "Blue Print for the Air," produced for Percival Aircraft, Ltd., showing stages in the design and construction of the Percival Prince air liner (running time, 13½ minutes); and "Air Line with Africa," produced for Hunting Air Transport, Ltd., which tells the story of a charter flight from England to Nairobi (running time, 17½ minutes). The films may be borrowed by societies and institutions from the Hunting Group Publicity Office, 35, Old Bond-street, London, W.1.

LABOUR NOTES.

New wage claims for an all-round increase, on behalf of the two and a half million persons employed in the engineering and shipbuilding industries, are likely to be presented to the employers in a few weeks' time. The executive council of the Confederation of Shipbuilding and Engineering Unions decided at a meeting in York on April 3 that executive officials of the 39 unions affiliated to the Confederation should meet in London on April 18 to consider the question. It was agreed that the London conference should be asked to approve an application being made for a "substantial" amount, without naming a specific sum, and, if this recommendation is carried, it is anticipated that the new claim will be presented to representatives of the Engineering and Allied Employers' National Federation about the second or third week in May. The exact amount to be entered in the Confederation's claim will probably be decided upon by the organisation's executive council a day or two before the meeting with the Federation. This arrangement, it is considered, will give the officials of the Confederation the maximum amount of time in which to study the repercussions of the Budget on the cost of living.

Suggestions for a further increase in engineering employees' wages were put forward recently by one of the largest of the unions affiliated to the Confederation, and the reactions of the other organisations to the proposal were considered at some length at the executive council's meeting in York on April 3. It is understood that there was overwhelming support for the presentation of a fresh claim but that there was considerable difference of opinion as to the amount for which the employers should be asked. It is generally considered, however, that the figure finally decided upon will not be less than 20s. a week all-round. Such a claim, if granted in full, would increase the wage bill for the two industries by not less than 120 million pounds a year. It may be recalled that the last increase in wages in these industries was granted in November last year and involved an addition of 70 million pounds to wage costs. Not only are the new claims likely to be the largest wage demand of any of the country's industries, but it will come from those most concerned in the nation's rearmament and export drives.

The answer of the Engineering and Allied Employers' National Federation to the demands of engineering and shipbuilding apprentices for an all-round increase in their wages by 20s. a week will be presented to representatives of the Confederation of Shipbuilding and Engineering Unions in London on April 17, the day before that chosen for the meeting of the London conference to consider a new claim on behalf of adult employees. It may be recalled that it was in support of this wage demand that young men in the engineering and shipbuilding industries went on strike last month at Glasgow, Edinburgh, Manchester, Liverpool and Sheffield. They stated that there had been "delay" on the part of the employers in dealing with the claim.

Employment levels and the effects of the Budget are discussed in a lengthy editorial article in the April issued of the *Journal* of the Amalgamated Engineering Union. It is stated that the necessity for keeping employment at "a high and stable level" has been accepted as a Government responsibility for nearly a decade, and that it was, in fact, proclaimed by the Churchill Government in May, 1944, as one of its primary aims and responsibilities. It is suggested that a very high degree of employment was reached during the period in office of the late Government, and that this increased during its last year "to the colossal total of practically 23 and a half million persons," while the "average number of unemployed workpeople in that year was barely a quarter of a million." Figures are quoted to show that unemployment is increasing in various trades and industries, mainly, it is contended, as a result of Government policy.

Exceptions to the growth of unemployment at the present time are to be found, however, the article states, in the engineering group of industries, two or three of the basic industries, and the group concerned with professional, financial and miscellaneous services. According to the latest returns, there were "approximately four hundred thousand registered unemployed in mid-February." On the other hand, the returns show that there were 1,158,000 persons in industry working overtime. That seems a counterbalancing factor to put against short time and loss of employment though it is obviously an inequitable factor as between one body of workpeople and another. But the fact is, the article proceeds, that the number of those working overtime was 120,000 fewer in January last than in September, 1951, while the amount of overtime worked averaged only 7½ hours a week.

Some hard words are contained in the article about the Government's dearer-money policy and the Budget, which, it is suggested, are a reversal of the policy of full employment. As to the Budget, the journal's "fundamental criticism of it is not that it abandons the policy of keeping prices down and sets aside the arguments by which the trade-union movement was exhorted to implement the system of wage restraint." All those arguments have gone, and, with them, "practically all the proposals set forth in the White Paper (Employment Policy, May, 1944) to guide the policy and action of a Government which is determined to maintain a high and stable level of employment." In the journal's view, the Budget has to be criticised, not on the level of a little less here and a little more there, but in the light of the proposals made by the Trades Union Congress General Council to the Chancellor before he completed his Budget.

The General Council referred to the maintenance of full employment as the first objective of Government economic policy, and it is on this, the journal states, that the fundamental criticism of the Budget, from the T.U.C. standpoint, rests. An earlier statement by the T.U.C., it is affirmed, contained positive suggestions by which full employment could be maintained, even under the abnormal economic conditions which now prevail. These suggestions included the maintenance and increase of food subsidies, the rejection of increases in National Health Service charges, the raising of the standard rate of income tax to 10s., and increases in the profits tax on both distributed and undistributed profits. The T.U.C. favoured a capital gains tax and defended the purchase tax, attaching particular importance to the exemption of utility articles.

Before the Budget, the article reminds its readers, there was talk of direct action by the trade unions to resist the proposed cuts in the social services, but the T.U.C. General Council and Labour Party leaders "promptly repudiated advocacy of a policy of this sort as irresponsible, mischievous and highly dangerous." The journal reiterates its view that one of the plainest lessons of the inter-war years was that unions use strike weapons for political purposes at their peril and that responsible leaders can have "no truck" with that kind of direct action. But, it concludes, when the Government consistently pursues a direct departure from the system of controls which aimed at keeping employment at a high level and protecting the consumer against exploitation, trade unions are bound to resort to the other kind of direct action, by which, through the established machinery of negotiation, they can protect their members' interests and secure wage advances to meet the higher costs of living.

Opposition to the working of shifts at collieries on Saturdays was expressed at a conference of delegates from the Scottish area of the National Union of Mineworkers, which took place at Edinburgh on Monday last. The conference decided against the renewal of the extended hours agreement, under which the working of voluntary shifts is permitted. This agreement between the union and the National Coal Board comes to an end on April 30. Mr. Abe Moffat, the President of the Scottish area of N.U.M., stated after the meeting that 84 branches in the area had voted against the agreement being renewed and 39 branches in favour. Another subject discussed by the conference was the prosecutions resulting from the Knockshinnoch colliery disaster. In this connection, a resolution was approved unanimously requesting the union's national executive to demand that the Coalmines' Act should be amended "without delay."

According to estimates issued by the National Coal Board on Saturday last, 679 coalmines throughout Great Britain worked a voluntary shift on that day. In the South Wales coalfield, the Board reported, 142 collieries were at work and 17 were closed. On the previous Saturday, March 29, no fewer than 730 coalmines worked a voluntary shift and produced between them 267,600 tons of coal.

In spite of renewed pressure by officials of the National Union of Mineworkers, opposition to the employment of Italians in British coalmines continues. The question was discussed by miners employed at Bullcroft Main Colliery, near Doncaster, on Sunday last, and a resolution requesting the withdrawal of the 31 Italians on the colliery's books was carried by 180 votes to 36. There were a number of abstentions, however, and it is considered likely, in some quarters, that, as about 1,600 miners are employed at the colliery, the union will hold a secret ballot on the subject in the near future. A number of young haulage men employed at the colliery recently refused to work with the Italians, mainly owing to a difference on wages, and went on strike. The Italians were subsequently suspended but have continued to draw their wages.

ACCELEROMETERS FOR DETERMINING AIRCRAFT FLIGHT LOADS.

Fig. 1. DIAGRAM OF ACCELEROMETER.

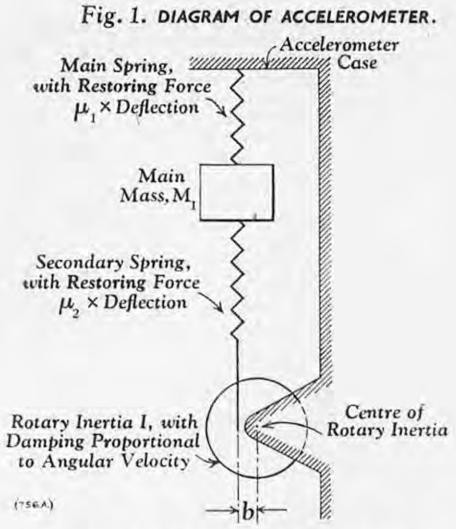


Fig. 2. PERMISSIBLE DEFLECTIONS IN AIRCRAFT STRUCTURES DUE TO VIBRATION.

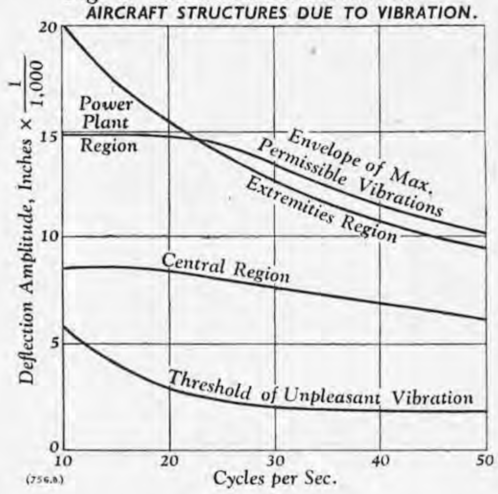


Fig. 3.

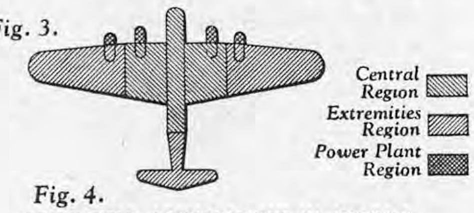


Fig. 4. PERMISSIBLE ACCELERATIONS IN AIRCRAFT STRUCTURES DUE TO VIBRATIONS

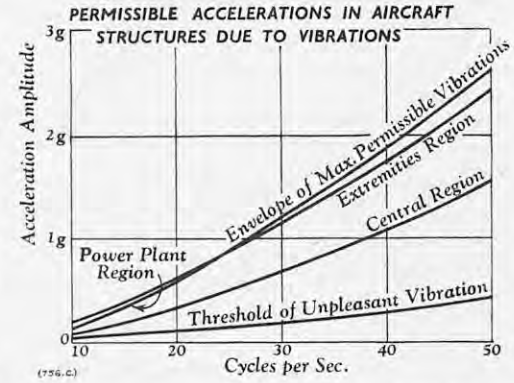
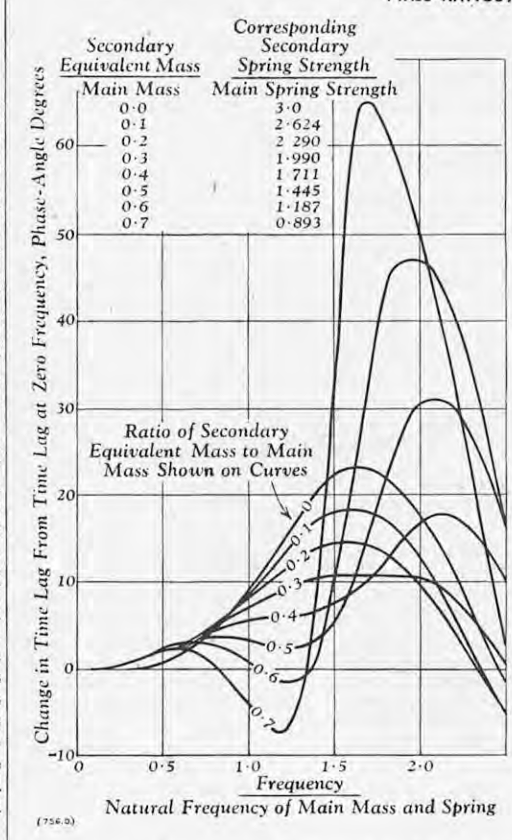


Fig. 5. CHANGE IN TIME LAG FOR DIFFERENT MASS RATIOS.



ACCELEROMETERS FOR DETERMINING AIRCRAFT FLIGHT LOADS.

By J. TAYLOR.

