15-MeV LINEAR ELECTRON ACCELERATOR.

AN important and interesting piece of apparatus for accelerating electrons for use in experimental nuclear physics has been completed recently and tested in the research laboratories at Salfords, near Redhill, Surrey, of Messrs. Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2. The apparatus is at present being installed at the Atomic Energy Research Establishment, Harwell, where it will be used in conjunction with a neutron time-of-flight spectrometer, also constructed in the Mullard research laboratories, for measurements required in the design of nuclear reactors. The design of the linear accelerator is based on work originally carried out by Mr. D. W. Fry and his collaborators in the Telecommunications Research Establishment at Malvern, and also at Harwell; and in the Mullard research laboratories it has been developed, under the direction of Dr. C. F. Bareford, by physicists and engineers led by Mr. M. G. Kelliher, on behalf of Philips Electrical Limited, under a Ministry of Supply contract.

The linear accelerator differs from other forms of accelerator, such as the cyclotron, the synchroton and the betatron, in that the particles are accelerated along a straight path instead of being accelerated in a spiral or circular path. It is, however, similar to the cyclic accelerators in that high voltages are not required in the accelerating process, although the final energy of the electrons may be many MeV.

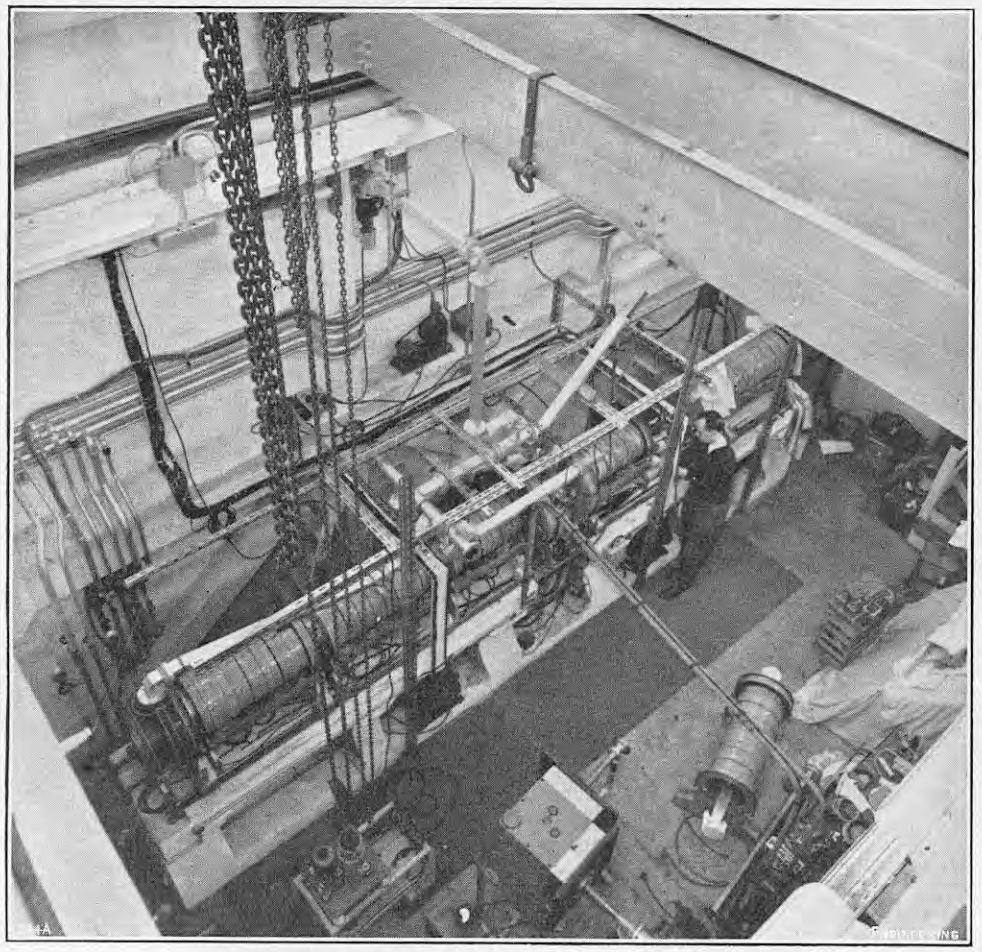


FIG. 1. ACCELERATOR IN TESTING PIT.

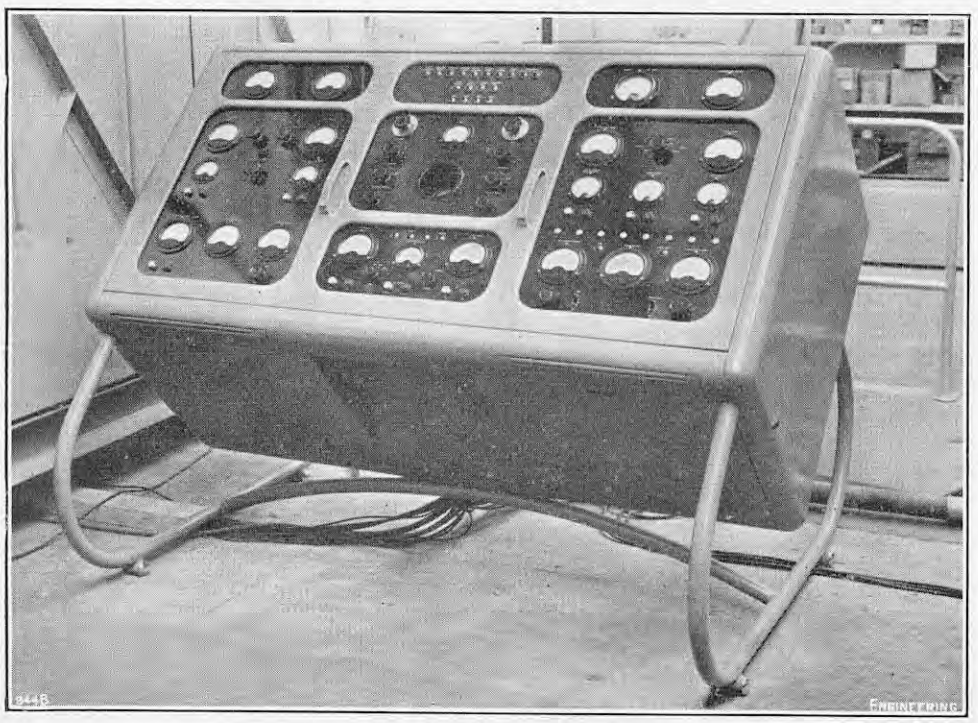


FIG. 2. CONTROL DESK.

Interest in linear accelerators during recent years has been mainly due to the many advances which have been made in the development of very high-frequency power sources and their associated new circuit techniques. These power sources are provided by magnetrons, which have made possible such rapid progress in radar during the past ten years. The principal advantage that the linear accelerator has over other electron accelerating apparatus is that it is capable of providing a vast quantity of electrons in pulses of short duration. These electrons may be stopped by a suitable target to produce a pulsed X-ray beam, which may in turn be used to produce neutrons from a source such as beryllium. It is the ability of the apparatus to provide vast quantities of neutrons in short pulses which makes it particularly valuable as a measuring tool for the nuclear physicist.

The linear accelerator also provides a very economical way of producing high-voltage X-rays. Another equally important application of the apparatus will, therefore, be as a high-voltage X-ray generator for use in the treatment of cancer, and work has just commenced on a further 15-MeV accelerator for St. Bartholomew's Hospital, London. A smaller accelerator, of 4-MeV capacity, is now being constructed for the Ministry of Health for installation at the Royal Victoria Infirmary, Newcastle-upon-Tyne.

Since the X-ray output of the 15-MeV accelerator is of the order of 2,000 Röntgens per minute at 1 metre, which is many million times the tolerance dose, elaborate precautions are necessary to protect the personnel operating the apparatus. For this reason, the accelerator was erected for testing purposes in a pit well below ground level, in which it is shown in Fig. 1, all adjustments and measurements being made from a control desk on the surface, shown in Fig. 2. A heavy concrete cover, partly visible in Fig. 1, is provided for the pit and this can be moved aside by an electrically-operated screw mechanism to give access to the apparatus, but all necessary precautions are, of course, taken by interlocking to prevent any possible access to the pit while the apparatus is energised. Fig. 3, page 162, reproduced from a photograph taken inside the pit, illustrates the apparatus as clearly as possible.

The principles of the linear electron accelerator are explained in detail in a report by D. W. Fry and W. Walkinshaw which appeared in the Physical Society's *Reports on the Progress in Physics*, vol. 12 (1948-49), but a general idea of its action may be obtained from the following notes, in conjunction with the diagram reproduced in Fig. 4, page 162. The essential part of the apparatus consists of six corrugated waveguides, each 3 ft. in length, placed end to end in a straight line as indicated in the lower part of the diagram, Fig. 4. Each of these waveguides is composed of a series of copper cups, the rims of each of which are spigoted to the base of the next one, the joint being made by a special eutectic solder. A circular aperture is made in the centre of the base of each cup, so that when the cups are joined by the solder a tube is formed with a smooth external surface and a series of internal cavities. The perforated diaphragms which separate the cavities are known as " irises " and they form a loading which ensures that the electrons are continually accelerated as they pass down the waveguide. A magnetron, having a peak capacity of 2 megawatts, generates electromagnetic waves of 10 cm. wavelength in the form of pulses of 2 micro-seconds duration, and these pulses are delivered through waveguides of rectangular cross-section to

15-MeV LINEAR ELECTRON ACCELERATOR FOR HARWELL.

MESSRS. MULLARD LIMITED, LONDON.