THE accelerations imposed on an aircraft in flight by gusts and manœuvres vary sufficiently slowly for the structural response to any instantaneous value of acceleration of the aircraft's centre of gravity to be much the same as if it had persisted for some time. In flight, however, structural vibrations, mainly originating at the power plant, are also present, which produce internal strains and forces that are small, but which occur at frequencies so high that the maximum accelerations within a cycle are also high. Any accelerometer for measuring aircraft accelerations due to gusts and manœuvres, therefore, must first filter out such high-frequency accelerations. This is particularly important for a counting accelerometer which gives no indication of how long any particular acceleration has persisted or been exceeded.

Conventional accelerometers consist essentially of a single mass and spring and a damping unit. By suitable choice of the natural frequency of the system and the damping, any desired degree of accuracy at low frequency can be achieved, but the corresponding behaviour at high frequency is then virtually fixed. In general, however, the attainment of reasonable accuracy at low frequency renders the elimination of the high-frequency records extremely difficult, and thus prevents exclusive recording of overall accelerations. In the first part of this article, a method is presented for achieving the desired low response at high frequencies without reducing the accuracy at low frequencies. The main feature of the apparatus proposed is an additional spring coupled to a rotary-inertia mass. Fig. 1 shows the essential parts of the system. By a judicious choice of secondary spring and rotary inertia, satisfactory properties for a standard accelerometer can be achieved.

An aircraft in flight is subject to external aerodynamic forces and to internal engine forces, which produce accelerations and strains at all points of the aircraft, the relationship between the acceleration and the strain depending on the character of the acceleration. The engine forces on the structure are sustained oscillations of definite frequencies. The oscillations at each frequency energise a particular mode of vibration in the structure, so that if the amplitude of the displacement at one point and the mode of vibration are known, the strain in any part of the whole structure is known. For displacements of about $\pm 0 \cdot 005$ in. at the wing centre-section, the strain anywhere in the wing is normally small, usually about 10^{-5} or even less (corresponding to a stress of 100 lb. per square inch in aluminium alloys), although this condition corresponds to an acceleration of $\pm 0 \cdot 8\ g$ at 40 cycles per second.

The aerodynamic forces due to gusts and manœuvres are usually varying and non-cyclical in character. The relation between extreme conditions and the structural response to them, moreover, is complex. There are two main considerations: (i) the delay in the change of aerodynamic forces with change of the velocity and direction of air-flow (Wagner effect); (ii) the natural frequency of the wing structure in relation to the rate of change of external force.

The acceleration-time relationship for the structure can be resolved into a series of cyclical elements of different frequency. The predominant elements have, in general, a frequency of less than 2 cycles per second. They are accompanied by minor perturbations of higher frequency, especially in the region of the natural frequency of the wing. The mode of deformation of the wing under accelerations of any frequency up to about $1\frac{1}{2}$ times the natural frequency of the wing does not differ much from the mode of deformation in straight and level flying conditions, and the strains may be assumed to correspond. Recent flight tests have shown that, for gusts and manœuvres, the components of the accelerations of the structure exceeding $1\frac{1}{2}$ times the wing natural frequency are small, and those exceeding $2\frac{1}{2}$ times the wing natural frequency can be disregarded entirely.

An accelerometer is used in an aircraft primarily to give an indication of the applied aerodynamic forces and induced structural forces. There are thus two main requirements for such an accelerometer: it should record accurately the low-frequency accelerations produced by the combined aerodynamic and structural forces, and should reject the large high-frequency accelerations which produce negligible strains. Both these requirements could be satisfied if the accelerometer had a perfect response up to $2\frac{1}{2}$ times the natural frequency of the wing and zero response above that frequency. To fulfil the requirements for low-frequency behaviour the response, expressed as the ratio of the recorded amplitude to the applied amplitude of acceleration, should be unity at all frequencies below $2\frac{1}{2}$ times the natural frequency of the wing, and the time lag between the application and the recording of an acceleration should be constant, if not zero. At high frequencies the amplitude-response ratio should be zero, but the time lag can have any value.

Since the ideal accelerometer cannot be achieved in practice, some compromise has to be made. The amplitude-response ratio should be nearly unity, and the time lag remain close to its value at zero frequency for all frequencies up to about $1\frac{1}{2}$ times the wing natural frequency. Gradual changes should occur in the amplitude-response ratio and time lag between $1\frac{1}{2}$ and $2\frac{1}{2}$ times the wing natural frequency. Above about $2\frac{1}{2}$ times the wing natural frequency, the amplitude-response ratio should reduce with frequency as rapidly as possible. As these higher-frequency accelerations produce no significant strain, their actual time of occurrence relative to the main acceleration does not matter, and there is no reason to restrict the allowable change in time lag. It is suggested that the loss in accuracy due to the changes in amplitude-response ratio should be roughly the same as the loss in accuracy due to changes in time lag. The change in time lag, i.e., the difference between the actual time lag and the time lag at zero frequency, is considered as the phase-angle change at the frequency concerned; the corresponding error has a sinusoidal variation with time of amplitude of ± 2 sin (semi-phase-angle change), so that the average error is $\pm \frac{4}{\pi}$ sin (semi-phase-angle change). The following are reasonable objectives in the design of a good accelerometer:—(i) Up to $1\frac{1}{2}$ times the wing natural frequency the amplitude-response ratio should be above 95 per cent. and less than 105 per cent., and the change in time lag should be within 5 deg. phase angle. (ii) Between $1\frac{1}{2}$ and $2\frac{1}{2}$ times the wing natural frequency the amplitude-response ratio should reduce gradually to not less than about 70 per cent. and the change in time lag should neither change abruptly nor by more than about 25 deg. phase angle at $2\frac{1}{2}$ times the wing natural frequency. (iii) As $2\frac{1}{2}$ times the wing natural frequency is exceeded, the amplitude-response ratio should be reduced from 70 per cent. or thereabouts to a negligible value as quickly as possible. There is no restriction on changes in time lag. The high-frequency response can be regarded as negligible, provided that the indicated accelerations are negligible for the maximum allowable vibrations specified in the official requirements*, as shown in Figs. 2, 3 and 4.

The high- and low-frequency requirements given above oppose each other. A conventional accelerometer consists of a single mass and spring, with damping proportional to the velocity, the relative movement of the mass and the accelerometer case being used to record the acceleration. Such a system has two parameters: the natural frequency of the mass on the spring, and the damping. The low-frequency requirement, that the amplitude-response ratio shall be not less than 70 per cent. at $2\frac{1}{2}$ times the wing natural frequency, means that the natural frequency of the mass and spring shall be at least $2\frac{1}{2}$ times the wing natural frequency. Having fixed the natural frequency of the mass and spring, the damping can then be chosen to satisfy the other low-frequency requirements. The high-frequency characteristics of such an accelerometer depend almost entirely on the natural frequency of the system, and are poor even with the lowest permissible

* Air Publication 970, "Design Requirements for Aeroplanes for the Royal Air Force and Royal Navy." H.M. Stationery Office. [Price 15s. net.]

ACCELEROMETERS FOR DETERMINING AIRCRAFT FLIGHT LOADS.

Fig. 6. AMPLITUDE RESPONSE RATIO FOR DIFFERENT MASS RATIOS.

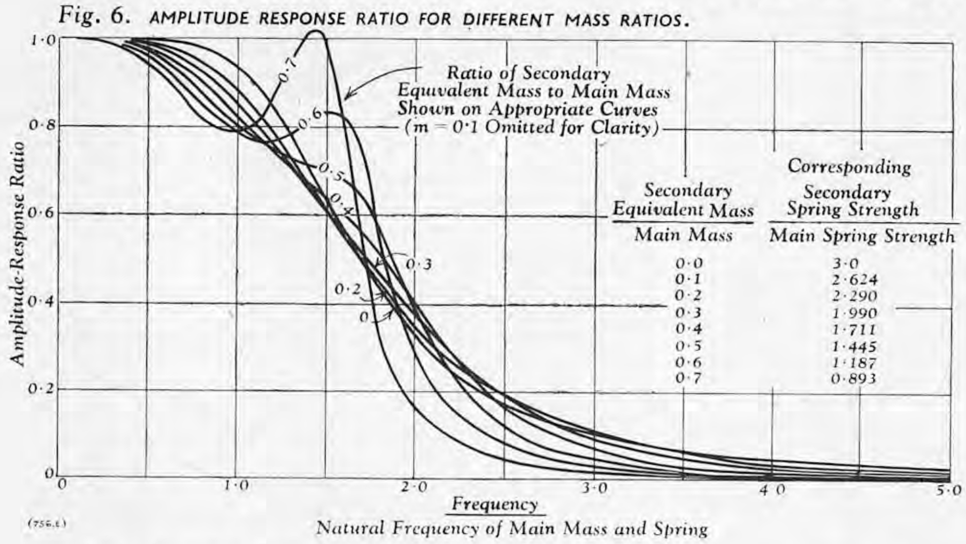


Fig. 7. CHANGE IN TIME LAG FOR MASS RATIO OF 0·4 AND DIFFERENT SPRING RATIOS.

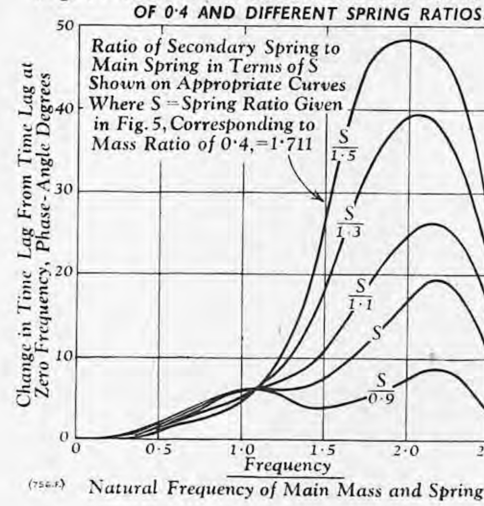


Fig. 8. AMPLITUDE RESPONSE RATIO FOR MASS RATIO OF 0·4 AND DIFFERENT SPRING RATIOS.

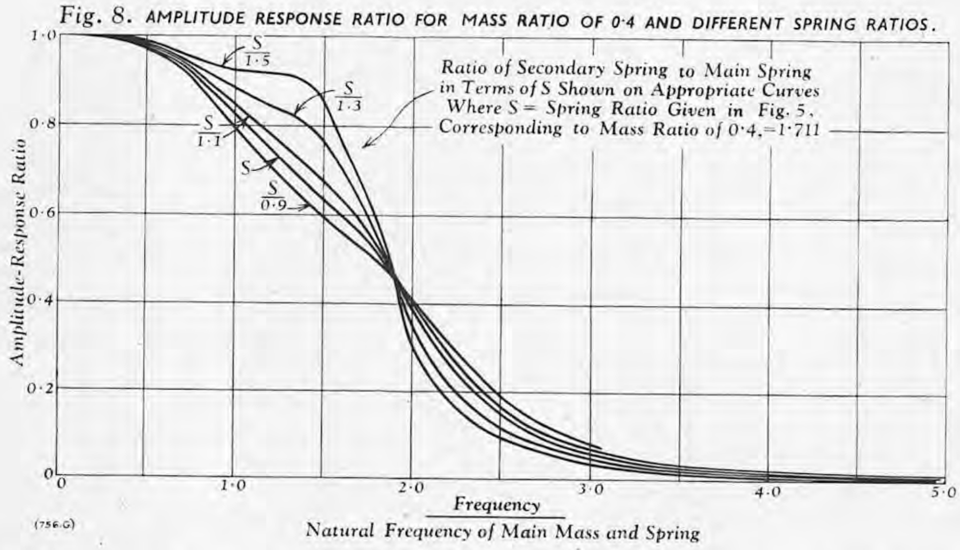
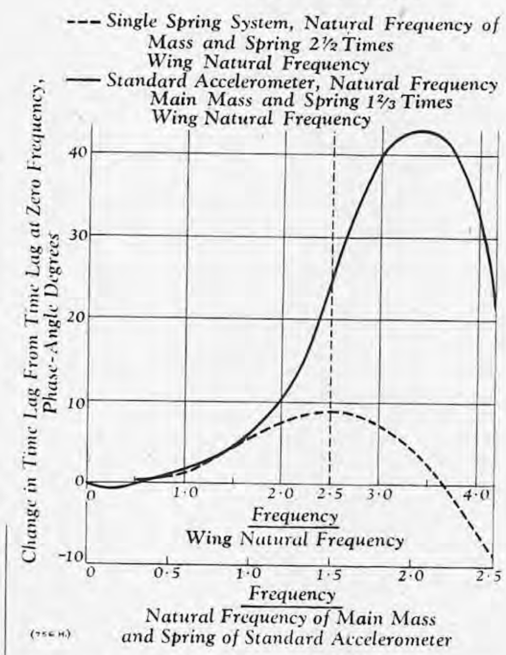


Fig. 9. STANDARD ACCELEROMETER CHANGE IN TIME LAG.



natural frequency. At very high frequency, the accelerometer mass is virtually fixed in space, and since the accelerometer case is fixed to the aircraft, the amplitude of the relative movement of the mass and the accelerometer case is approximately the same as that of the aircraft movement.