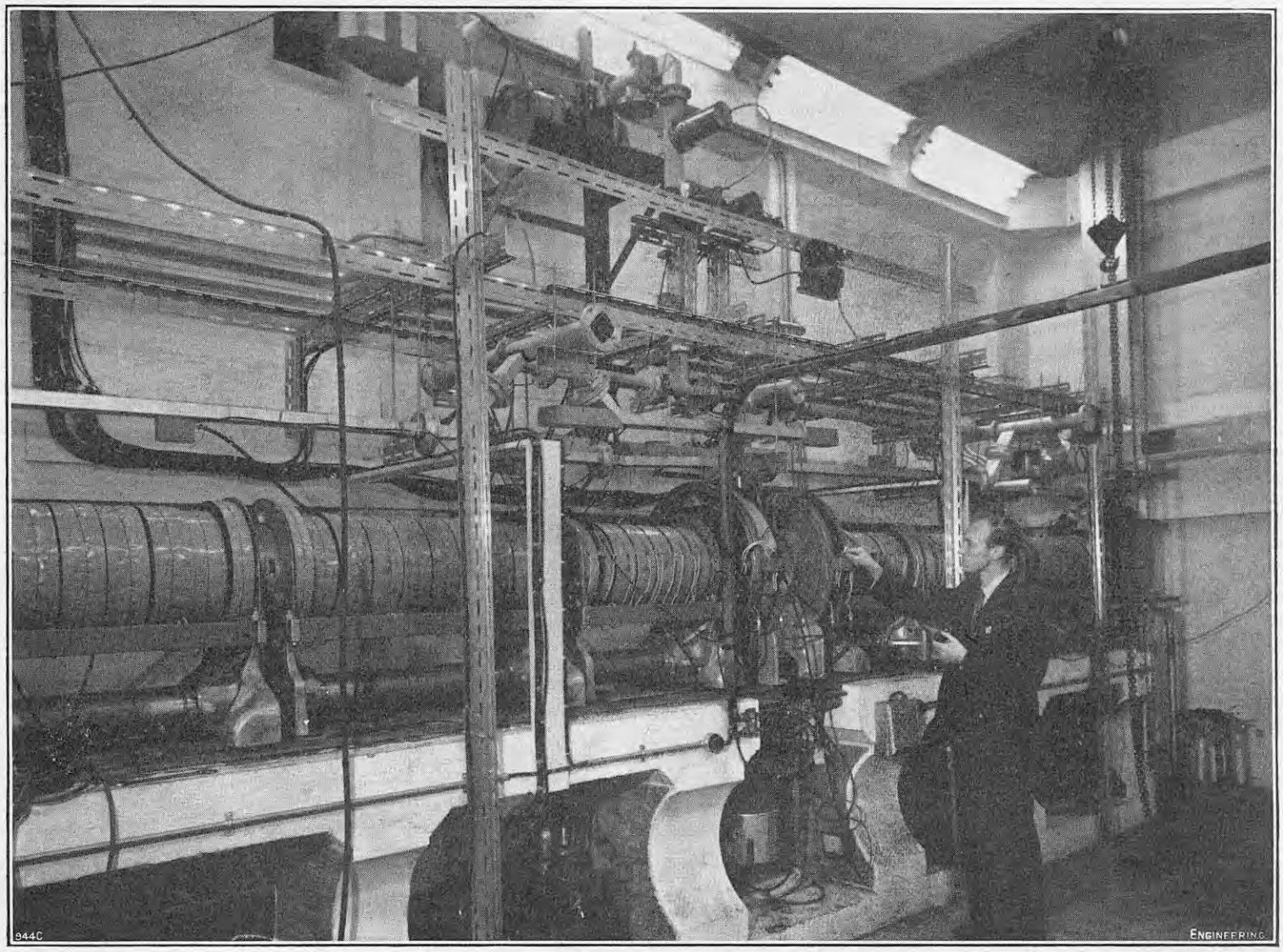
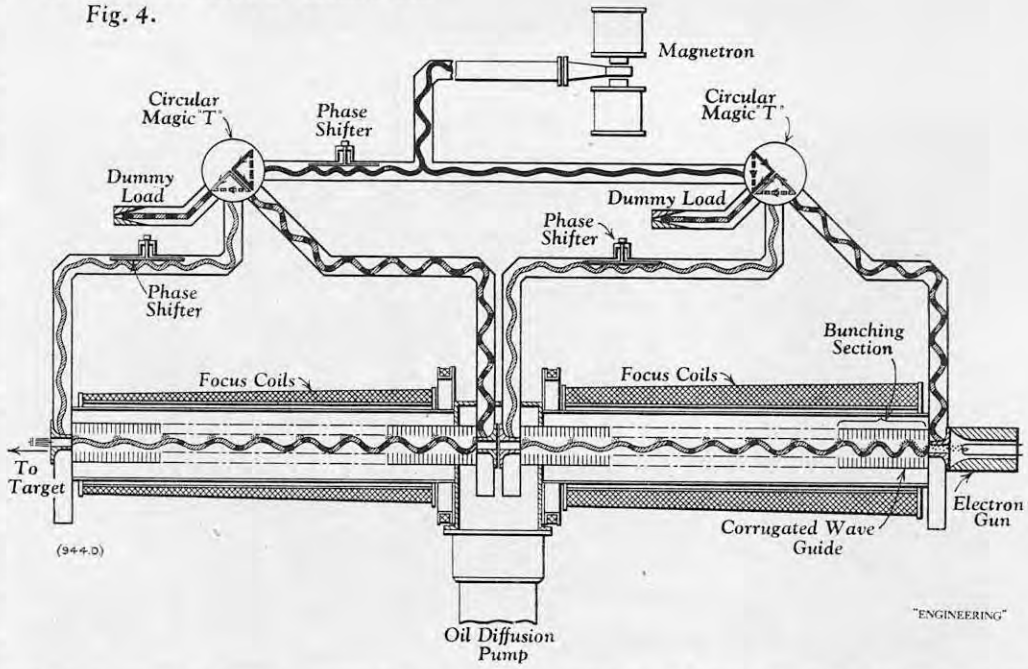


Fig. 3. Apparatus in Testing Pit.

Fig. 4.



one end of each set of corrugated waveguides, some of the energy being fed back from the outlet end to the inlet end as indicated in Fig. 4.

Electrons from an electron gun, shown on the right in Fig. 4, enter the corrugated waveguide, the first section of which, known as the "bunching section," causes them to collect in groups. They then receive an acceleration due to the axial component of the electric field of the radio-frequency wave. As the electrons pass through the irises they are accelerated forward until they attain a velocity nearly equal to that of light, at which velocity they leave the corrugated waveguide and are directed on to the target, as indicated on the left of Fig. 4; their mass has then been increased 30 times, a fact which is in accordance with the Special Theory of Relativity. As can be seen in Figs. 1 and 3, the corrugated waveguides have external windings, the object of which is to provide an axial focusing magnetic field for maintaining the electrons in the axial path. When the accelerated electrons are stopped by a target of heavy metal, they produce very hard X-rays, and when the latter are directed on to a neutron source, such as beryllium, large numbers of neutrons are released.

To reduce as far as possible collisions between the electrons and gas molecules in the waveguides, the whole system is kept at the lowest pressure obtainable, of the order of 10^{-9} atmosphere, the vacuum being maintained by a backing pump and an oil-diffusion pump which operate continuously as long as the apparatus is in use. A very high degree of precision is essential in the construction of the corrugated waveguides to preserve the bunching of the electron beam; the radial dimensions, for instance, are accurate to within 0·0003 in. and the error in the overall length of the guides, which amounts to 20 ft., does not exceed 0·030 in. Another interesting point in the design of the apparatus is that the corrugated waveguides are mounted on trolleys which run on rails. This feature, which is most clearly seen in Fig. 3, greatly facilitates assembly and servicing, and also simplifies the construction of larger accelerators of higher energy output without necessitating any fundamental alteration in design.

LITERATURE.

Tables of the Error Function and of its First Twenty Derivatives.

By the Staff of the Computation Laboratory of Harvard University. Harvard University Press, Cambridge 38, Massachusetts [Price 8 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-quare, London, E.C.4. [Price 52*s.* net.]

THE normal error function, introduced by Gauss and sometimes called the probability integral, occupies a central position in the theory of probability. It is here defined in the modern form, now almost universally adopted in statistical work, as

$$\phi^{(-1)}(x) = \frac{1}{\sqrt{2\pi}} \int_0^x e^{-\frac{t^2}{2}} dt.$$

In this notation $\phi^{(0)}(x)$ will represent the ordinate of the probability curve and $\phi^{(n)}(x)$ its nth derivative. Prefacing the tables themselves is a 28-page introduction, divided into four sections. The first, contributed by Warren Semon, contains a full discussion of the mathematical properties of the functions. The derivatives of the error function are shown to be related to the Hermite polynomials and to be expressible in terms of the confluent hypergeometric function, and the orthogonality property, on which their usefulness so largely depends, is established. A number of useful recurrence formulæ and integral representations of the functions is also derived.

Section II explains the method adopted in carrying out the computation. This section is by Warren Semon, who was responsible for preparing the control tapes for the automatic sequence-controlled calculator and for supervising its operation. The third section, due to Professor David Middleton, deals with representative applications of the functions. Besides their obvious applications in the field of probability and statistics, the error function and its derivatives, being solutions of a general partial differential equation of the parabolic type known as the equation of Fokker and Planck, may be expected to play a significant role in physical problems where "the basic model is statistical or where large aggregates of essentially independent elementary particles are involved." Such problems are encountered in heat flow, molecular diffusion, Brownian movement, kinetic theory of gases, hydrodynamics and wave mechanics. A fundamental aspect of communication theory is concerned with the influence of noise on the transmission of signals. Regarding noise as due to the superposition of a very large number of independent random effects, so that the distribution functions of the noise will be normal or nearly so, it is clear that any analysis of noise problems will involve the error function and its derivatives and a list of half a dozen such problems is provided. The final section of the introduction is a table, to ten decimal places, of the zeros of the first twenty derivatives of the error function. It would have been of interest to have, in addition, graphs of these functions.

The entries in the four main tables are to six decimal places. No special provision has been made for interpolation since the derivatives themselves may be used in a Taylor series for this purpose and the argument intervals have been chosen with this in view. Table I gives values of $\phi^{(-1)}(x)$ to $\phi^{(4)}(x)$ for arguments from 0·000 to 6·468 at intervals of 0·004. Table II gives $\phi^{(5)}(x)$ to $\phi^{(10)}(x)$ for values of the arguments from 0·000 to 8·236 at intervals of 0·004. Table III contains values of $\phi^{(11)}(x)$ to $\phi^{(15)}(x)$ for the arguments $x = 0{\cdot}000$ (0·002) 9·610; and Table IV, values of $\phi^{(16)}(x)$ to $\phi^{(20)}(x)$ for the arguments $x = 0{\cdot}000$ (0·002) 10·902.

The standard of accuracy and quality of presentation are those we have come to associate with this series. The present volume, which is the 23rd of the *Annals* of the Computation Laboratory of Harvard University, provides a sufficiently extensive tabulation of the error function and of its derivatives to meet a real need in applied statistics and modern physics.

The Story of the Mushets.

By FRED M. OSBORN. Thomas Nelson and Sons, Limited, Parkside Works, Edinburgh, 9. [Price 21*s.* net.]

THIS book deals with two relatively neglected figures of industrial history—the Mushets, David the father, and Robert Forester the son. David is known for his discovery of Black Band ironstone, which eventually revolutionised the iron trade of his native Scotland; Robert achieved fame for his self-hardening steel, which he introduced in 1868. Otherwise, their history is not widely known; yet, between them, the Mushets were responsible for much that was of value in the iron and steel industry. In Robert's case, his work was of importance to engineering as well, for his new tool steel, which made possible speeds and feeds previously unheard of, had a profound influence on machine-tool design. The late Mr. Fred M. Osborn, who was closely connected with Mushet's special steel at the turn of the century, and who knew and worked with Robert's two sons, has brought together the relevant facts, previously scattered and not easily accessible, into one volume. He has not attempted too detailed an analysis of the evidence he has collected; rather has he relied upon a presentation of facts which can speak for themselves.

David Mushet's discovery of Black Band ironstone, the refusal of the ironmasters to accept it at first, and their subsequent use of it with great benefit to themselves and none at all to Mushet, are familiar enough. What is not so widely known is that David was one of the first of the scientific investigators of the phenomena of iron-making. He entered the iron trade at a time when the process was carried on in an atmosphere of ignorance, prejudice, and, it might almost be said, superstition. His researches were conducted in the face of ridicule and often of hostility, but he lived to see many of his ideas adopted, even if he received no reward for them. Robert, to whom Mr. Osborn has devoted about two-thirds of his text, was responsible for several developments of great importance. His own writings have been drawn upon extensively to provide the material for studying his activities. In the course of the survey of Robert's work, some little-known facts have been brought to light. Among these may be cited Robert's introduction of the "dozzle," or clay funnel used on ingot moulds, and his use of china clay as one of the ingredients for crucible-making. His patents, a list of which is given as an appendix, show how busy he was during the eleven years which began in 1856, the year of Bessemer's announcement of his process for decarburising molten iron by blowing air through it. Robert Mushet had close associations with the Bessemer process, though the value of his own contribution to its success was by no means generally admitted. In fact, right from the beginning, there was considerable controversy, in which Bessemer and Mushet were the central figures.

It is well enough known that the Bessemer process was not successful at first, and that, when it did become a practicable proposition, it was based on the use of spiegeleisen. Mushet had experimented with spiegeleisen some years earlier, and had recognised the important effect which this alloy of iron, carbon and manganese would have on decarburised iron. Bessemer admitted that spiegeleisen was essential to his process. A similar admission was made by William Kelly, of America, who patented a process similar to Bessemer's in 1857, and who is considered by some to have anticipated Bessemer in the use of air for decarburising molten iron. The controversy arose over the fact that Mushet had a patent for the use of spiegeleisen, dated a little earlier than Bessemer's patent, and centred on the question whether or not Bessemer had used manganese, the vital element in spiegeleisen, before Mushet obtained his patent. More than three chapters are devoted to the differences between Bessemer and Mushet, to Mushet's work on spiegeleisen, and to the latter's relations with the Ebbw Vale Iron Company. Of the many facts which emerge, not the least interesting is that Mushet, like more than one pioneer, might well have fared better had he chosen different business associates and taken other legal advice.

Before the conflict was over, Robert had made another important discovery—his self-hardening steel. It was the first of the alloy steels, using the term in its modern sense, and its effect on the engineering industry was far-reaching. Mushet formed a small company to make and market the new steel, but it only survived for a short time. The product was sound, but the company was not, and the rights to make the steel were transferred to Samuel Osborn and Company, of Sheffield, in 1871. Robert never went to Sheffield—indeed, there is his own statement as evidence that he never went inside any steelworks except his own. Instead, he went into semi-retirement, concerning himself only with the preparation of the alloying materials. He had had enough of patents, and made no effort to obtain legal protection for his steel. His method of protecting himself this time was secrecy, and he prepared his alloys at a little works near Coleford, in the Forest of Dean, letting no one into the secret except one or two trusted workmen.

While Robert was living in semi-retirement, the old Bessemer-Mushet controversy broke out again. In 1883, W. T. Jeans published his *Creators of the Age of Steel*, in which he dismissed the work of Robert as of no consequence. Robert was quick to take up the challenge. Literary ability ran in the Mushet family, and Robert showed himself as much at home with his pen as in his laboratory. The correspondence which appeared in the leading technical journals of the time is of more than ordinary interest. The reader can judge for himself whether or not Robert made out a good case, for a large selection of the correspondence is given in an appendix. It is unusual for documentary evidence to be presented so fully as it is in this book. Nineteen pages are devoted to Robert's own statement of his claims (it is, in fact, a reprint of his booklet, *The Bessemer-Mushet Process*, of 1883), and extracts relating to William Kelly and the Mushet-Jeans controversy occupy no fewer than 32 pages. Such lengthy extracts are justified, however, as they enable the reader to form his own judgment of a rather complicated case.

There are a few paragraphs which might be considered irrelevant. The account of Henry Cort's misfortunes on pages 56 and 57, for example, have nothing to do with the Mushets; Robert was connected with the appeal for a pension for Cort's son, but that is all. In this account, the old error that Cort "invented the process of rolling" is repeated, and the text implies that he was also responsible for the use of iron oxide in the puddling furnace. A few of the illustrations (there are 32) might have been omitted, or better ones chosen in their place. These, however, are minor points and do not detract from the value of the book, which is an honest and successful attempt to present the facts in a straightforward manner. The author says that it is not a treatise on metallurgy; that is true, but the reader will find that a working knowledge of the subject will be useful. That it deals with some of the technical points is all to the good, for technical history, like the Mushets, has not always been given the attention it deserves.

COLD-ROLLING OF FILLETS.

Fig. 1.

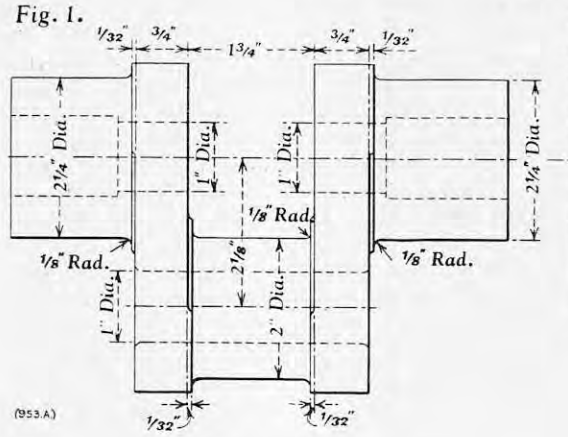


Fig. 2.

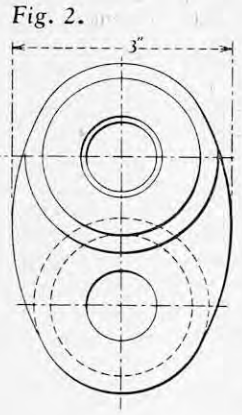


Fig. 3. "REVERSED" BENDING TESTS.

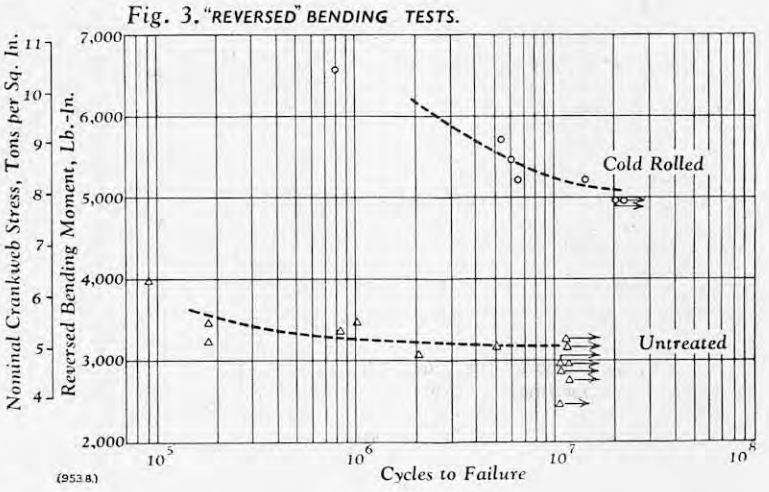


Fig. 4. "ONE-WAY" BENDING TESTS.

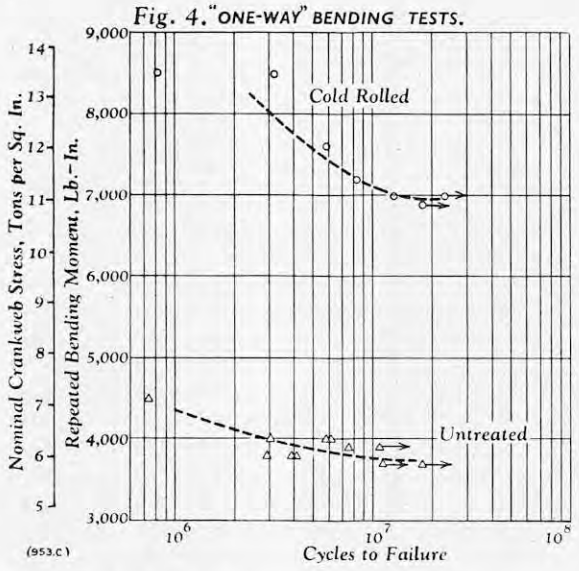


Fig. 5.

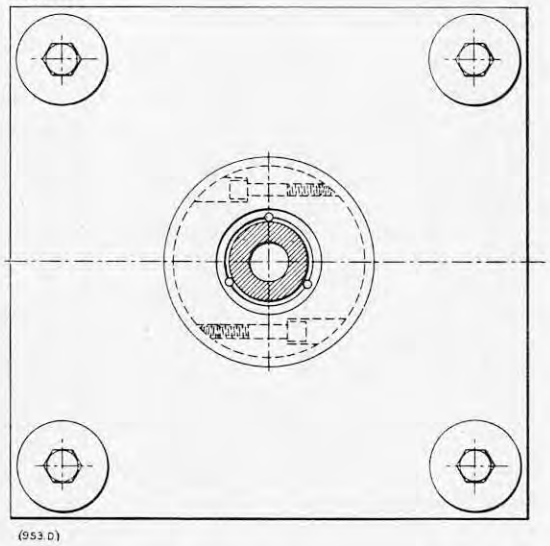
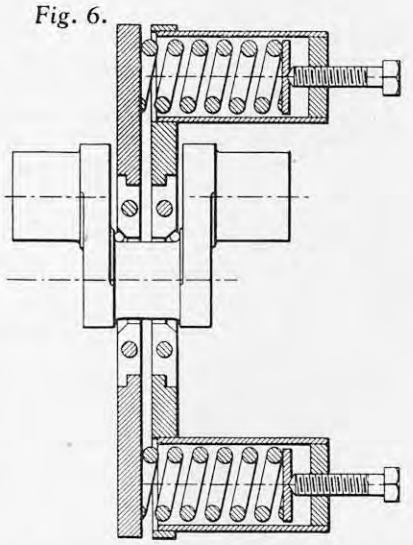


Fig. 6.



COLD-ROLLED FILLETS.

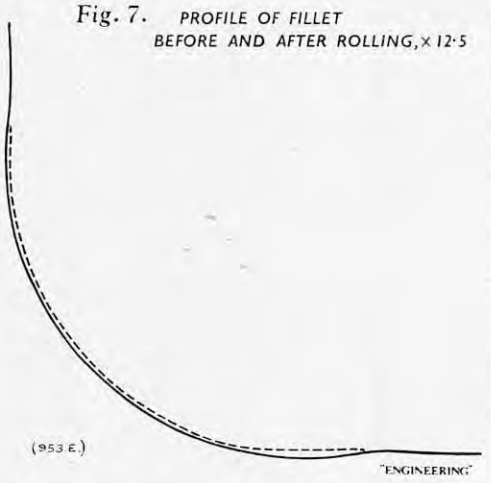
By R. J. Love, Wh.Sc., A.M.I.Mech.E.

It is well known that the fatigue strength of many engineering components is determined by the strength at some "critical" section—a notch or stress concentration; therefore, processes which may be used for local strengthening are of great interest. This is especially true at the present time when there is a necessity to use lower-alloy materials. Small modifications to design and treatment may produce strength increases which more than compensate for the reduction of strength that would otherwise result from using materials which are basically of less strength.