A better accelerometer can be made by adding a secondary spring and a rotary inertia to the main spring and mass, as indicated in Fig. 1. The damping unit, in which the damping is proportional to the angular velocity, is connected to the rotary inertia, and the rotation of the rotary inertia is used to record the acceleration. At very high frequencies the apparent acceleration tends to zero, since, although the main mass is again virtually fixed in space, the rotary inertia is virtually fixed in rotation and is therefore stationary relative to the accelerometer case. This system has four parameters: the natural frequency of the main mass and spring, the damping, the ratio of the spring constants and the ratio of the masses. The interaction between the behaviour at low and high frequencies is not as great as with the single-spring system, and a choice of parameters to give satisfactory properties at low and high frequencies can be made.

In choosing the four parameters, the natural frequency of the main mass and spring may be regarded as fixing the extent of the low-frequency response. The equations of motion are given in Appendix I in non-dimensional form. In order to maintain a high accuracy at very low frequencies, the damping should not depart appreciably from the critical damping, which is defined as that by which the rate of change of the amplitude-response ratio with frequency is reduced to zero at zero frequency. The other two parameters, the mass ratio and the spring ratio, are examined separately, maintaining critical damping throughout, and their optimum values are chosen. In order to examine the effect of changing the mass ratio, the spring ratio of each system in turn was chosen so that the time lag corresponding to a phase lag of 90 deg. was identical with the time lag corresponding to a phase lag of 180 deg. Thus it was intended to have a fairly constant time lag at low frequency. Fig. 5 on page 473, gives change in time lag with frequency and Fig. 6, above, gives amplitude response ratio with frequency for an equivalent secondary mass of 0, 0·1, 0·2, 0·3, 0·4, 0·5, 0·6 and 0·7 times the main mass (the equivalent secondary mass being equal to the rotary inertia divided by the square of the distance of the line of action of the secondary spring from the point of rotation). It can be seen that as the equivalent secondary mass increases, the amplitude-response ratio decreases at very high and at very low frequencies. The optimum equivalent secondary mass will be that which gives the best compromise between the improved high-frequency behaviour and the deteriorated low-frequency behaviour, and is probably in the region of 0·4 times the main mass; above this value the change in time lag is rather high at frequencies of about half the natural frequency of the main mass and spring. In Figs. 7 and 8, are shown, for a mass ratio of 0·4, the effects of changing the spring ratio on the change in time lag and on the amplitude-response ratio, plotted against frequency. It can be seen that reducing the secondary spring strength increases the amplitude-response ratio at low frequency and reduces it at high frequency. These beneficial effects are accompanied by a marked increase in time lag in the region of twice the natural frequency of the main mass and spring.

Figs. 6 and 8 show that the frequency corresponding to an amplitude-response ratio of 70 per cent. is in all cases close to 1½ times the natural frequency of the main mass and spring. If this frequency is also chosen to be 2½ times the wing natural frequency, conditions (ii) and (iii), as specified above, are fulfilled as far as the value of amplitude-response ratio at this frequency is concerned.

A standard design of accelerometer is obtained by selecting the parameters in the following order. The natural frequency of the main mass and spring is fixed at 1⅔ of the wing natural frequency, as shown above. Critical damping is selected, i.e., the rate of change of amplitude-response ratio with frequency is made zero at zero frequency. The mass ratio is fixed and then the secondary spring is made small enough to give a change in time lag near to, but not greater than, 25 deg. phase angle. If the requirements below 1½ times the wing natural frequency are not satisfied, a final slight adjustment to the low-frequency behaviour can be made by altering the damping, but major changes can be made only by altering the natural frequency of the main mass and spring.

From a careful examination of the mass ratios and spring ratios in Figs. 5 to 9, it can be seen that there is little change in behaviour of an accelerometer if the secondary spring is increased slightly provided that the secondary inertia is reduced a corresponding amount. For a practical accelerometer, a robust secondary spring is advisable, and it is therefore suggested that in selecting the properties of the standard accelerometer there should be a bias towards having a stronger secondary spring and a smaller secondary inertia. Because of this, the rotary inertia was chosen to have an equivalent mass of 0·35 times the main mass. The corresponding strength of the secondary spring is then 1·25 times the strength of the main spring. It was found that this accelerometer satisfied the requirements outlined above; it was not necessary to make any final adjustments of the damping or the natural frequency of the main mass and spring.

Fig. 9 shows the change in time lag with frequency of a "standard" accelerometer, with a natural frequency 1⅔ times that of the wing, in which (i) the rotary inertia has an equivalent mass of 0·35 times the main mass, (ii) the ratio of the secondary-spring strength to the main-spring strength is 1·25 and (iii) the rate of change of response ratio is zero at zero frequency. The variation of amplitude-response ratio with frequency is shown in Fig. 10. For comparison, the behaviour of a single spring-mass system with a natural frequency 2½ times that of the wing, is also shown.

The apparent accelerations which would be recorded on an accelerometer under the maximum permitted vibrations (see Fig. 4) depend on the frequency range for which the accelerometer is designed. Fig. 11 gives these apparent accelerations for the "standard" accelerometer and a single spring-mass accelerometer, both of which are designed for use on an aircraft with a wing natural frequency of 4 cycles per second. In order to cater for different types of aircraft, a range of

ACCELEROMETERS FOR DETERMINING AIRCRAFT FLIGHT LOADS.

Fig. 10. STANDARD ACCELEROMETER-AMPLITUDE RESPONSE RATIO.

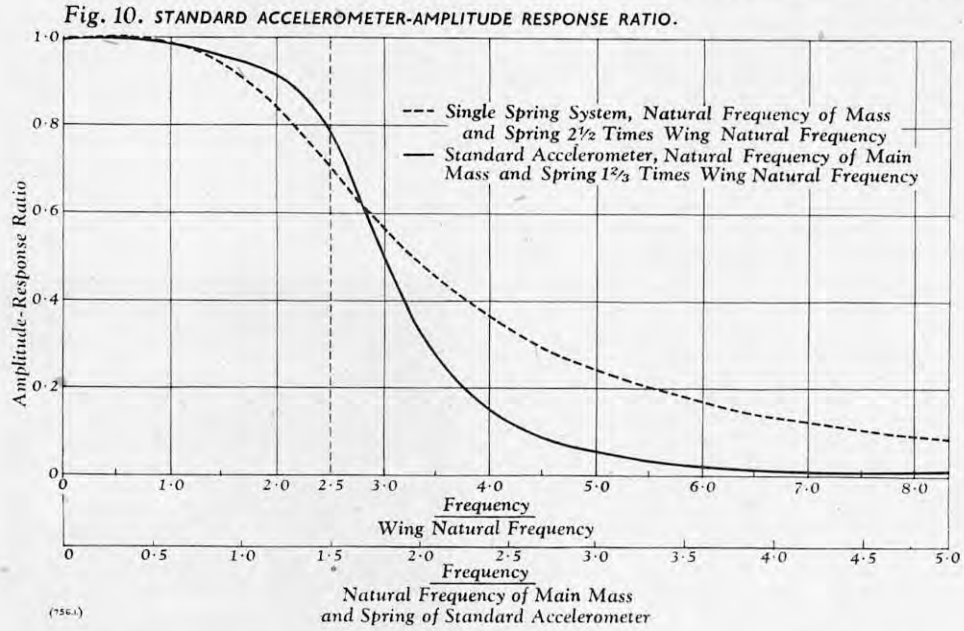


Fig. 12. EFFECT OF CHANGE OF DAMPING ON TIME LAG.

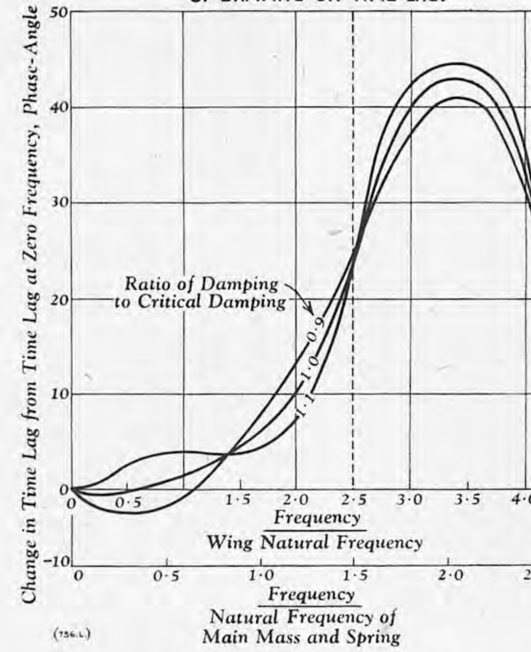


Fig. 11. APPARENT ACCELERATION UNDER VIBRATION.

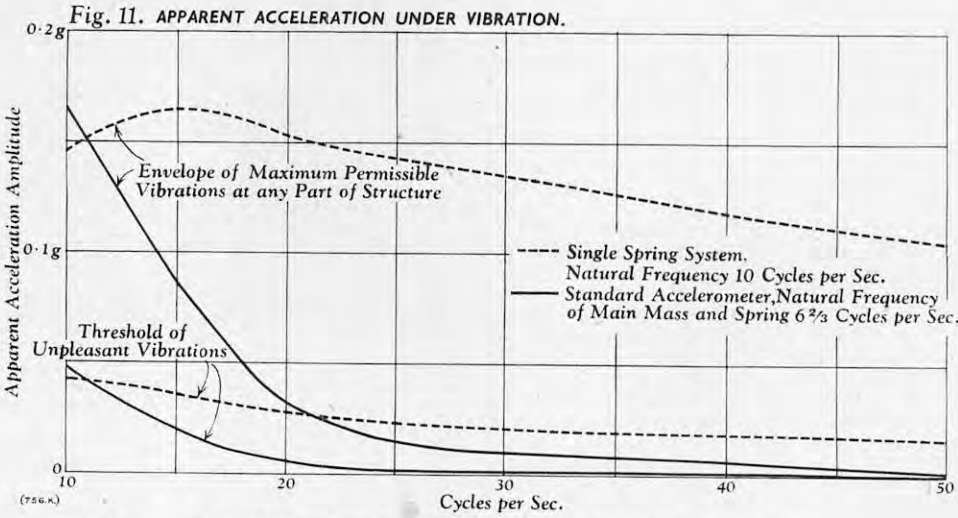
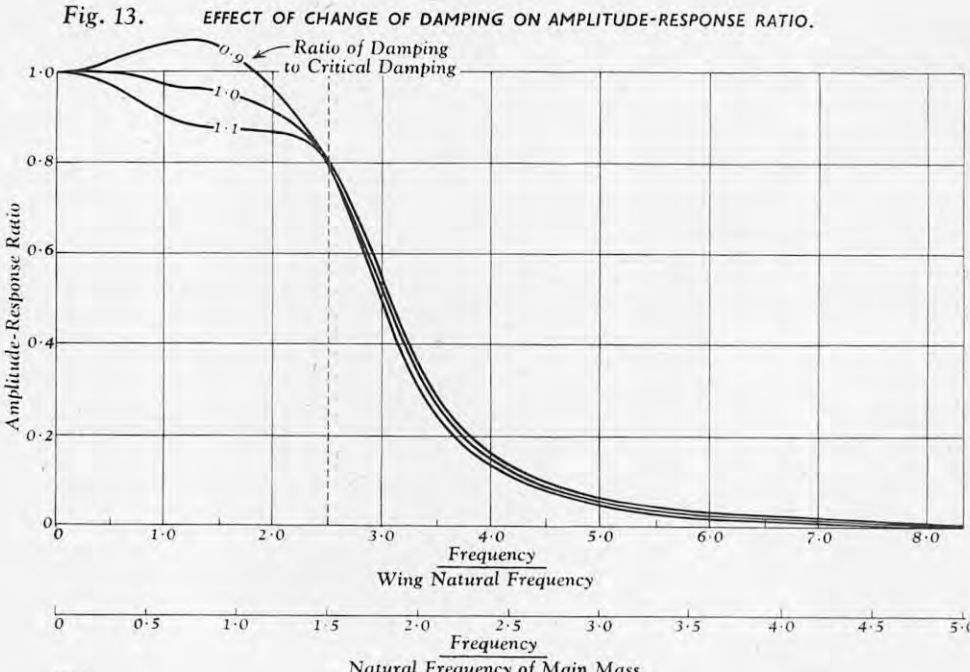


Fig. 13. EFFECT OF CHANGE OF DAMPING ON AMPLITUDE-RESPONSE RATIO.



standard accelerometers is necessary. In selecting an accelerometer for use on an aircraft of particular wing natural frequency, the standard accelerometer for a wing frequency nearest and above should be chosen. This avoids a loss of accuracy at low frequency, but involves some loss of filtering efficiency at high frequencies.