At the laboratory of the Motor Industry Research Association, a process devised for strengthening fillets, consisting of cold-rolling with steel balls, has given striking results. It was used, in fact, on cast crankshaft specimens, of the type illustrated in Figs. 1 and 2, herewith, the material being a flake-graphite iron which is in current use for the production of a wide variety of crankshafts. Fatigue-test results are given in Figs. 3 and 4, showing that, under reversed bending, the cold rolling has increased the limiting stress of crankshafts by 60 per cent., and that, under "one-way" loading, the increase of strength is as much as 80 per cent. The two kinds of loading were investigated because a crankshaft in service is probably subjected to a loading intermediate between these two conditions. These considerable strength increases have been achieved without any significant change of fillet radius.

The method of rolling was to use three balls equally spaced round the fillet and held in place by a loading ring with an internal 45-deg. chamfer. When rolling crankpin fillets, the loading rings were, of course, split and assembled on the crankpin.

Fig. 7. PROFILE OF FILLET BEFORE AND AFTER ROLLING, × 12·5



It was possible to roll both the fillets at the same time, the rings being loaded endwise by a simple device containing four coil springs, illustrated in Figs. 5 and 6, herewith, and this could be rotated readily by hand when under load. It was found desirable to rotate the loading rig only a few times, since, if many turns were used, in an attempt to obtain sufficient rolling when using light loads, the surface began to crumble rapidly. The load chosen was such as would produce a small but detectable deformation of the fillet, and this was achieved when the rings were subjected to a load of one ton; the load pressing each of the $\frac{1}{4}$-in. diameter balls into the fillet $= 1 \times \frac{1}{3} \times \sqrt{2}$ tons. The rig was given two revolutions, in which case each ball makes approximately one revolution of the fillet.

The deformation produced, about 0·003 in., is indicated in Fig. 7, herewith. The fillets are clearly much superior to those produced by conventional methods, since, apart from the beneficial cold-working effect, they are very smooth, truly circular and—of great importance in production—of closely controlled radius. However, to ensure that the surface is rolled uniformly, the fillet must be machined to a reasonable degree of accuracy of form and size before it is rolled. The rolling may produce a small ridge of metal (about 0·0005 in., in the present case) at the junction of the fillet and the journal, but this can be removed by a simple polishing operation. The process, which has been demonstrated to be beneficial when used on high-duty cast iron, can be expected to give similar, if not better, results on steel parts also, since steel is known to react very favourably to cold rolling.*

Institution of Heating and Ventilating Engineers.—The bronze medal of the Institution of Heating and Ventilating Engineers, 75, Eaton-place, London, S.W.1, has been awarded to Mr. R. A. Rose, A.M.I.H.V.E., for his paper on "Heating by Means of Tetra-Cresyl Silicate."

Local Authorities and Scrap Salvage.—A circular has been sent by Mr. Harold Macmillan, Minister of Housing and Local Government, to local authorities in England and Wales, requesting them to review their salvage arrangements to ensure that as much iron and steel scrap as can be recovered commercially is collected from all available sources. It is pointed out, in the circular, that local authorities as users of steel for housing and other applications, will realise how urgently every ton of scrap is needed at present. Details of the current prices for scrap are given in the circular.

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* *Stressing Axles and Other Railroad Equipment by Cold Rolling*, by O. J. Horger. Amer. Soc. for Metals Symposium on Surface Stressing of Metals, February, 1946, pages 85-142.

THE EDUCATION OF ENGINEERS IN SOME EUROPEAN COUNTRIES.*

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

(*Continued from page* 117.)

IN addition to the technical high schools, Germany has many good *Ingenieurschulen*, at which courses are provided for engineering students and may also, after suitable preliminary study, be taken by apprentices from industry. At least three years of full-time attendance and two years of practical experience are required for engineers to qualify in the mechanical and electrical engineering branches; attendance at the school may be part-time for a correspondingly greater number of years. Some 4,150 engineers are turned out annually in these branches, together with 3,400 civil and constructional engineers, who, however, have a minimum of only two years of full-time study. The best of these men can pass later to the technical high schools and may, after a shortened period of study, become *Diplom-Ingenieure*, that is, engineers with diplomas, of full professional status.

Austria has two independent technical high schools, at Vienna and Graz, and a small mining and metallurgical high school at Leoben. The two large schools work on similar lines to those in Germany. Austria trains more engineers than can be employed internally, and many find employment in Germany and in other countries. There is a long and sound tradition in engineering practice, and Austrian engineers have made notable contributions. The Vienna school has difficulty in rebuilding, but that at Graz is in good order. For its population, which lives largely from the soil, Austria is well provided with facilities for engineering education.

ENGINEERING EDUCATION IN SCANDINAVIA.

While the Scandinavian countries offer some interesting points of similarity, they also have widely varying conditions. Sweden has about twice the population of either Norway or Denmark. It has important mineral resources; so, also, has Norway, but to an extent not yet so well exploited. Much of Sweden is flat and communications are very much easier than in Norway. Denmark is flat and fairly compact, but relatively poor in natural resources; only by the energy of its people is a high standard of living possible. Sweden has independent technical high schools at Stockholm and Gothenburg; Denmark and Norway each have one, situated, respectively, at Copenhagen and Trondheim.

The Royal Institute of Technology at Stockholm was founded in 1827. The nine branches of study are set out in the first column of Table III, herewith. The courses in all of these take four years, except those in mining and metallurgy, which require four and a half years. A diploma from each of the first seven branches gives the right to the title

TABLE III.—*Number of Diplomas Awarded in Sweden in* 1951.

Branches.	R.I.T., Stock-holm.	C.I.T., Gothen-burg.	Total.
Physics	9	—	9
Mechanical Engineering ..	52	46	98
Civil Engineering	54	37	91
Electrical Engineering ..	49	49	98
Aeronautical and Shipbuilding	46	24	70
Surveying	23	15	38
Mining and Metallurgy ..	19	—	19
Architecture	26	—	26
	31	21	52
Totals	309	192	501

Civilingenjör, or civil engineer; one from mining and metallurgy that of *Bergsingenjör*, or mining engineer; and one from architecture, that of *Arkitekt*. A higher degree, the *Teknisk Licentiatexamen* (Tekn. L.) can be taken after two years of supplementary study in two subjects; a doctorate, called the *Teknologie Doktor* (Tekn.D.), is awarded for research, and after a public disputation of the candidate's dissertation. A high proportion of qualified students return for special courses, for which certificates are awarded.

The Royal Institute at Stockholm is clearly a principal research centre for all engineering and other activities in Sweden, but the branches as set out in the Table give an over-simplified picture. It had in 1949 about 1,700 diploma students, 220 special students, and 34 students reading for the higher degree of licentiate; the Chalmers Institute at Gothenburg, in the same year, had 910 diploma students. At Stockholm, there are 170 senior teachers and 265 assistants, figures which emphasise the potentiality for research of the school. The branch given as mechanical engineering, for example, has divisions for refrigerating engineering, workshop technology, industrial economics, machine tools, steam plant and machinery, hydraulic engineering, internal-combustion engines, heating and ventilating, materials, foundry technology, welding engineering, mechanical technology of wood, elevators and cranes and conveyors, vehicles, and painting and metal protection. Surveying, for example, also comprises forestry, agriculture, and building design. Each division is in the hands of one or more senior teachers. No conditions for practical training are attached to the award of the diploma, but, with the excellent workshop and laboratory facilities available, this is possibly of less importance here than elsewhere. The Institute publishes its own journal, and its library serves also the general public as a central technical library.

There are in Sweden technical secondary schools from which the exceptionally gifted pupil may pass to the technical high school, but this is rare. Many, on completing the secondary courses, continue their studies at technical schools and, with the necessary practical training, gain the qualification of *Ingenjör*, which, however, is not of full professional standing.

The Danish Technical High School at Copenhagen has, as will be noted from Table IV, herewith, approximately the same number of graduates annually as the Royal Institute of Technology at Stockholm, but the number of branches of study

TABLE IV.—*Number of Diplomas Awarded in Denmark.*

Branch.	No.
Mechanical Engineering	80 to 90
Civil Engineering	110 to 120
Electrical Engineering	60 to 70
Chemical Engineering	60 to 70
Totals	310 to 350

is four instead of nine. It forms, similarly, the principal research centre of the country, and possesses its own journal, in which the results of research work are published.

The courses are in two parts, of which the first part consists mainly of pure and applied mathematics, physics and chemistry, and the second part comprises the technical instruction appropriate to the chosen branch. The courses for the examination at the end of the first part take two years, but about 40 per cent. of the students require three years in order to reach the necessary standard. After passing the first examination, students of mechanical and electrical engineering go for at least one year of workshop practice. The courses for the second part lead to the diploma, and normally require two and a half years of study. In the last year, each student has to choose one main subject and one or two supplementary subjects in which to specialise. One large individual piece of work, either experimental or of design, has to be carried out in the last half-year, and great weight is attached in the examination to the standard reached by the student in this special task.

The total number of professional engineers in Denmark may be judged from the membership of the Danish Engineers' Association, most of whom were educated at the Technical High School. They comprised, in a total of 5,607 members, 1,328 mechanical, 957 electrical, 2,291 civil, and 1,031 chemical engineers; of these, 617 were working outside Denmark. There are also in Denmark six lower schools of engineering, called *Technica*, which provide three years of full-time study for young men having at least four years of practical experience. A capable "*technica*-engineer" can rise to any position in industry. Those who make good are admitted, under sponsorship and after careful investigation, to the Danish Engineers' Association, whereas graduates of the Technical High School are admitted directly. Some 15 to 20 *technica*-engineers are admitted annually and are thereby accepted as of equal status with the graduates.

The scope of the instruction given at the Norwegian Technical High School at Trondheim can best be understood by considering the data set out in Table V, herewith. The total number admitted at present is 260 a year, but will be increased as new and projected buildings are completed. The next extension, to be opened within two years, will permit the intake of students of industrial chemistry to be increased by about 40 a year. With present accommodation, the total number of students fluctuates between 1,000 and 1,200. The full

TABLE V.—*Diplomas Awarded by the Norwegian Technical High School, Trondheim, in* 1949.

Branch.	No.
Civil Engineering	58
Mechanical Engineering	34
Naval Architecture	8
Marine Engineering	
Electrical Power Engineering	11
Electrical Communications Engineering ..	5
Industrial Chemistry	30
Mining	13
Physics	1
Architecture	33
Totals	193

courses take 4½ years and, with the exception of civil engineering and industrial chemistry, practical experience in works, etc., must have been obtained by the students before entry; six months is the period for architecture and electrical engineering, and nine months for the remaining branches. In addition, there are technical schools at Oslo, Bergen, and Trondheim at which full-time courses of lower grade may be taken. The best students, on leaving, may be admitted to the Technical High School.

ENGINEERING EDUCATION IN THE NETHERLANDS.