An examination of Figs. 9, 10 and 11 shows that the standard accelerometer and a single-spring system each have a similar amplitude-response ratio and a similar change in time lag up to a frequency of 1½ times the natural frequency of the wing of the aircraft on which they are to be used (i.e., 0·6 of the natural frequency of the single-spring system and 0·9 of the natural frequency of the main mass and spring of the double-spring system). Between 1½ times and 2½ times the natural frequency of the wing, the amplitude-response ratio of the standard accelerometer is slightly higher, but the change in time lag is also higher, and therefore more likely to introduce errors. With either type, the errors are small because the applied accelerations in this region are only a small proportion of the total acceleration to be measured. Above 2½ times the natural frequency of the wing, the only important characteristic is the amplitude-response ratio, and as the frequency is increased the standard accelerometer rapidly becomes superior. Standard accelerometers for use with aircraft with wings of natural frequency 4 cycles per second have apparent accelerations under maximum permissible vibrations of less than $\pm 0{\cdot}01g$ for all frequencies above 30 cycles per second. The corresponding value of the apparent acceleration is $\pm 0{\cdot}135g$ with the single-spring system.

The apparent accelerations between 10 and 20 cycles per second are high with either system for the maximum permissible vibrations, but it is found that, in practice, aircraft usually have vibrations far below these maxima. If for any particular aircraft the vibrations at these frequencies are such that the apparent accelerations are an intolerable fraction of the total recorded acceleration, then a detailed analysis of the acceleration-time relationship is necessary. The accelerations and corresponding strains must be examined separately for frequencies above and below 10 cycles per second. When such a situation exists it is not possible to use accelerometers, such as a counting accelerometer, which do not have an acceleration-time curve. This problem arises at the transition from low- to high-frquency characteristics with all standard accelerometers, no matter to what wing frequency they have been designed; it emphasises the importance of having a rapid transition.

The characteristics which give the rapid transition from good low-frequency response to good high-frequency rejection make the low-frequency behaviour very sensitive to damping changes. The effect of increasing and decreasing the damping by 10 per cent. from critical damping is shown in Figs. 12 and 13. The change due to variation in damping is much more than would be found with a single mass and spring, and close control of the damping is essential if full advantage is to be taken of a double-spring system.

(To be continued.)

AVRO "ORENDA" JET ENGINE.—It has been announced by A. V. Roe (Canada) Limited, Malton, Ontario, Canada, that their Orenda axial-flow jet engine, designed originally for the Avro Canada CF-100 all-weather fighter, has been selected as the power unit for Sabre fighter aircraft being built in Canada under licence from North American Aviation Incorporated, Los Angeles, California.

THE INSTITUTION OF CHEMICAL ENGINEERS.—The arrangements for the 28th associate-membership examination of the Institution of Chemical Engineers have now been completed and application forms may be obtained from the honorary registrar of the Institution, 56, Victoria-street, London, S.W.1. These should be returned not later than June 2. Sections C, D, E and F of the examination will be held in September, 1952, and three months, namely, from January to March, 1953, are allowed for the papers worked at home and comprising sections A and B of the examination.

PROBLEMS OF SPACE WARMING BY ELECTRICITY.

The object of a paper on "The Logical Approach to the Problems of Space Warming by Electricity," read by Mr. D. H. Parry before the Utilisation Section of the Institution of Electrical Engineers on Thursday, April 3, was to combat the fear that electric heating was too expensive as a wholesale substitute for solid fuel. According to the Egerton report, the coal economy efficiency of electric heating was 18 per cent. and, since the total coal used in generating stations was 15 million tons, it might be deduced that this figure would have to be multiplied about 11 times and the plant capacity perhaps 30 times to take over the domestic heating at present achieved by raw coal. It might therefore seem fantastic, when shortage of generating plant was a major problem, to contemplate the use of electricity in substitution for the combustion of domestic solid fuel. There were, however, many good reasons for so doing. Firstly, the substitution was already in progress, in spite of well-meant efforts to curb it; and, secondly, if electricity were properly used for space heating its coal economy efficiency need be no worse than that of solid fuel and might even be better. Thirdly, space heating by electricity could be provided without excessive demand at the time of peak load. There were, therefore, good reasons for the electricity supply industry to take active steps to secure the building and testing of houses designed to use electricity as the main agent for providing warmth. Electric heating requirements must also be studied to secure a reduction of peak load demand and, if usage could be made more efficient, both demand and coal consumption would be reduced with attendant advantages in amenities and economy.

The thermal insulation of pre-war houses was notoriously bad; and it would be economic to spend at least five times the cost of the Egerton report standards on all-electric houses to secure the highest practicable insulation values. In America the standard thermal-insulation requirements for electrically-heated houses were represented by a thermal transmission coefficient of 0·1 B.Th.U. per square foot of surface per deg. F. per hour for ceiling and walls, compared with the Egerton report standards of 0·15 to 0·2; and it was suggested that 0·075 B.Th.U. per square foot of surface per deg. F. per hour would be a reasonable target. It would be better for electricity to take the background heating and for solid-fuel heating to be used in emergency. In fact, the ideal well-insulated house should have low-temperature radiant heating on the lower floor; and there would then be sufficient convected heat to give background heating in the upper floor without excessive heat in warm weather. The thermal capacity of the ideal house was so great that most of the electric heating load would be met during the night and other off-peak times. It was believed that the electrical demand at peak times could be very small—probably less than that from houses now fitted with a solid-fuel stove.

According to the Egerton report the coal economy of the electric fire was better than that of the gas fire or any other acceptable method of heating for periods of less than one hour. For longer periods it was less satisfactory and more care should be exercised in its use. There was scope for more efficient high-temperature radiators and one idea would be to use the technique developed for infra-red heating. The radiator could have an element in the form of a vacuum tube enclosing an infra-red filament with the back gold-plated or silvered to act as a reflector. Such an element could conveniently be mounted out of reach. The advantage of infra-red radiation was that a glass envelope could be used without risk of overheating. It did not burn dust and penetrated the air with little convection loss. Its radiation differed little from that of an ordinary coal fire and was therefore unlikely to prove either more or less deleterious to health. Convectors, tubular heaters, unit heaters and liquid filled "radiators" were effective in providing background heating. They were, however, only suitable for continuous use and their thermal efficiency was less than that of properly designed radiant heating. Low-temperature radiant-heating could be the most efficient form of space warming. As they required a mass of continuously heated building material, the problem of heat storage to even out the electricity demand or to carry over a period of load shedding was simplified. Thermostatic control was essential. The cost of a heat pump for a small house would be excessive and the money might be better spent on improving the heat insulation. In large houses, where a refrigerator was in regular use, a partial heat pump effect could be obtained at no great cost by coupling it to a ventilation system.

It was of the first importance to reduce the heat losses from buildings. A house to be warm should be built on waterproof foundations and, except for the fresh air needed for the occupants, should be air-tight. There was as yet no satisfactory substitute for brick walls, but a concrete shell lined with laminations of building board and aluminium foil, designed to enclose a large number of air spaces, might be a solution. Building boards could also be substituted for plaster. Window frames should be made of more rigid material than wood and of heat-insulating material rather than steel or aluminium. Double glazing should be standard practice and the commercial possibility of a vacuum space between thicknesses of glass should be explored. Interior decoration of walls and ceilings should be carried out with materials of low thermal conductivity and low specific heat.

The heating equipment of an all-electric house should consist of one emergency coal fire in the living room; main heating by low-temperature radiation in the floor of the living room; "comfort" heating by high-temperature radiant heaters of the infra-red type in the other living rooms and controlled fan ventilation, with heat regeneration, circulating through ducting in all rooms. The main heating would be from the ground floor by heating cables buried in concrete. Full "comfort" conditions could then be obtained without raising the temperature of the floor surface above 75 deg. F., the floor loading being about 10 watts per square foot. Floor heating was recommended on the assumption that the heat insulation would be good, i.e., that the thermal transmission coefficient (U) would be less than 0·1 B.Th.U. per square foot of surface per deg. F. per hour. The demand from this form of heating in cold weather would be about 1·5 kW continuously, but the elements could be switched off for several hours without noticeable fall in temperature. The system might therefore be designed for night loading only by time-switch control. A typical municipal house operating with Egerton report standards ($U = 0{\cdot}24$ overall) and heated by solid fuel, would require 3·5 tons of coal or coke per annum for space heating. If built to a standard of $U = 0{\cdot}075$, it would require 2·75 tons per annum. The all-electric house built to this standard would require only 2·5 tons of coal to maintain Egerton standards of comfort.

The foregoing proposals provided a long-term policy which would permit space-warming by electricity without excessive demands at times of peak. A short-time policy was required to deal with the heavy heating load at peak times. Much good could be done by positive publicity aimed at educating the public to use electric heat more efficiently. The present negative method by which consumers were requested to switch off at peak times was ineffective. Consumers should be advised to use reflector type radiators rather than the simple bar type; interior decorations which responded efficiently to intermittent radiant heat in rooms only occasionally used; improved insulation when redecorating or renovating existing rooms; panels to close up fireplaces when substituting electric fires; and concrete for new floors. The electricity-supply industry should seek Treasury encouragement in the form of remission of taxation for apparatus and materials intended to save fuel.

Royal Statistical Society.—A provisional Merseyside Group of the Royal Statistical Society has been inaugurated and during the remainder of the 1951-52 session, the new group will hold its meetings in Liverpool. Mr. R. L. Plackett, Mathematical Institute, The University, Liverpool 3, has been appointed honorary secretary.

New Company for the Production of Agricultural Machinery.—A new agricultural-machinery company, to be known as the Alpema Agricultural Machinery Development Company, Limited, has just been formed. The company's head office is at Redhill Aerodrome, Surrey, and in addition to having its own manufacturing and sales organisation, will carry out research and development work. It will specialise in machinery designed for the farmer with from 50 to 200 acres and, as a consequence, most of the equipment will have a dual purpose. The first three products to be handled by the company are a mobile grass drier, a portable air heater and a fertiliser distributor. Originally designed by Tiltman Langley Laboratories, Limited, the grass drier is constructed round an oil burner of the type used in gas turbines and the machine, which can easily be towed behind a standard farm tractor, has a capacity of 3 cwt. of dried material an hour. The portable air heater can be transported by one man and is designed to meet the need for a heat generator for all systems of grain drying. It is fitted with the same type of oil burner as the grass drier, and apart from grain drying, can be used for many other duties such as heating greenhouses, defrosting orchards, etc. Known as the Vedor, the fertiliser distributor can be used for all powdered fertilisers, basic slag, lime and chalk; it can also be used for broadcasting grain and grass seed. Three types are being made at present, suitable respectively, for direct towing behind a tractor, mounting on an existing trailer and hand operation. Full world rights have been obtained for the production of this machine and it is to be developed for use in hop gardens, orchards, market gardens and on golf courses.

COMPACTING MACHINE FOR ROADS AND FOOTPATHS.