The Netherlands also is a country in which the training of professional engineers is concentrated at a single independent Technical High School, namely, at the well-known school at Delft. The size of the school and the scope of its courses can be judged by consideration of Table VI, herewith. It is possible also, on the Table, to trace its rate of

TABLE VI.—*Diplomas Awarded at Delft.*

Branch.	1945-46.	1946-47.	1947-48.	1948-49.	1949-50.	1950-51.
Civil	41	62	52	75	110	140
Constructional ..	8	6	10	20	12	13
Mechanical	81	80	48	77	111	160
Marine	11	12	4	4	12	11
Aeronautical ..	5	6	10	14	8	23
Electrical	52	53	41	34	65	74
Chemical	28	34	54	47	60	67
Mining	19	8	12	10	5	24
Physicists	28	11	21	27	33	47
Surveyors, etc. ..	0	0	0	0	9	26
Total	273	272	252	308	425	585

recovery in the years since the end of the war. The number of graduates in 1951 was 585. Since the official courses take five years, and the average time taken by each student is over six years, a conservative estimate shows that there must be well over 3,000 students in residence.

In order to gain admission, the student must possess the Netherlands secondary-school certificate in mathematics, physics, and chemistry. At Delft, the student must pass three examinations: (*a*) *propaedeutisch*, or preliminary, mainly in the basic sciences; (*b*) the candidate's examination, mainly in the subjects of engineering science appropriate to his proposed branch; (*c*) the engineer's examina-

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

PROGRESS OF THE "BRITANNIA" AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

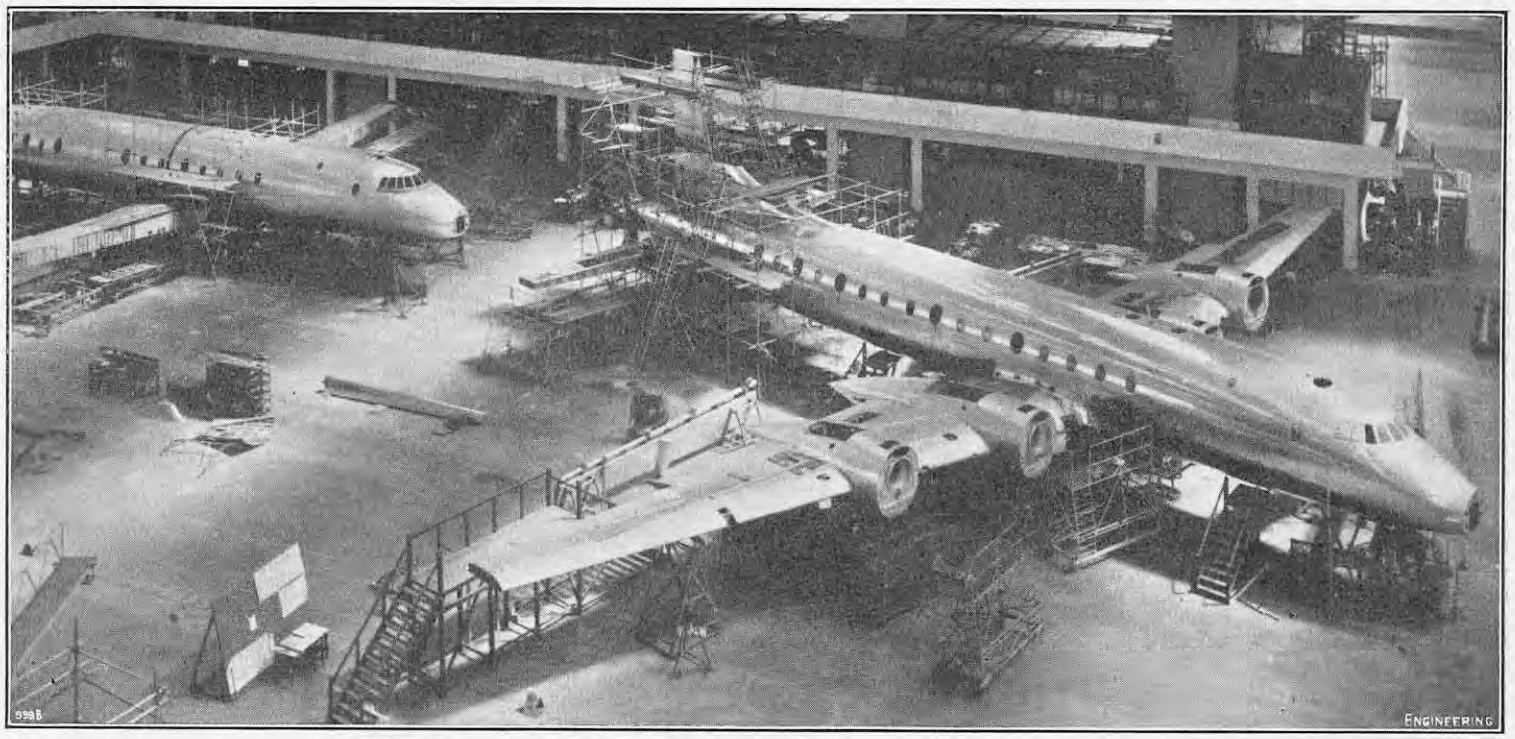


Fig. 1. Aircraft Under Construction.

tion, in technical investigations and design. On gaining his diploma, the graduate may legally call himself *Ingenieur*, a title abbreviated by custom before his name to "Ir." He must before graduating, except in the case of an engineer-physicist, obtain certain periods of practical experience; these periods range from eight weeks each, for the chemical and mining engineers, to nine months for the surveyor. The strength of the scientific and technical societies of the Netherlands, and the numerous original contributions they publish, afford evidence of the high standard of the research work carried out by Delft graduates.

The students, before entering at Delft, may either have attended a Gymnasium, roughly a grammar school of the old type, or a higher-grade school, at which the sciences receive more emphasis. Boys leaving these two types of school, and not going to Delft, may enter a day technical school, at which the courses take four years, including one spent in gaining practical experience. Such schools train the higher class of technician, and, in 1951, gave leaving diplomas to about 1,600 students. A very small number of the best of these transfer to the Delft courses. Other technicians combine an apprenticeship by day with study at evening technical schools. Technicians who, by their standing or achievements merit the honour, may be admitted to membership of the Royal Institute of Engineers, but they do not, through their election, acquire the legal status of *Ingenieur*.

(To be continued.)

North-East Coast Shipbuilding.—The First Lord of the Admiralty, Mr. J. P. L. Thomas, stated in Parliament on July 30 that the tonnage of new ships laid down on the North-East Coast during the second quarter of 1952 totalled 102,935 tons gross, compared with a gross tonnage of 164,993 during the corresponding three months of last year.

Industrial Waste Eliminators, Ltd.—The firm of Industrial Waste Eliminators, Ltd., 7-11, Old Bailey, London, E.C.4, was established on July 16, 1912, to acquire the business of the late Mr. Jean Schmidt, who made centrifugal extractors to recover oil from engineers' waste. The 40th anniversary of its foundation was celebrated on July 23, 1952, by a reception at the May Fair Hotel, London, W.1, presided over by the chairman, Mr. Alan P. Good. The firm is now a wholly-owned subsidiary of Heenan and Froude, Ltd., and is engaged entirely on the equipment of abattoirs (a connection acquired in 1930 from J. and F. Howard & Co., of Bedford) and the design and construction of plant for the meat and animal by-product trades.

PROGRESS OF THE BRISTOL "BRITANNIA" AIR-LINER.

A second progress report on the 140,000-lb. Britannia air-liner with four Proteus propeller-turbine engines, which is expected to fly later this summer, has been issued by the constructors, the Bristol Aeroplane Company, Limited, Filton, Bristol. Fig. 1, above, shows the aircraft under construction before the engines had been installed. They have since been fitted and preliminary ground running tests have commenced. Fig. 1 also shows the second aircraft of this class under construction. A summary of the first progress report, issued earlier this year, was given on page 343 of our 173rd volume (1952), and described tests on the "functional mock-up" of various systems. The present report is concerned mainly with structural tests on the wing; the programme of structural tests on the Britannia, including a complete wing, a half-scale rear fuselage mounted on stub wings and a full-scale front fuselage, is the largest ever undertaken by the company.

Fig. 2, opposite, shows the wing in the structural test rig before loading commenced. The rig is of the "mechanical-hydraulic" type in which the loads are applied mechanically and are measured hydraulically. In designing the test frame, hydraulic load application was considered, but was discarded because of the difficulty of providing hydraulic jacks with sufficiently long strokes, the wing-tip deflection under the ultimate gust loading being of the order of 7 ft. Fig. 3, opposite, shows three stages in the deformation of the wing under the ultimate gust loading, photographed in succession on the same plate. The mechanical measurement of the loads was also investigated, but was not adopted owing to the difficulty of obtaining sufficient accuracy by this means, particularly since all the load and deflection indicators, and the load controls, were to be grouped in a central control room.

The test frame illustrated is similar to the Cathedral rig at the Royal Aircraft Establishment. Six portal frames are mounted on a heavily-reinforced concrete raft, provision being made for moving the frame stations for varying wing layouts of future aircraft. Each portal frame carries a mechanical straining unit, consisting of a horizontal pivoted beam on which are mounted twin worm-driven straining screws, a four-speed gearbox and an electric motor. The floating end of the beam rests on a hydraulic load-measuring jack which is connected to a common dynamometer. Vertical loads are applied by the straining screws to the wing specimen, through a series of "Christmas tree" loading beams.

Design calculations indicated that landing loads would give rise to the most severe torsion and shear loads in the inner wing, and that the critical bending stresses would be imposed by gust loads. Since it was not practicable to test more than one wing specimen, it was agreed that the proof landing loads (i.e., 66·6 per cent. of the ultimate load) should be applied first, to check that no appreciable permanent deformation would occur under these loads. The ultimate fully-factored gust loads would then be applied. The wing specimen comprised a complete wing span less the wing tips, measuring about 136 ft. The whole of the aircraft primary structure was reproduced; the leading and trailing edges were omitted in the landing-load test, but were added for the gust case. No control surfaces were fitted. To ensure a correct distribution of stress at the wing-to-fuselage joints, a 46-ft. length of fuselage was added.

In the landing-load test, only the two innermost straining units, one on each wing, were used to provide the main undercarriage reactions, the inertia loads from the inner and outer engines, and an additional vertical up-load at the rear spar to produce the correct stresses in the rear shear web in the critical region. The undercarriage drag and side loads were applied by a separate hydraulic rig. As the test proceeded, it was found that certain modifications to the fuselage and to the nacelle structure were necessary. After carrying out these modifications, the specimen was satisfactorily loaded to the proof value, and after unloading no appreciable permanent deformation was observed.

For the gust case, all six straining units were used to apply distributed up-loads over the whole wing span, representing lift-minus-inertia loads. Certain down-loads were applied by a separate hydraulic system to reproduce the correct wing torsion. The fuselage section had to be pressurised to a differential pressure of 8·3 lb. per square inch, in order to reproduce the correct loading at the front and rear spar frames. The specimen was tested to destruction. At 95 per cent. of the ultimate design load it appeared to be completely satisfactory, but failure occurred at 98 per cent. It was concluded, by technicians of the Bristol company and the Royal Aircraft Establishment, that the primary site of failure was in the front

PROGRESS OF THE "BRITANNIA" AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

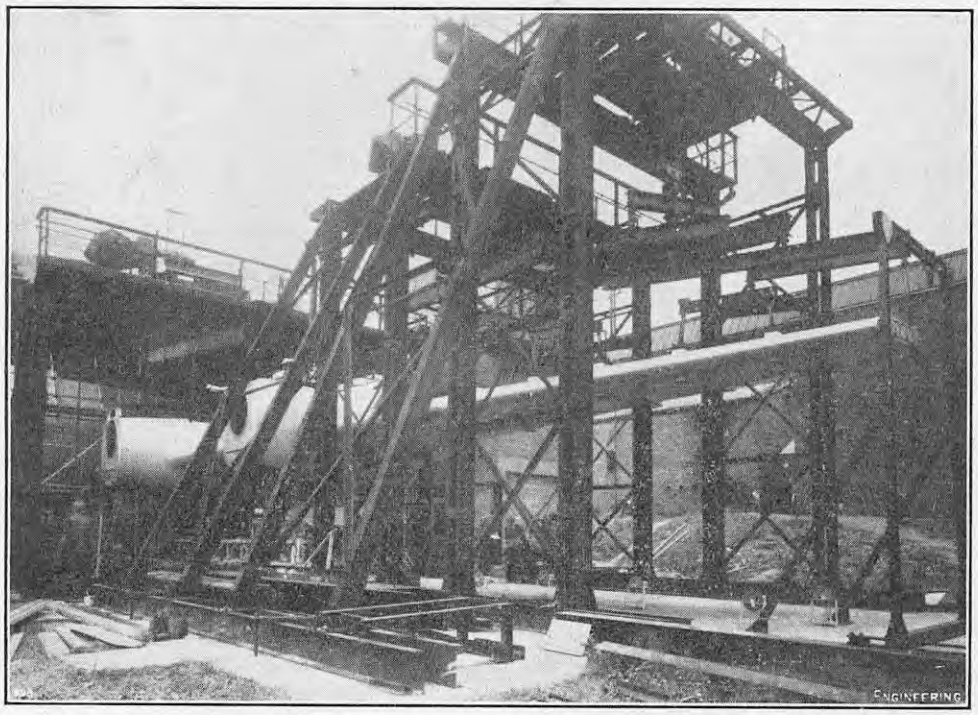


Fig. 2. Wing in Test Rig, Before Loading.

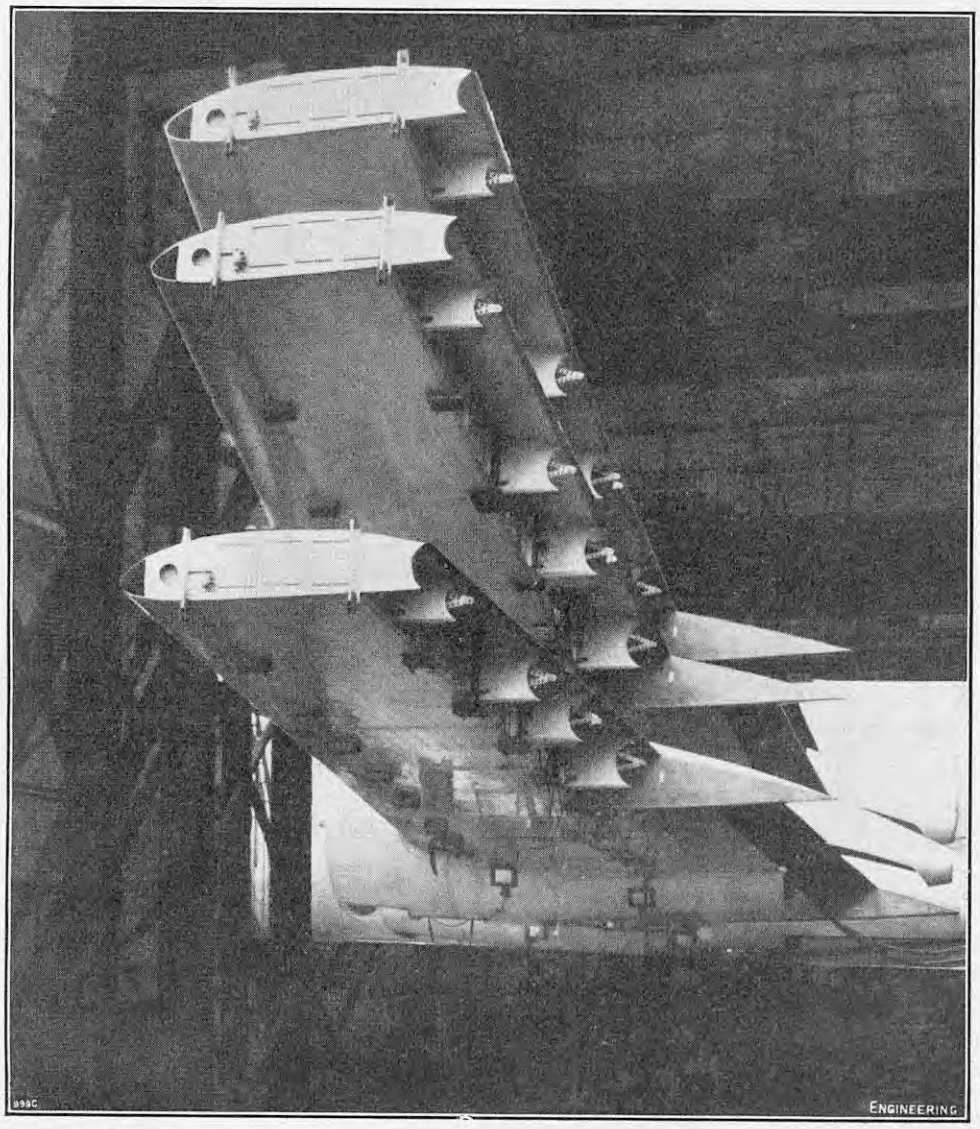


Fig. 3. Three Stages in Deflection of Wing Under Ultimate Gust Loading.

spar, outboard of the outer nacelle in the starboard wing; relatively small modifications are required to bring the wing strength up to 100 per cent. The rest of the damage suffered by the wing was considered to be secondary, and to have been caused by an inherent disadvantage of the "fixed deflection" type of test rig—the way in which the deflected shape of the wing is held by the mechanical straining units.

The progress report records also that some tests of the wing leading-edge hot-air de-icing system have been carried out on a ground test-rig, to determine the flow pattern of cold air through the duct in order to adjust the flow regulators appreciably. The final determination of the gas-flow pattern will be carried out in flight. Undercarriage retraction tests are also in progress, on the "functional mock-up." The test schedule includes an endurance run of 1,000 retraction cycles, to check the operation of hydraulic valves, switches and warning lights, and to determine the wear on rubber rings and seals in the jacks, accumulators and swivel joints. At regular intervals, the emergency lowering systems are operated. At each lowering, the hydraulically-operated brakes are applied to check the hydraulic circuit and mechanism.

POLYVINYL-CHLORIDE SHEET IN RIGID FORM.

Polyvinyl chloride (P.V.C.) has hitherto been known in its flexible plasticised forms, one of the many important uses being the insulation of cable. A more recently-developed rigid, unplasticised form is now available in sheet form in a range of thicknesses and colours, including white. Rigid P.V.C. sheet is characterised by excellent chemical resistance and very high impact strength. Several manufacturers in Great Britain are now using white P.V.C. sheet for interior lighting fittings of various designs. The material has many advantages for this application, including high reflectivity, good mechanical strength and excellent resistance to chemical attack, making it particularly suitable for fittings used in the corrosive atmospheres typical of many heavy industries. Because of its high impact strength, rigid P.V.C. sheet only $\frac{1}{16}$ in. thick has been found suitable for the manufacture of lighting fittings.

Although opaque, and therefore lacking the upward light component which is an important advantage of opal Perspex reflectors, the optical properties of white rigid P.V.C. compare very favourably with those of stove-enamelled and vitreous-enamelled steel. It has a reflection factor of approximately 85 per cent., with little variation between batches. As there is no risk of chipping, with consequent base-metal corrosion, and the material does not deteriorate with age, rigid P.V.C. fittings maintain their optical performance for a long time. Rigid P.V.C. sheet is worked in a similar fashion to Perspex. It can be cut with normal power-driven woodworking tools and machined on standard lathes. Special cements are available for jointing, and the material can be welded. Being thermoplastic, it softens on being raised to a sufficiently high temperature and can then be shaped by pressing or blowing. It retains the imposed shape on cooling. Many of the rigid P.V.C. lighting fittings made so far are similar in design to those made from Perspex, with certain modifications. The thermoplastic nature of the material limits the working temperature of rigid P.V.C. lighting fittings. They must be designed so that no part operates at temperatures higher than 55 deg. C. This means that the most important use of the material in lighting equipment will probably be for fluorescent lamp fittings, where this temperature limitation is not important. Rigid P.V.C. sheet is made by Imperial Chemical Industries, Limited, Plastics Division, Welwyn Garden, Hertfordshire.

The Price of Copper.—The Ministry of Materials state that they have concluded negotiations with their main Commonwealth suppliers on the price of copper from August 1, 1952. The arrangements provide for a fixed price which will remain in force for a minimum period of six weeks and thereafter unless, owing to changed circumstances, any of the parties give notice of desire to re-negotiate. In view of these arrangements, the Ministry are able to reduce their selling price by 2*l.* from 287*l.* to 285*l.* per ton delivered consumers' works. Discounts and premiums remain unchanged.

THE COUNTING STRAIN GAUGE.