A small tamping machine, known as the Tampactor, has recently been produced by Messrs. E. P. Allan and Company, Limited, 45, Great Peter-street, London, S.W.1, for use on roads and pathways, particularly in confined spaces, the tamping shoe having been designed so that it can be operated right up to the bounding wall or kerb. It is claimed that the compaction obtained with this machine is equal to that of a small road roller. A photograph of the Tampactor is reproduced below. It is driven by a 3-h.p. air-cooled B.S.A. or J.A.P. petrol engine, on the shaft of which are mounted adjustable eccentric weights

which impart a vibrating and forward-creeping motion to the tamping shoe. To suit different materials and depths of compaction, the impact force can be varied between 400 lb. and 550 lb. by increasing or decreasing the number of tamping weights fitted. In most cases, the manufacturer states, the best results are obtained by maintaining a low tamping frequency. The engine-ignition switch and throttle control are mounted on a tubular-steel guiding handle which insulates the operator from vibration.

The tamping shoe is of welded-steel construction, and is heated by the exhaust gases, which pass through a flexible pipe and manifold built in the base. The heated shoe, it is claimed, improves the finish and surface bond of asphalt and macadam surfaces. Behind the trailing edge of the shoe is a 6½-in. diameter roller. In operation, the Tampactor is allowed to assume its natural balance. It will then work forward, compacting as it advances. At the end of a pass, the machine can be tilted and drawn back on the roller for a second pass. With hot-rolled asphalt, bituminous and tarred chippings, the manufacturers advise rolling before compacting. In addition to its use for compacting road and pathway surfaces, the Tampactor can be used for soil stabilisation and for compacting dry concrete.

Engineering Drawing Films.—A series of 16-mm. films on the principles of engineering drawing was shown recently to an invited audience by the distributors, Metro-Goldwyn Mayer Pictures, Ltd. The films are produced by the McGraw-Hill Text-Films, and are correlated with the text-book "Engineering Drawing," by Thomas A. French, published by the McGraw-Hill Book Company, Incorporated. Professors from the engineering department of the Ohio State University acted as advisors. The films deal with the third-angle system of orthogonal projection which is used in the United States. The subjects of the films and their running times are as follows: "According to Plan: Introduction to Engineering Drawing," 9 minutes; "Orthographic Projection," 18 minutes; "Auxiliary Views: Single Auxiliaries," 23 minutes; "Auxiliary Views: Double Auxiliaries," 10 minutes; "Sections and Conventions," 15 minutes; "The Drawings and the Shop," 15 minutes; "Selection of Dimensions," 17 minutes. Further particulars may be obtained from Mr. W. E. Finch, M.G.M. 16-mm. Division, 1, Belgrave-place, London, S.W.1.

HIGH-VOLTAGE DIRECT-CURRENT POWER TRANSMISSION.

A REPORT (B/T111), recently published by the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey, reviews the early work, present position and future possibilities of direct-current power transmission at high voltages. Some extracts from this report are given below.

Economic conditions in many countries are increasing the use of hydro-electric power so that the length of the transmission lines is also constantly rising. To keep the relative cost of these lines reasonably low, the power per circuit must be raised to the highest practicable value. Both these factors, however, prejudice the stability of a long alternating-current line and the power per circuit cannot be increased much beyond the surge impedance load without the use of stabilising equipment and a consequent increase in costs. The limit is about 250 miles, intermediate stations being necessary for greater distances. Alternatively, the power per circuit can be increased by raising the voltage, but this again is limited by the corona loss, which can only be reduced by increasing the number or diameter of the conductors. Direct-current transmission over long distances has the advantage that, for a given insulation level and conductor section, both higher voltages and currents can be used than with alternating current. The power per circuit is also not limited to the impedance load since there is no need to keep the two alternating-current systems at the end of the line in synchronism. For the same reasons, there is no limit to the length of a direct-current line on the grounds of stability. On the other hand, the existing difficulty of switching direct current limits its application to linking two points, so that wide interconnection is impossible. The use of direct-current transmission is promising where cables have to be used, as, for instance, for water crossings, through desert areas and in densely populated districts where it is becoming more and more difficult to obtain rights of way for overhead lines. Such cables can be designed technically and economically only for high-voltage direct current.

The earliest example of direct-current power transmission was that inaugurated by Thury in Switzerland and France over 40 years ago. The system could not be developed, however, owing to the large number of rotating machines required as the demand for power increased. Impetus was given to direct-current transmission in this country by the invention of the transverter* by Calverley and Highfield. It became evident, however, that synchronously rotating brushes could not handle the powers required. The machine was therefore never actually put into commercial service, and the same applies to the Marx air-blast rectifier, upon which much money was spent in Germany in the 1930's, as well as to the Siemens contact rectifier. The most practical form of current converter for power transmission purposes is now the mercury-arc rectifier, which can be used at both ends of the line. In Germany, a 15-MW, 100-kV experimental plant gave useful information, which led to the installation of a system between the Elbe and Berlin, a distance of 70 miles, to transmit 60 MW by cable at 400 kV. In 1943, Brown Boveri, in Switzerland, erected a station at Biachina to test rectifiers suitable for 13 MW at 33 kV. Steady progress has been made in Sweden by A.S.E.A. and the Swedish Power Board. A 30-mile line has been transmitting 6·3 MW at 90 kV between Trollhatten and Mallerad for some years and a test plant for two single-anode converter groups of six units, each of 25 MW at 63 kV, is being constructed. Plans are being considered for the transmission of 20 MW at 200 kV by a single conductor sea cable from the mainland to the Island of Gothland, while certain 380-kV alternating-current lines are intended for conversion to direct-current when suitable converting plant has been developed. In the United States a scheme for transmitting 5 MW at 27 kV, using thyratrons, and later ignitrons, for conversion was developed by the General Electric Company in 1936, while in 1943 two direct-current links with powers of 6·6 MW and 20 MW were installed between two alternating-current systems operating at different frequencies. Russia has also shown great interest in the question.

The technical advantages of overhead direct-current systems are that two conductors will carry at least 1·33 times the load of three alternating-current conductors, assuming the same percentage of ohmic losses in each case. Alternatively, if the same power is transmitted over a three-phase line and a two-conductor direct-current circuit, the equivalent insulation level of the latter will be 0·865 that of the former, again assuming the same percentage ohmic losses. The voltage rating of a given size of cable is considerably higher with direct than with alternating current because of the internal losses. These losses impose a limit to the alternating voltage a cable can support, a limit which is not far removed from the higher transmission voltages at present contemplated. The permissible working stress for mass-impregnated cables is 50 kV per centimetre and for oil-filled or gas-pressure cables 100 kV per centimetre with alternating current, as compared with about 300 kV per centimetre with direct current. A cable for direct-current working at 400 kV between lines would therefore require a dielectric thickness of only 0·5 in., the same as for a 60-kV mass-impregnated cable or a 132-kV oil-filled or gas-pressure cable.

There is no steady state charging current when direct-current cables are used. For a three-phase installation, however, the wattless charging current is considerable, being 2,000 kVA per circuit per mile at 132 kV, 5,000 kVA at 220 kV, and 15,000 kVA at 400 kV. When long-distance cables are used, charging current cannot be supplied from the terminals only, and it is necessary to do this at intervals of 40 miles at 132 kV, of 25 miles at 220 kV, and of 15 miles at 400 kV. At very high voltages alternating-current transmission by cables is therefore only practicable over short distances. As the stability problems which arise with direct-current transmission are related only to terminal apparatus, and do not depend on the length of the lines, the latter can be extended to any length without additional compensation. The possibility of using an earth return on direct-current is still controversial. However, as, with earth return, a circuit consists of one conductor only instead of two, the cost could be reduced by about 25 per cent. for the same power. Each case must, however, be judged on its merits, consideration being given to corrosion of cable sheaths, gas and water mains, and to interference with communication circuits or railway-signalling systems.

Fig. 1. COST OF OVERHEAD LINE AND TERMINAL STATIONS. 240 MW, 3 CIRCUITS.

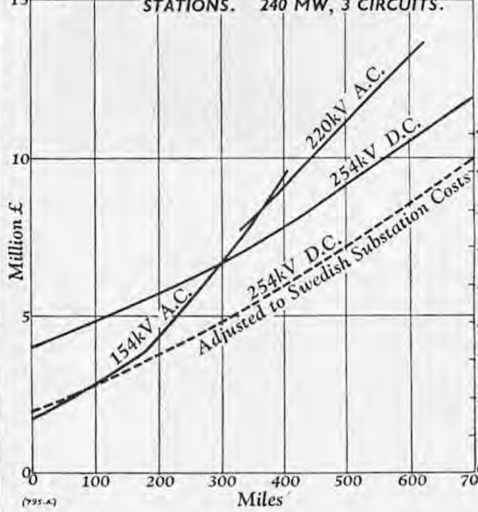
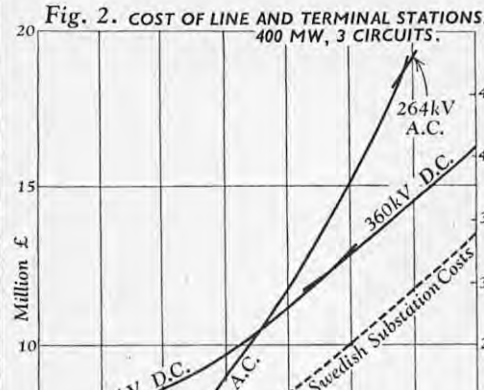


Fig. 2. COST OF LINE AND TERMINAL STATIONS. 400 MW, 3 CIRCUITS.



The technical disadvantages of direct-current systems are that the conversion equipment, auxiliary gear, the synchronous plant required for inverter operation, and the additional buildings, will cost about twice the figure for alternating-current substations of corresponding size and output. In order to ensure safe commutation in the inverter, it is also necessary to operate the convertors with leading current, and the inverter therefore requires reactive kilovolt-amperes. This may be of the order of 50 to 80 per cent. of the active power of the system. The value of this kilovolt-ampere component is independent of the length of the line. There is no simple equipment by which one direct-current voltage can be transformed to another. For this reason, alternating current will maintain its superiority for distribution purposes, leaving direct-current for use in the bulk transmission of large blocks of power over long distances. No direct-current circuit-breakers are likely to be available for some time at economic prices, but since each converter station is essentially an electronic switch, switching problems can be dealt with by proper grid control of the converters. Several proposals for direct-current circuit-breakers have, however, been put forward, and interesting developments can be expected.

The main economic advantage of direct-current over alternating current lies in the saving of cost on overhead lines and its use with underground or submarine cables. Against this must be placed the increased cost of the substations. There is, then, a lower limit of length of overhead line which must be exceeded before the capital cost of a direct-current system becomes less than that of an alternating-current system. On the other hand, it is clear that, no matter how much progress is made with the stability problems of alternating-current transmission, the economic advantages of direct-current for very long lines and for high-voltage cables will remain. There is also the additional fact that by using direct-current cables along certain routes, as, for instance, by the side of railways or canals, difficulties associated with obtaining way-leaves would be largely reduced as compared with alternating-current overhead lines.

Reports have been prepared which include graphs showing comparative costs (including building, etc.) of alternating and direct-current schemes for 240 MW, 400 MW, 1,000 MW and 2,000 MW transmitted up to about 800 miles, and based on a maximum overall loss of 15 per cent. These findings are illustrated in Figs. 1 and 2, herewith, which show the costs of 240-MW and 400-MW systems. They indicate that the capital cost for direct current becomes lower than that for alternating current at about 300 to 350 miles. This value will probably fall as the development of direct-current converter stations advances. The figures for substation costs, estimated by the Swedish Power Board in conjunction with the A.S.E.A. Company, give the values shown by the dotted lines. In this case the critical point lies at about 150 miles and eventually will lie somewhere between these two estimates. On the best available information, therefore, in cases where overhead lines are feasible, direct current becomes economically competitive with alternating current for distances over 300 to 400 miles, and this will undoubtedly be reduced when the manufacture of converters and other conversion equipment becomes standardised. Where, however, overhead lines are not feasible, and cables have to be used, direct current becomes economically competitive for all distances above about 25 miles.

The principal problem for research is the development of the converter equipment and the necessary valves. The nearest approach to the required type of valve, which is manufactured in this country at the present time, has a rating of the order of 50 amperes at 17 kV. Valves suitable for direct-current transmission on a commercial basis, however, may require a minimum rating of some 500 to 650 amperes at 60 to 80 kV. The principles underlying the design of such valves appear to be known, and they differ in certain important respects from the 17-kV valves now in production. This development is, therefore, likely to require considerable time and money, particularly in regard to the time required for tests of reliability and life. Other items coming under the heading of apparatus will include converter accessories for grid control, power and instrument transformers, choke coils, insulators for overhead lines, and so on. The majority of problems concerned with these consist essentially of the extension of well-established fields of electrical engineering; the circuit-breakers being an exception. Such features as corona losses, insulation levels, telephone and radio interference, which have been investigated for alternating current, have still to be explored for direct-current.

Preliminary mathematical investigations of the control problem and of the reactive kilovolt-ampere requirements of the inverter have already been made. To check and extend these investigations, a model plant has been erected at the Electrical Research Association's laboratories on a scale of about 10 kW and 1 kV. This plant is giving useful information on control and protection, and to a less extent on operation and interference. In order to share in the pioneer work of development, some of which may take place in the Colonies, Britain will have to compete with Sweden and Switzerland which already have plant on this scale. To give Britain equal opportunity and the necessary experience, a trial plant could be erected using

* See ENGINEERING, vol. 117, page 563 (1924).

mercury-arc converters similar to designs already available for other purposes, and used to transmit power over an existing transmission line to gain operating experience. Such a plant could be in operation in 7 to 8 years time on a load of the order of 20 MW and 200 kV. It should preferably be a link between two points on a large alternating-current system which could supply the wattless requirements. A plant of this size would provide the flexibility necessary for a study of optimum converter arrangements, etc. It would be large enough to use on the problems of conversion equipment on systems under actual service conditions, such as details of the commutation process, the influence of transformer self-capacitance, and the damping of oscillations in the transmission system and transformer windings, connection of rectifiers to reduce backfire faults, lightning and communication interference. The results and operational experience gained would be immediately applicable to commercial schemes of intermediate power and provide experience for the design of much larger installations. The development of large converters would be part of the programme, but the starting of the project need not be prejudiced or impeded until these are ready because initial work at lower power could be undertaken using existing designs of converter.

Table I shows a number of possible transmission schemes in different parts of the world, involving transmission of 200 MW and more, over distances of 200 miles upwards, and where it is known that the power is available and that the possibility of economic transmission would lead to active investigation and probable installation of the system. It is becoming clear that, owing to the increase in cost of transport of fuel, it may be desirable to transmit 750 MW of power to London from the coalfields. By alternating current this would involve overhead lines for four three-phase 275-kV circuits. The difficulty of obtaining wayleaves and the loss of amenities that such a scheme would involve make it almost impracticable. If, however, direct current were used, then cables could be employed. The table also gives the estimated cost of the line or cable, rectifiers and inverters, transformers and synchronous condensers, switchgear and buildings, in terms of pounds sterling on the 1947 level. The new market for schemes of 500 miles or more in length not economically realisable with alternating current, and others in the 300 to 500 mile range which include some appreciable lengths of cable. It would also cover all cases of high-power high-voltage transmission exclusively by cable if the distance were greater than, say, 25 miles. Some such schemes enumerated in Table I aggregate over 5,250 MW for an average distance of 480 miles and represent 96*l*. million for transmission

TABLE I.—PROSPECTIVE OR PROPOSED ELECTRICITY SCHEMES INVOLVING LONG DISTANCE TRANSMISSION.

Country.	Line.	Power, MW.	Total Distance, Miles.	Cable, Miles.	Circuits.	Minimum Voltage, kV	Current per Circuit, Amp.	Prices* in Millions of Pounds.			
								Overhead Line.	Cable.	Stations.	Total.
Great Britain	Midlands–London ..	750	150	150	3	300	625	—	7·7	11·25	18·95
Norway	North–South	300	600	—	3	360	280	7·2	—	4·5	11·7
	Mid Norway–Denmark ..	300	300	85	3	254	395	2·1	3·4	4·5	10·0
Sweden ..	Lapland (Lule R.)–Mid-Sweden	500	600	—	3	360	465	8·4	—	7·5	15·9
Egypt ..	Aswan–Cairo	240	480	—	3	360	220	5·7	—	3·6	9·3
	Wadi Halfa–Cairo ..	200	670	—	2	360	280	5·4	—	3·0	8·4
Sudan	Nimule–Malakal ..	100	400	400	2	300	167	—	9·5	1·5	11·0
S. Africa ..	Kariba Gorge–Rand ..	400	600	—	3	360	370	7·8	—	5·0	13·8
India ..	Teesta–Calcutta ..	800	330	—	5	254	630	5·9	—	12·0	17·9
	Brahmaputra–Calcutta	1,000	700	—	5	360	550	18·2	—	15·0	33·2
	Bhakra–Delhi	600	250	—	4	254	590	3·2	—	9·0	12·2
	Backbone lines Calcutta, U.P. for interchange Bombay between industrial area Nagpur	400	600	—	3	360	370	7·8	—	6·0	13·8
		240	400	—	3	254	320	3·7	—	3·6	7·3
Australia	Tasmania–Melbourne ..	400	362	117	3	254	525	2·7	5·0	6·0	13·7
	Snowy R.–Sydney ..	500	280	—	3	254	650	2·8	—	7·5	10·3
New Zealand	Milford Sd.–East coast ..	500	250	—	3	254	650	2·5	—	7·5	10
	S. Island, N. Island, across Cook St. by cable	500	300	25	3	254	650	3·0	1·0	7·5	11·5
Canada	Des Joachims	200	200	—	3	254	260	1·6	—	3·0	4·6
	St. Lawrence	350	250	—	3	254	460	2·3	—	5·25	7·55
Argentine ..	Salto Grande–Buenos Aires	420	500	—	3	360	390	6·5	—	6·3	12·8
Total for all schemes		8,700	—	—	—	—	—	96·8	26·6	130·5	253·9
Total for schemes less than 300 miles		2,900	—	—	—	—	—	12·5	7·7	43·5	63·6
Total for schemes of 300 miles and upward		5,800	—	—	—	—	—	84·4	18·9	87·0	190·30

* 1947 basis.

total erected and in working order would be about 190*l*. million. There are also many other cases where available water power could be transmitted to distant load centres if direct-current transmission were used.

Examination of these figures, and of the curves in Figs. 1 and 2, shows that, if the three schemes in the range of, say, 300 to 500 miles, which do not include cables, were undertaken as alternating-current systems, the aggregate power transmitted would amount to 1,280 MW for an average distance of 370 miles and would involve the expenditure of 26*l*. million on overhead lines and 13*l*. million on transformer-station equipment totalling 39*l*. million. If, however, these were direct-current schemes, the cost for the lines would be about 15*l*. million and for the converter stations about 19*l*. million, totalling 34*l*. million, showing a saving of much material and about 13 per cent. in capital expenditure. In addition, if direct-current equipment were available it would create a lines or cables and 79*l*. million for substations and their equipment.

Work is continuing on submarine transmission, particularly in connection with Cook Strait between the North and South Islands of New Zealand, a cross-Channel tie to link Electricité de France and the British Electricity Authority, and a link from the mainland of Sweden to Gottland.

VIRGIN-ALUMINIUM PRICE INCREASE.—The Ministry of Materials announce that as from April 1, the price of virgin aluminium in ingot form was increased from 148*l*. to 154*l*., per long ton, delivered into consumers' works. For metal in notch-bar form there is an addition of 2*l*. 10*s*. a ton. The new price applies to metal of a purity of from 99 per cent. to 99·5 per cent. The premiums paid for higher-purity ingots will remain unaltered.

SELF-PRIMING MARINE PUMP.

MEGATOR PUMPS AND COMPRESSORS, LIMITED, LONDON.

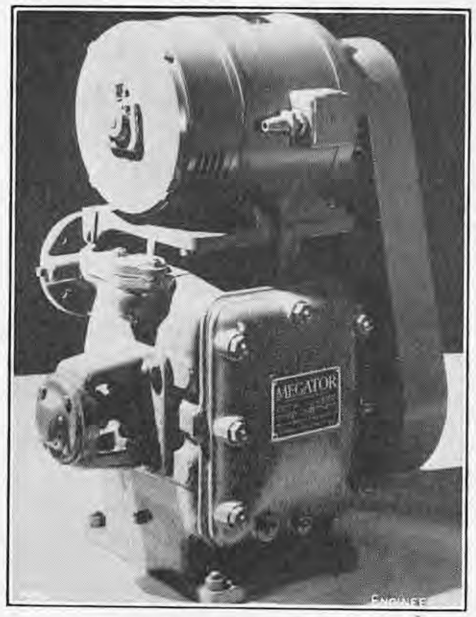


FIG. 1. "MEGATOR" M.16 PUMP.

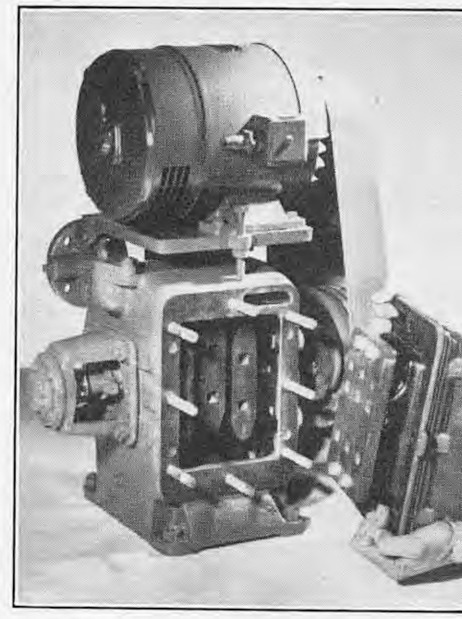


FIG. 2. COVER REMOVED, SHOWING SHOES.

SELF-PRIMING MARINE PUMP.

THE pump illustrated in Figs. 1 and 2 is the M.16 pump designed and constructed by Megator Pumps and Compressors, Limited, 43, Berkeley-square, London, W.1, and is well known to the marine-engineering industry in its bilge-pumping and sea-water circulation applications. It is self priming and is capable of handling gritty and viscous liquids. It can now be arranged, as shown in the illustrations, to be belt-driven by a 1-h.p. English Electric marine motor, mounted above it to form a compact unit, the total weight of which is 250 lb. In this form it has a maximum capacity of 1,000 Imperial gallons per hour against a total head of 75 ft. of water, and gives a maximum suction lift of 25 ft. of water. Marine units of similar design are available in capacities ranging from 500 gallons to 3,000 gallons per hour. The pump discharge is proportional to speed and is almost independent of the head.

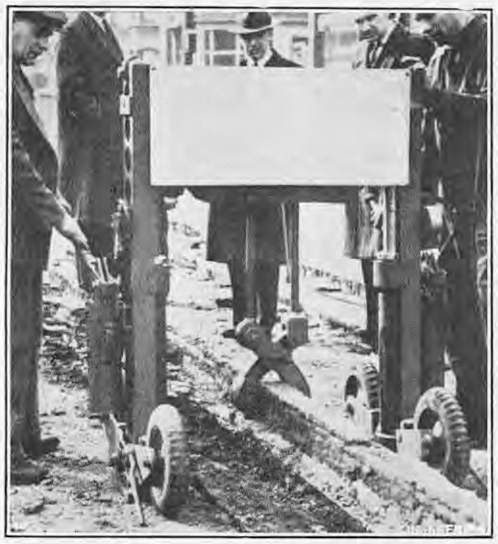
The Megator pump is simple in construction and is designed for easy servicing. The mechanism comprises a balanced rotor shaft running in two grease-packed ball bearings, which are mounted on brackets outside the pump housing so that they are completely separated from the liquid being pumped. The rotor shaft carries three eccentric discs which fit closely into recesses in three rubber-and-plastic " shoes " which act as slide valves. The shoes can be seen in Fig. 2, which shows the cover plate removed to give access to the moving parts. To inspect the rotor, the shoes can be easily withdrawn. In the end of each shoe are two ports, which register alternately with inlet and discharge ports in the inner wall of the cover plate as an eccentric disc rotates within it. The cover plate forms a division between the suction and delivery sides of the pump. Liquid from the suction inlet pipe passes through a channel in the pump body, which can be seen in Fig. 2, and enters a space enclosed in the cover plate. As the rotor uncovers the inlet ports, liquid is drawn from this space into the shoe recess until it is filled. As the eccentric rotates further, the inlet ports are closed, the delivery ports are opened and the liquid is expelled through them into the pump body and out through the discharge pipe. There are no metal-to-metal moving contacts.