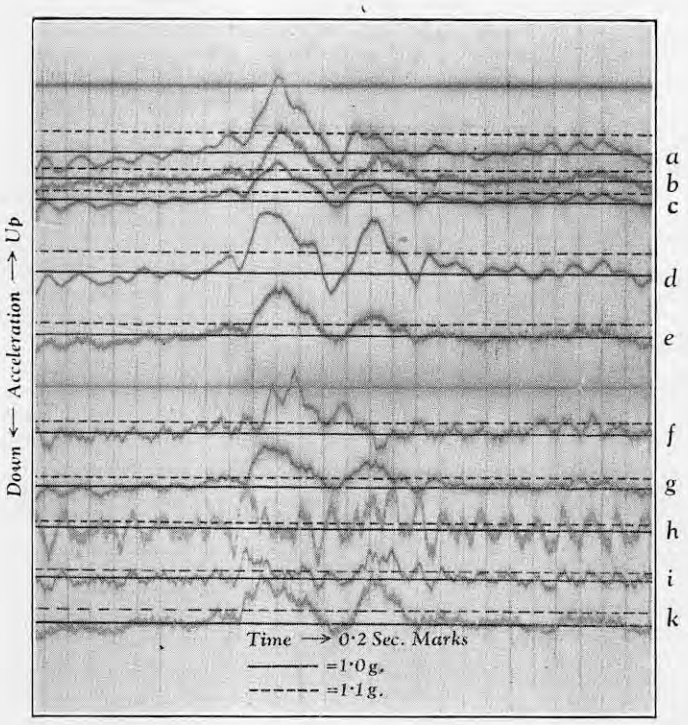
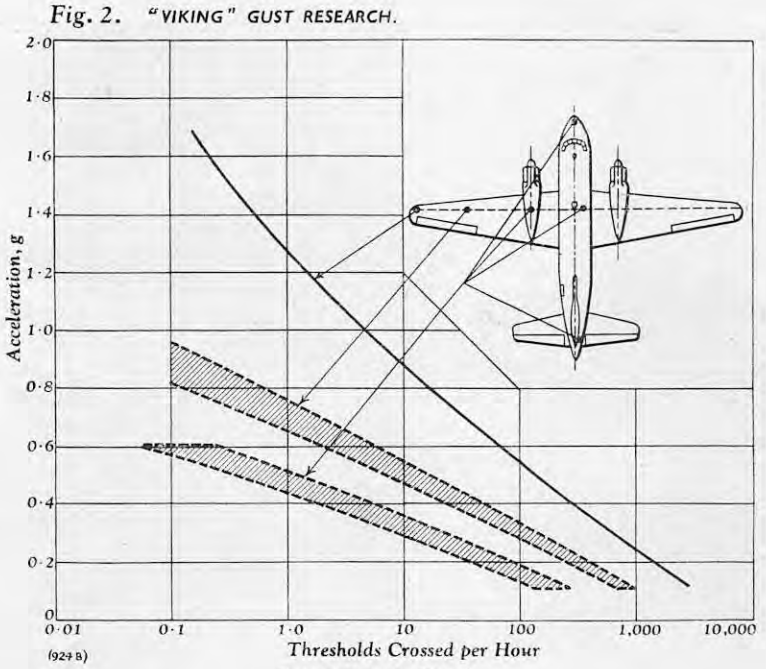


Fig. 1. "Viking" Aircraft Gust Research: Typical Recordings.

Fig. 2. "VIKING" GUST RESEARCH.



References to Fig. 1.

(*a*) Starboard strain gauge.
(*b*) Tail accelerometer.
(*c*) Centre-line strain gauge.
(*d*) Port strain guage.
(*e*) Accelerometer at centre of gravity.
(*f*) Nose accelerometer.
(*g*) Starboard mid-wing accelerometer.
(*h*) Port wing-tip accelerometer.
(*i*) Port mid-wing accelerometer.
(*k*) Nacelle accelerometer.

Fig. 3.

THE COUNTING STRAIN GAUGE.

By J. B. Lambie, M.Eng., A.F.R.Ae.S.

During the last twenty years there have been many occasions when a statistical analysis of the loads experienced by a structure would have been of value in formulating design requirements or investigating fatigue effects. An instrument is now in existence, known as a counting strain gauge, which is capable of yielding much useful information in fatigue and other investigations. Since this instrument was developed, by the Weybridge Division of Messrs. Vickers-Armstrongs Limited, (Aircraft Section), Weybridge, Surrey, during investigations of repeated loading in flight on an aircraft structure, it may be appropriate to discuss the background briefly before describing the instrument. The problem of fatigue in aircraft structures, which has always been present, has become accentuated during the last few years. The advances in performance and utilisation rates, combined with the improvements in structural efficiency and the introduction of the new high-strength light alloys, have given rise to some anxiety when attempting to assess structural life. The fact that the higher ultimate strength of the latest light alloys has not been accompanied by a proportionate increase in fatigue strength is a problem which must be solved by the metallurgist.

The solution of the problem of assessing aircraft structural life can be divided into four distinct parts. Firstly, the fatigue properties of the materials used must be known. This knowledge is available for most existing materials, and reasonably adequate means are available for acquiring it for new ones. Secondly, knowledge of the fatigue properties of complete structures and structural details, such as joints, are required; a fair quantity of data is available on a few types of riveted and bolted joints. The third part of the solution is the collection of information on the magnitude and frequency of the loads which occur during the normal operational life of aircraft. These loads will vary according to the role of the aircraft, since an aeroplane operating from rough grass fields over short distances at low altitudes will experience more continuous turbulences than one operating from smooth concrete runways over long distances at higher altitudes, where turbulence is generally less. Long sea routes could be expected to give less turbulence than routes over tropical or mountainous terrain where convection and katabatic effects can produce violent disturbances. The speed and dynamic characteristics of the aircraft will also have their effect. The fourth part is the problem of interpreting a random series of loads, as measured in flight, in terms of laboratory tests on the materials and structures. The only attempt at such interpretation has been the "cumulative damage" hypothesis, but it has not been found to be true in general, since the application of a large number of small loads or a few large loads is known to increase the endurance under normal fatigue-test loads. The order of the application of the loads may also have some effect. Eventually, it is hoped, the ultimate structural life will be known from the commencement of the design as surely as the ultimate strength is now.

Of the earlier methods of statistical recording only the V-g recorder, i.e., an instrument recording simultaneously the aircraft's velocity and acceleration, has yielded a reasonable quantity of data. From the fatigue aspect, however, it is of little use, since only the maximum accelerations are recorded. Another method which has been attempted is the analysis of an oscillographic record of strains and accelerations. Fig. 1 shows a typical section of recordings, of 25 seconds duration, which were taken at intervals on a Viking flown over European routes. The intervals were varied with the turbulence encountered. Each run had subsequently to be analysed and the results extrapolated to cover the total flying time. This analysis proved to be an extremely laborious task. One hour's flying required 25 hours' analysis time; consequently, only a limited amount of information could be gained in this way. It was clear, therefore that an instrument was required which would automatically analyse the information continuously. As a result, a counting strain gauge, or more exactly, a counting extensometer, was developed.

The choice of strain as the measured quantity was made since it is a strain, or stress, measurement which is of immediate and general value in fatigue work. Fig. 2 shows the results of an analysis of the film records of which Fig. 1 is a part. It can be seen that the acceleration varies for different parts of the aircraft and cannot, in general, be taken as a measure of the structural stresses. For instance, spar stresses at the engine position will not be properly indicated by the acceleration at that point. It might be argued that a measurement based on acceleration would yield sufficiently accurate data: however, there is some lack of correspondence between the accelerations developed at the centre of gravity of the aircraft and the wing spar strains. In Fig. 3 are reproduced parts of a short recording, similar to that of Fig. 1, of the strain on the centre-section spar and the acceleration at the centre of gravity of a Viking aircraft while passing through turbulent air.

In obtaining this record both the accelerometer and the strain gauge were calibrated by subjecting the aircraft to a steady acceleration of about 2*g*, by diving the aircraft and performing a slow steady pull-out. The accelerometer had been calibrated immediately beforehand by removing it from its

THE COUNTING STRAIN GAUGE.

Fig. 4.

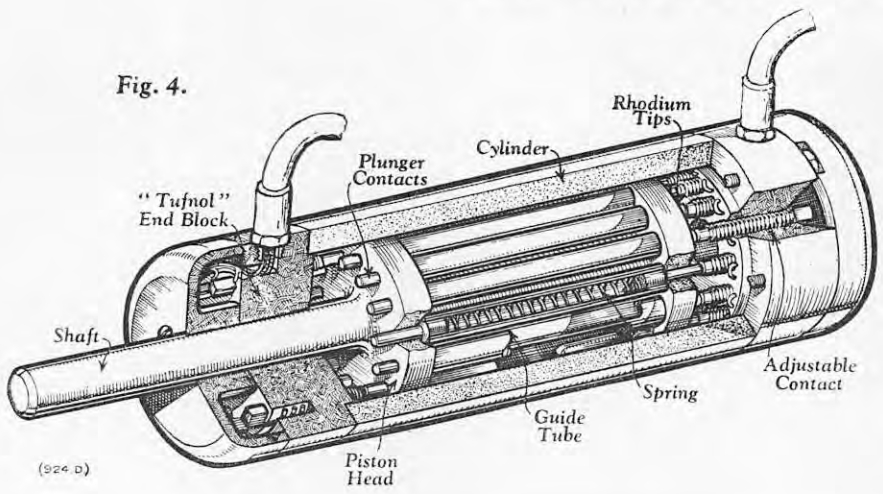


Fig. 5.

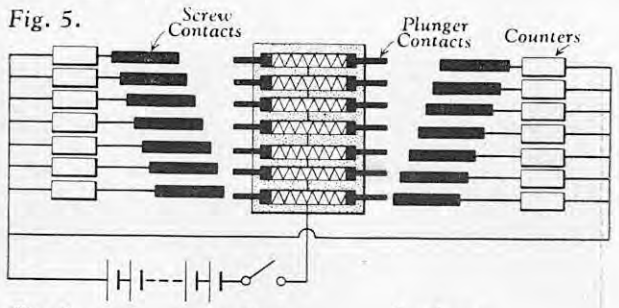
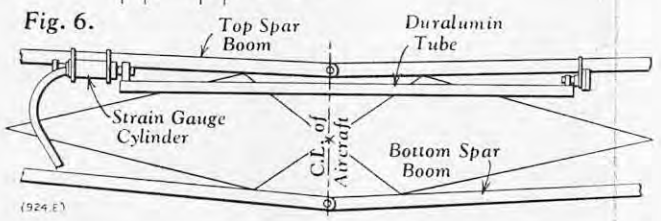


Fig. 6.



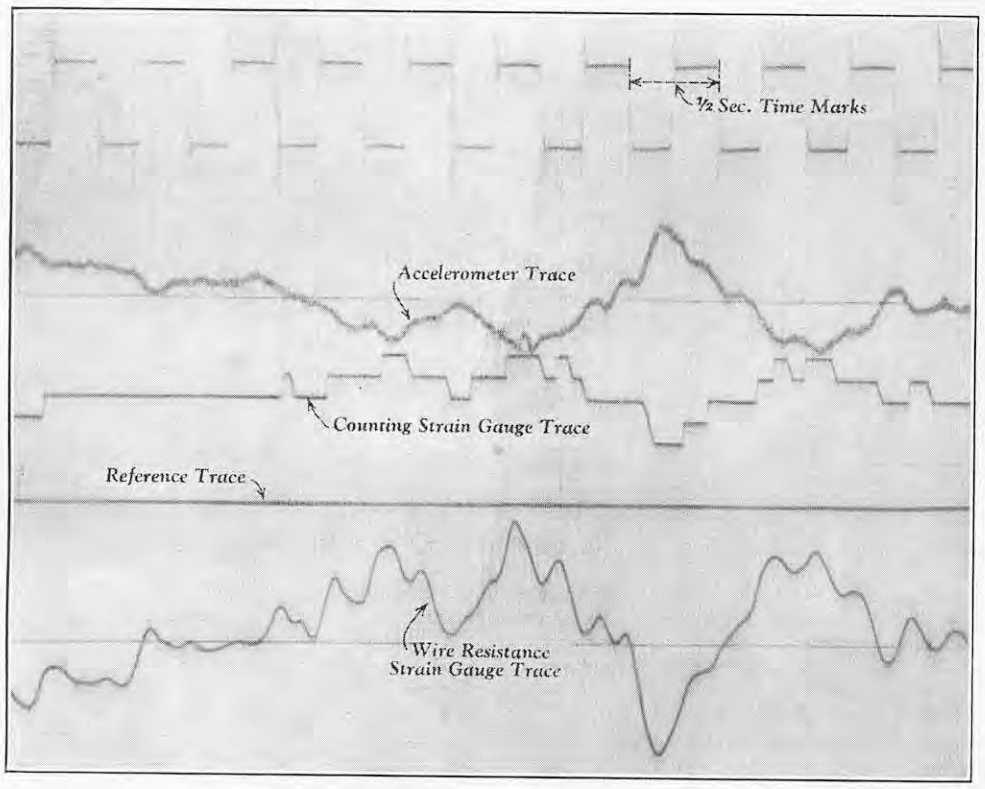
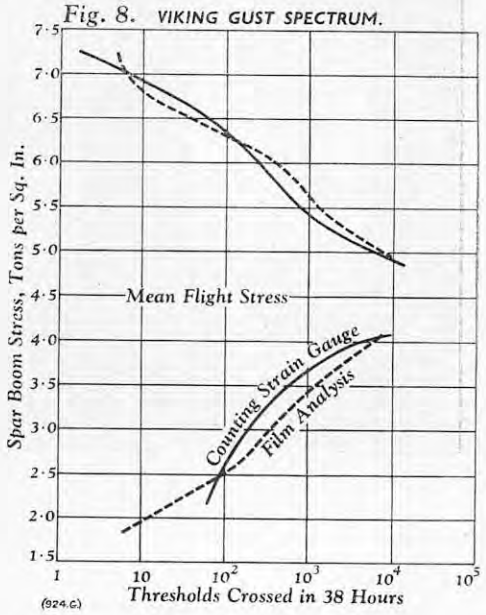