OIL WELL TO BE DRILLED IN THE ISLE OF WIGHT.—According to a statement issued by the Anglo-Iranian Oil Company, Limited, an exploratory oil well is to be drilled in the Isle of Wight by the D'Arcy Exploration Company, the Anglo-Iranian's prospecting subsidiary. Work on this well, it is stated, will commence as soon as that being drilled near Ainsdale-on-Sea, Lancashire, which has now reached a depth of 2,000 ft., is completed. The site of the proposed drilling is almost exactly in the middle of the island, approximately half a mile southwest of the village of Arreton and will, therefore, be remote from holiday centres. Drilling on the Isle of Wight has been planned for a number of years but, before geophysical work was undertaken, the only locations suggested by geological survey were on the edge of the sea and for scientific reasons, considered unsuitable. The site for the drilling was selected by gravity survey and confirmed by seismic-reflection survey.

HYDRAULIC LIFTER FOR TRAMWAY TRACK.

THE accompanying illustration shows a portable hydraulic mechanism for recovering obsolete tramway track economically and quickly. Known as the Staffa track lifter, it has been developed by Messrs. Chamberlain Industries, Limited, Staffa Works, Leyton, London, E.10.

It will be seen that the track is gripped by tongs suspended from a connecting bridge between two hydraulic rams. The latter, which are mounted on



the inner sides of two upright members, are actuated by hydraulic hand pumps, building up a steady lifting force on the rail until, at a force of about 3,000 lb., the rail begins to move. During the build-up of pressure in the rams, the concrete screed holding the rail gradually cracks and eventually the rail frees itself and can be lifted easily to a height of about 2 ft. above the road surface. It can then be cut to convenient lengths for removal. It will be observed that the frame housing the jacks are provided with pairs of rubber-tyred wheels so that the unit can be readily towed from one site to another. It can also be quickly dismantled into three units and re-assembled in a few minutes at the new site. The total weight of the track lifter is about 5 cwt.

CONTRACTS.

THE CALEDON SHIPBUILDING AND ENGINEERING CO., LTD., Caledon Shipyard, Dundee, have received an order for a motor tanker of 13,000 tons deadweight capacity, from Athel Line, Ltd., London. Propelling machinery of the Doxford type will be supplied by HAWTHORN, LESLIE & CO., LTD., Newcastle-on-Tyne.

COOK, WELTON AND GEMMELL, LTD., Beverley, East Yorkshire, are to build a 1,500-h.p. steam tug to the order of the Société Cherbourgeoise de Remorquage et de Sauvetage, Cherbourg. The vessel will have a length, between perpendiculars, of 125 ft., a breadth moulded of 32 ft., and a depth moulded of 14 ft. 6 in. The triple-expansion propelling engine will be supplied and installed by CHARLES D. HOLMES & CO., LTD., Hull.

LOBNITZ & CO., LTD., Renfrew, have received an order from the London County Council for a new sewage-sludge steamer of 2,925 tons laden displacement to replace the G. W. Humphreys lost as a result of enemy action on October 29, 1940. She will be a twin-screw, oil-burning vessel fitted with triple-expansion engines, capable of carrying 1,560 tons of sewage sludge in four cargo tanks, at a normal service speed of 11 knots. The ship has a length of 262 ft., a moulded breadth of 43 ft. 6 in., and a moulded depth of 17 ft. 3 in. She will ply between the Council's outfall works at Beckton and Crossness and the Black Deep depositing area in the North Sea, a round trip of some 120 miles.

JAMES MITCHELL & SON, LTD., Greenock, are to supply a salt-water distillation plant at Kuwait, Arabia, involving the construction of three boilers and some 200 tons of fabricated pipe.

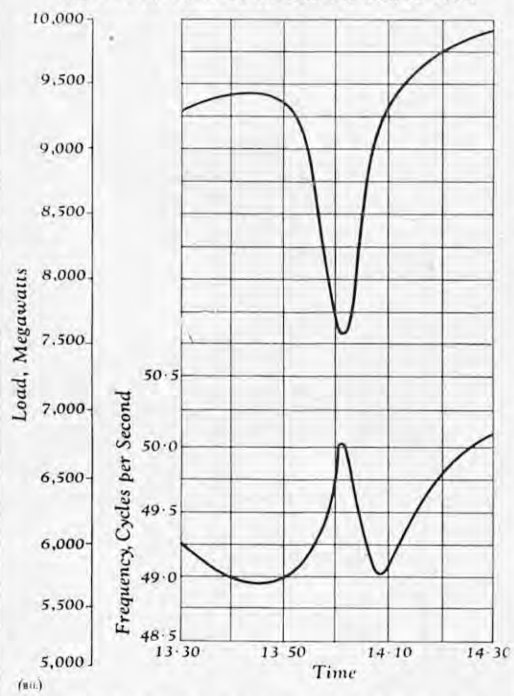
THE ENGLISH ELECTRIC CO., LTD., have been awarded an order valued at 200,000 dols., by the United States Bureau of Reclamation, which is responsible for a large transformer installation for the Folsom power station, California. The 80,000-kVA three-phase transformer required is to have a voltage ratio auto-connected, of 230,000/115,000. In the firm's Stafford Works the first 120,000-kVA 275,000/132,000-volts auto-connected transformer is building for the British Electricity Authority.

GUY MOTORS LTD., Wolverhampton, have received an order for 30 double-deck motor omnibuses from the East Kent Road Car Co.

EFFECT OF A SUDDEN LOAD REDUCTION ON ELECTRICITY SUPPLY CONDITIONS.

THE system control arrangements of the British Electricity Authority were severely tested by the heavy and rapid fluctuations in load which occurred as a result of the two minutes silence, commencing at 2 p.m., on the occasion of the funeral of His late Majesty King George VI, on Friday, February 15. As shown in the accompanying graphs, the national load fell from 9,400 to 7,600 MW, that is, by 19 per cent., between 1.30 and 2.30 p.m., while the system frequency fluctuated from just under 49 cycles (to which it had been deliberately reduced) to just over 50 cycles at the time when the demand was at a minimum. If an approximate allowance is made for the change in frequency, the fall in load was about 21 per cent. The rate of change of frequency was abnormally high, exceeding 0·25 cycle per second per minute at times, while during the five minutes following the silence the mean rate of rise in demand exceeded 330 MW per minute. The rapidity and magnitude of the drop in demand just before the silence were partly compensated by the rising frequency. Similarly, when the output was being restored after the silence, the drop in frequency reduced the rate and

NATIONAL LOAD AND FREQUENCY CURVES FROM 13·30 TO 14·30 HOURS ON FEB. 15 1952.



magnitude of the rising demand. The rise of the load curve to a higher level after than before the silence was, of course, due to the normal after-lunch recovery, which had been postponed by the observance.

These conditions were, to some extent, foreseen and various complicated arrangements were made to meet them. Some of the stations, usually the smaller ones, were given programmes for decreasing generation before and increasing it after the silence. Others were directed to carry their full load but to be ready to reduce generation rapidly just prior to the silence. A third class were directed to reduce their output some time previously to the silence and to be ready to increase it rapidly immediately afterwards. In one case, this arrangement was adopted, where the station was close to a cathedral, in order to avoid the possibility of disturbance due to blowing-off. Yet other stations were warned to be ready to decrease output before and to increase it after the silence, if instructed. A drop of as much as 50 per cent. of the total output was planned in this way. Finally, some stations were given import or export programmes, so that generation was reduced or increased to follow the rise and fall in local demand.

It may also be mentioned that the flexibility of the Scottish water-power plant was utilised successfully to control the power flow in the Meaford-Crewe and Peterborough-Bourne interconnectors. Nevertheless, practically the whole of the changes in demand were borne by steam plant, the effects of this being particularly severe in the Midlands, where the relative fluctuations were greater than elsewhere, owing to the preponderance of industrial load, and the limited transmission capacity preventing them from being shared equally by the system as a whole. In addition, it was necessary to abandon the economic loading of the plant during the period. That all this complicated procedure was justified may be illustrated by mentioning that no boiler safety valve lifted during the period when the load was fluctuating rapidly.

LAUNCHES AND TRIAL TRIPS.

M.S. "ATLANTIC DUKE."—Single-screw oil tanker built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Mr. Stavros George Livanos, Piræus, Greece. Main dimensions: 500 ft. between perpendiculars by 69 ft. 6 in. by 38 ft.; deadweight capacity, 16,652 tons on a draught 29 ft. 10⅜ in. Hawthorn-Doxford five-cylinder opposed-piston two-stroke airless-injection oil engine, developing 5,500 b.h.p. at 112 r.p.m., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed in service, about 13¼ knots. Trial trip, February 13.

M.S. "CALTEX CALCUTTA."—Single-screw oil tanker, built and engined by William Doxford & Sons, Ltd., Sunderland, for Overseas Tankship (U.K.), Ltd., London, W.1. Last vessel of a series of four for these owners. Main dimensions: 490 ft. overall by 61 ft. 9 in. by 36 ft. 3 in.; deadweight capacity, about 12,000 tons on a draught of 28 ft. 2½ in. Doxford five-cylinder opposed-piston balanced oil engine, developing 5,150 b.h.p. at 108 r.p.m. Speed, 13⅝ knots. Launch, March 11.

S.S. "DUNELMIA."—Single-screw cargo vessel, with accommodation for two passengers, built and engined by William Gray & Co., Ltd., West Hartlepool, for the Metcalfe Shipping Co., Ltd., West Hartlepool. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 27 ft. 10½ in. to upper deck; deadweight capacity, about 8,900 tons on a draught of 25 ft. Triple-expansion steam engine with Bauer Wach exhaust turbine and two oil-fired boilers. Speed, 10½ knots. Launch, March 12.

M.S. "SCOTTISH LION."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Scottish Tanker Co., Ltd. (Managers: Cayzer, Irvine & Co., Ltd.), London, E.C.3. First tanker for these owners. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 38 ft. 4½ in. to upper deck; deadweight capacity, 16,310 tons on a draught of 29 ft. 11 in.; gross tonnage, 11,169; oil-tank capacity, 743,375 cub. ft. Wallsend-Doxford six-cylinder two-stroke opposed-piston oil engine, developing 6,400 b.h.p. at 115 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend. Speed, 14 knots. Trial trip, March 20.

M.S. "JANITA."—Single-screw oil tanker, built and engined by Harland & Wolff, Ltd., Belfast, for Anders Jahre & Co., Sandefjord, Norway. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston oil engine. Launch, March 25.

M.S. "ESSEQUIBO."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Govan, for Royal Mail Lines, Ltd., London, E.C.3. Second of two sister ships. Main dimensions: 415 ft. between perpendiculars by 58 ft. 6 in. by 38 ft. 4 in. to shelter deck; gross tonnage, about 5,500. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Launch, March 25.

M.S. "TYNEFIELD."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for Hunting & Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 557 ft. overall by 70 ft. by 39 ft. 6 in. to upper deck; deadweight capacity, about 18,000 tons. Hawthorn-Doxford six-cylinder opposed-piston oil engine, developing 7,600 b.h.p. at 114 r.p.m. in service. Launch, March 25.

M.S. "LONDON SPIRIT."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for London and Overseas Freighters, Ltd., London. Last vessel of a series of three. Main dimensions: 475 ft. between perpendiculars by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, about 15,300 tons on a summer draught of 29 ft. Four-cylinder opposed-piston oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 12½ knots. Launch, March 26.

S.S. "SHELLPHALTE."—Single-screw oil tanker, built by John Crown & Sons, Ltd., Sunderland, for the Société Maritime Shell, Paris. Main dimensions: 315 ft. between perpendiculars by 46 ft. by 19 ft. 6 in. to harbour deck; deadweight capacity, 3,000 tons on a draught of about 16 ft. Reciprocating steam engines and two multitubular oil-burning boilers, constructed and installed by Smith's Dock Co., Ltd., South Bank-on-Tees. Launch, March 26.

S.S. "CAPE SAMBRO."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for the National Sea Products, Ltd., Halifax, Nova Scotia. Last vessel of a series of five. Main dimensions: 137 ft. between perpendiculars by 26 ft. 6 in. by 13 ft. 9 in.; gross tonnage, 400. Triple-expansion engines and one oil-burning boiler, constructed and installed by Amos and Smith, Ltd., Hull. Launch, March 27.

M.S. "GYLFI."—Single-screw trawler, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Icelandic Government, Reykjavik, Iceland. Main dimensions: 185 ft. by 30 ft. 6 in. by 16 ft. Six-cylinder Diesel engine, developing 1,450 b.h.p., constructed by Ruston and Hornsby, Ltd., Lincoln. Speed, 13½ knots. Trial trip, March 29.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Dimensions of Conduit Dies.—A newly issued specification, B.S. No. 1813, relates to conduit dies, guides and stocks, of the type used by electrical contractors. Simplified ranges have been standardised with a view to securing the greatest possible measure of interchangeability. The principal dimensions for three sizes of dies, with corresponding guides and stocks, are provided, and recommended screwing ranges of British Standard Conduit threads are given for each size of die. [Price 2*s*., postage included.]

Steel Bars for Production of Machined Parts.—A fourth revision of B.S. No. 32, covering steel bars for the production of machined parts has now been issued to replace the third, 1935, edition which has been out of print for some time. In effect, however, B.S. No. 32 has been superseded by B.S. No. 970, covering wrought steels for automobile and general engineering purposes but the older specification is being retained for an interim period until the use of B.S. No. 970 has become sufficiently established in general engineering practice, particularly overseas. In the new edition of B.S. No. 32, the chemical composition and tensile properties of the steels have been made identical with those of the corresponding steels in B.S. No. 970. A new grade, which represents a quality superior to that associated with the obsolete Grade 3, has been added, for rapid machining in repetition work. In the specification it is requested that orders, in future, should quote the En. steel number referring to B.S. No. 970. [Price 2*s*. 6*d*., postage included.]

TRADE PUBLICATIONS.

Aircraft Tools.—The Atlas Diesel Co., Ltd., Beresford-avenue, Wembley, Middlesex, have issued a leaflet giving particulars of pneumatic drills, reamers, tappers, rivet shavers, routers, and riveters for use in aircraft manufacture.

Small Fans.—We have received from the Standard and Pochin Brothers, Ltd., Evington Valley-road, Leicester, an illustrated leaflet describing briefly their range of small fans for industrial ventilation and cooling and for supplying furnace draught, etc.

Arc-Welded Band-Sawing Machine.—Details of the way in which arc-welding has been used in the construction of a band-sawing machine, thus increasing the capacity and reducing the weight, compared with the original cast-iron design, are given in a pamphlet received from Lincoln Electric Co., Ltd., Welwyn Garden City, Hertfordshire.

Gusset-Plate Truss Joints.—The latest of the "Studies in Structural Arc Welding," which are published from time to time by Lincoln Electric Co., Ltd., Welwyn Garden City, Hertfordshire, deals informatively with the lay-out of gusset plate truss joints and indicates the welding procedure to be followed in dealing with them.

Diffusing Water-Discharge Regulators.—Streamline diffusing discharge regulators of the cylindrical balanced type, which have been designed for destroying the energy in the water issuing from the outlets of high-head dams, are described in a leaflet received from the English Electric Co., Ltd., Kingsway, London, W.C.2.

Battery-Operated Pallet Trucks.—The second edition of a brochure entitled "Mechanical Handling Today" has been issued by Chloride Batteries Ltd., Exide Works, Clifton Junction, near Manchester. It contains illustrated examples of the use of electric-battery-operated pallet trucks for handling and stacking goods in factories and warehouses.

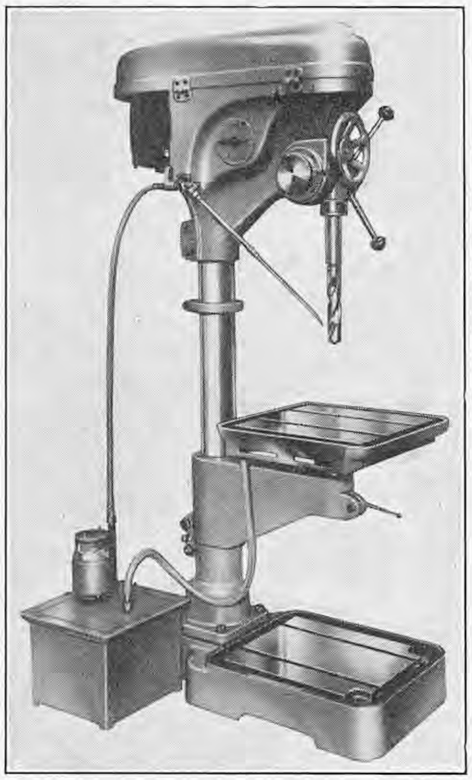
Electric Motors.—Brook Motors, Ltd., Huddersfield, who were founded nearly 50 years ago, have published a booklet entitled "About Ourselves," in which their works and manufacturing methods are described. The firm state that they make one-third of all the industrial alternating-current motors produced in Great Britain to-day; their output averages one motor every 30 seconds, or 12 motors per employee per month. They also specialise in the manufacture of control gear for the motors.

Plastic Extrusions.—A brochure recently issued by Thomas de la Rue & Co., Ltd. (Plastics Division), Imperial House, 84-86, Regent-street, London, W.1, gives useful data on the physical and chemical properties of the types and grades of thermo-plastic materials which they supply in the form of extruded sections. These materials are polyvinyl chloride, cellulose acetate, cellulose acetate butyrate, polythene and polystyrene. Some of the applications of the extrusions are illustrated and notes on machining, forming and cementing them are included.

$1\frac{1}{2}$-IN. DRILLING MACHINE.

A $1\frac{1}{2}$-IN. capacity heavy-duty drilling machine of robust construction, known as the Pacera M.F.6, has been introduced recently by Messrs. W. J. Meddings, Limited, Kingsley Works, Ipswich-road, Slough, Buckinghamshire. A photograph of the machine is reproduced below. The spindle has a travel of 6 in. and eight speeds ranging from 90 to 1,130 r.p.m., are provided. The work table, which can be rotated, measures $20\frac{1}{2}$ in. by 20 in. The machine is driven by a two-speed three-phase motor developing $1\frac{1}{3}$ h.p. at 1,500 r.p.m. and $1\frac{1}{2}$ h.p. at 3,000 r.p.m. The motor is mounted rigidly at the rear of the head casting.

The drive, enclosed by a spring-loaded hinged cover on the side of the head, is transmitted through a



V-belt and four step pulleys, and helical reduction gearing. The belt tension is regulated by a jockey pulley. A normal fast hand feed, by a star-wheel through a quill rack and pinion, is fitted; a slow hand feed is also provided through a worm and worm-wheel operated by a handwheel. The spindle is machined from chromium-nickel steel and is provided with a No. 4 Morse taper. It is mounted in a ground-steel quill, with a tapered-roller bearing at the drill end and a ball thrust bearing at the driving end. In all, eight ball or roller bearings and one sleeve bearing are incorporated in the spindle and drive assemblies. A graduated circular disc can be easily and accurately adjusted for setting drilling depth. The height of the work table can be adjusted by an enclosed worm and wormwheel driving a rack-and-pinion assembly. It can be swung round the column and locked clear of the base so that large work can be mounted on the base, which is ground and provided with T-slots. The table revolves on a ball thrust race and can be locked in any position. A coolant trough is provided, suitably drilled for connection to a coolant-supply unit.

ADHESIVES FOR PLYWOOD.—In a circular letter issued by the Director of the Forest Products Research Laboratory, it is stated that in tests carried out at the Laboratory, in which unprotected plywood was fully exposed to weather, not all types of adhesive complying with the AX100 requirement of B.S. 1203, "Synthetic Resin Adhesives for Plywood" (which calls for six hours' immersion in boiling water), had shown equal durability; some showed negligible deterioration in ten years whereas others failed in five or six years. Since "Exterior"-"Weatherproof" plywood is accepted as a grade which will withstand full exposure to the elements for a long time without serious weakening of the glue bond, the terms "Exterior"-"Weatherproof" and "AX100 plywood" should not be regarded as synonymous. (B.S. 1455, "British Made Plywood for Building and General Purposes," laid down that "Exterior"-"Weatherproof" plywood should be bonded "with an adhesive complying with the test requirements of B.S. 1203 for Type AX100.") In collaboration with the British Plastics Federation, the Forest Products Research Laboratory are preparing a revised draft for B.S. 1203, to be submitted to the British Standards Institution, which will probably contain revised test requirements.

BOOKS RECEIVED.

Helicopter Analysis. By PROFESSOR ALEXANDER A. NIKOLSKY. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 60*s*. net.]

Architectural and Engineering Law. By BERNARD TOMSON. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 7 dols.]; and Chapman and Hall, Limited, 37, Essex-street Strand, London, W C.2. [Price 56*s*. net.]

Strain Gauges. Theory and Application. By PROFESSOR J. J. KOCH and others. N.V. Philips' Gloeilampenfabrieken (Technical and Scientific Literature Department), Eindhoven, Holland. [Price 8 florins]; and Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 15*s*.]

Safety Rules for Use in Chemical Works. Part II. *Detailed Instructions.* The Association of British Chemical Manufacturers, 166, Piccadilly, London, W.1. [Price 25*s*., post free.]

Ship and Boat Builder Year Book, 1952. John Trundell (Publishers) Limited, Temple Chambers, Temple-avenue, London, E.C.4. [Price 30*s*. net.]

Adhesives for Wood. By R. A. G. KNIGHT. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 25*s*. net.]

The Manchester Association of Engineers. Transactions. Session 1950-51. Offices of the Association, 20, Booth-street, Manchester 2.

The Institution of Mechanical Engineers. Proceedings. W.E.P. Nos. 55-62, 1950. Volume 163. Offices of the Institution, Storey's Gate, St. James's Park, London, S.W.1.

The New Zealand Institution of Engineers. Proceedings. Volume 37. 1950-51. Ferguson and Osborn Limited, Lambton Quay, New Zealand.

The London Chamber of Commerce. Seventieth Annual Report of the Council. Work of the Year 1951. Offices of the Chamber, 69, Cannon-street, London, E.C.4.

King's Manual of Gas Manufacture. Section 4, containing Chapter VI. *Coke Oven.* By DR. G. E. FOXWELL. Second edition. Walter King Limited, 11, Bolt-court, Fleet-street, London, E.C.4. [Price 7*s*. 6*d*., post free.]

United States National Bureau of Standards. Miscellaneous Publication No. 202. *Report of the Thirty-Sixth National Conference on Weights and Measures.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 50 cents.]

United States National Bureau of Standards. Handbook No. 48. *Control and Removal of Radioactive Contamination in Laboratories.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 15 cents.]

United States National Bureau of Standards. Circular No. 510. *Tables of Chemical Kinetics. Homogeneous Reactions.* [Price 4 dols.] No. 515. *Energy and Angle Distribution of the Photoprotons from Deuterium.* By MARTIN WIENER. [Price 15 cents.] No. 517. *Calibration of Commercial Radio Field-Strength Meters at National Bureau of Standards.* By FRANK M. GREENE. [Price 10 cents.] The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.

Engineering Machine Shop Practice. By B. RICHARD HILTON. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.1. [Price 15*s*.]

Department of Scientific and Industrial Research. A Survey of the Sulphur and Sulphuric Acid Position. By R. ASHTON, A. L. THOROGOOD, and D. NEVILLE-JONES. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. 6*d*. net.]

Aircraft Gyroscopic Flight Instruments. Fifth edition. Sperry Gyroscope Company Limited, Brentford, Middlesex. [Price 3*s*. 6*d*.]

The Law Relating to Building and Engineering Contracts. By W. T. CRESWELL. Fifth edition by T. R. D. DAVIES. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 30*s*. net.]

The College of Aeronautics, Cranfield. Report No. 51. *Stress Distribution near a Rectangular Cut-Out in a Reinforced Circular Cylinder due to Direct Shear Loading and Torque. Part I. Test Results.* By G. HENSON. No. 55. *Aileron Reversal and Divergence of Swept Wings with Special Consideration of the Relevant Aerodynamic and Elastic Characteristics.* By J. R. M. RADOK. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5*s*. each.]

The Welding Review Year Book, 1952. Edited by J. V. BRITTAIN. Engineering Trader Limited, Morley House, 26-30, Holborn Viaduct, London, E.C.1. [Price 10*s*. post free.]

Basic Mathematics of Technology. By J. CHANCE and G. F. SIMS. Volume II. University of London Press Limited, Little Paul's House, Warwick-square, London, E.C.4. [Price 12*s*. 6*d*. net.]