FIG. 7. TYPICAL RECORD.

Fig. 8. VIKING GUST SPECTRUM.



mounting bracket and inverting it, thus applying a $2g$ acceleration. It was thus possible to determine, from the pull-out results, the steady acceleration achieved. From this, the deflection of the strain trace, under effectively static conditions, was obtained, and hence a calibration of the strain gauge in terms of acceleration. Thus, if there were no dynamic effects, the strain would be expected to follow the acceleration exactly, but since, in fact, dynamic effects are present, the result is as shown in Fig. 2. The difference is due to the excitation of the wing fundamental mode of vibration at about 4 cycles per second. Another point to be noted is the smoothness of the strain trace compared with the acceleration trace. The high frequency showing in the latter is due to engine vibrations and is, in fact, much larger than it appears in the illustration. It has beer reduced by the use of a filter. These records show the desirability of measuring strain as a basis for the accurate prediction of the safe life of aircraft structures. A further reason for choosing strain is that it can be associated with a considerable force which is available to drive the recording device. The difficulties of having to reject any unwanted part of the measured quantity, as in acceleration measurements, are absent.

The construction of the instrument is shown in Fig. 4. It consists of a dumbbell-shaped piston which slides in a cylinder. This piston carries a number of pairs of spring-loaded plunger contacts which are rhodium-tipped. End blocks of insulating material are attached to each end of the cylinder and are fitted with a number of adjustable screw contacts corresponding with the plunger contacts in the piston. Each adjustable contact is connected to an electromagnetic counter, as shown diagrammatically in Fig. 5. A typical installation of the instrument is shown in Fig. 6, which represents the structure of the Viking centre-section spar, where the strain of the top boom of the centre section spar is the quantity being measured. The cylinder is firmly attached to the boom on the one side and the piston is attached to the other side through a light Duralumin tube. Thus an increase of lift on the aircraft causes the piston to move further into the cylinder.

In Fig. 5 the piston is shown in such a position that no contacts are made. This corresponds to normal steady flight. An increase of lift causes contacts on the left-hand side to be made, the number depending on the magnitude of the strain. The counters are cocked when the contact is made, and register a count when the contact is broken. The number recorded by a counter is then the number of times the strain has crossed and recrossed that particular strain value. The screw contacts can be readily adjusted to detect any desired value of strain. The screws are of brass, and are a tight fit in the end blocks to provide automatic locking. The instrument in its present form is 2·15 in. in outside diameter and 6 in. long. It could be made considerably smaller, but this would require the technique of an instrument workshop. It should be pointed out that the mechanisms have all been made in the normal production shops of an aircraft factory.

In order to investigate the operation of the instrument in flight, a tapping was made in the battery supply to the counting strain gauge and a signal was fed into the recorder. The result is seen in Fig. 7, marked "counting strain-gauge trace." Each step on this trace indicates a count on the appropriate counter. This record shows how the strain is analysed and recorded by the instrument.

As an example of the type of results to be expected, two sets of curves are reproduced in Fig. 8, indicating the number of times a particular spar stress has been exceeded. One of each set has been obtained by the laborious method of film analysis, and the other by the counting strain gauge. Although they are taken from different flights, the results have a certain similarity.

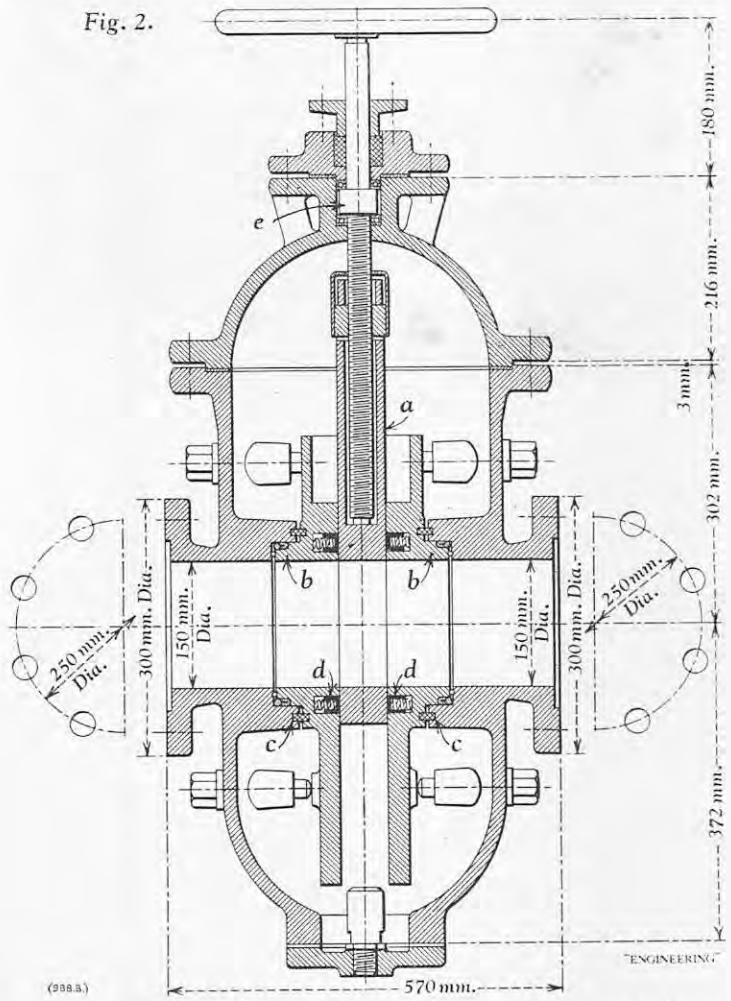
Up to the present this instrument has only been used on the centre-section spar of an aircraft, but it has many other applications. Tail loads could be investigated for the resultant effects of variation of trim, and atmospheric gusts and buffeting. Statistical information on undercarriage reactions are also required. The instrument could yield useful information in other engineering fields, such as stresses in ships' hulls, railway-bridge loads, stresses in motor vehicles, wind loads on buildings, and crane loads. The instrument is capable of being adapted or included in apparatus for a variety of measurements involving deflection where the result is required in the form of a statistical analysis.

SLUICE VALVES FOR GAS MAINS.

ZIMMERMANN AND JANSEN, G.M.B.H., BOCHUM, GERMANY.

Fig. 1.

Fig. 2.



Another version of the instrument is being developed to record strain range, an important factor in fatigue.

The results which will be obtained by the counting strain gauge on aircraft in service will eventually have to be interpreted in terms of fatigue life. Tests will have to be made on specimens to investigate the effect of a series of different loads, and whether the order in which they are applied has any influence. Eventually this work must reduce to equating a random series of various loads to the effect of the continual application of one load. If ever a fatigue-testing machine is made to apply a random series of loads to a specimen, the counting strain gauge could be used as the indicator. It is essential that some such machine should be developed, since only in this way can the ultimate effect of the loads measured be properly assessed.

Referring to the four parts into which the solution of the fatigue problem can be divided, it can be seen that, in each case, the means are now available for work to proceed. It would, however, be highly uneconomical to provide more than one wing, say, for fatigue test. At present this means that a standard set of loads, derived from the statistical investigation of flight loads, is applied to the wing, and if it passes this test it is considered acceptable for a given life. However, there is another approach which could be applied now. In the case of an aircraft which is about to go into service, if a wing is available for test, it would be feasible to fit five of the operational aircraft with strain counters and to set the wing up in a test rig which is capable of rapidly applying any desired load likely to be encountered in service. The loads measured in flight by the five strain counters could then be applied to the test wing as they become available from the actual aircraft. It would be quite possible to arrange for the test wing to accumulate "flying hours" at least three times as fast as the operational aircraft. In this way the aircraft in service would always have a good safety margin, and, if the test wing showed signs of failure, modification could be put in hand with the full knowledge that it was necessary.

It has been suggested recently that aircraft constructors must become accustomed to the idea that their structures wear out in much the same way as do engines. The engine manufacturers, however, test their engines on test-beds under operational conditions to find out exactly when they do wear out. The suggestion, as outlined above, that particular structures should be tested under the actual measured loads, which would include all the effects of role, performance and dynamic characteristics of the aircraft, is not only possible, but, in the opinion of the author, essential.

New Reservoirs and Water Towers for Glasgow.—With the construction of new housing schemes on the higher ground surrounding the city, Glasgow Corporation Water Department find it necessary to provide pumped water supplies to high-level reservoirs, as most of the new developments are above the levels which can be reached by the gravitational system. At their meeting on June 26, the Corporation authorised the appointment of Messrs. F. A. Macdonald and Partners, Glasgow, as consulting engineers for a further two reinforced-concrete reservoirs, each of one million gallons capacity, at Castlemilk housing estate, and also a water tower, to hold 400,000 gallons, at Drumchapel housing estate. The Castlemilk reservoirs will be constructed with top water levels of 420 ft. and 565 ft., respectively, above sea level, and will be supplied from a pumping station, at present under construction, which will be fed by water from the gravitational mains. The installed horse-power of the pumping station will be 1,210 h.p. The total number of houses to be supplied in the Castlemilk area is approximately 7,600. The water tower at Drumchapel, which will have a top water level some 300 ft. above sea level, will be about 70 ft. in height and will supply approximately 1,720 of the 7,600 houses in the area. The Drumchapel pumping station, of about 60 h.p., will draw its supply from gravitational mains via the new 36-in. West Main, at present under construction, and will be in operation between the Milngavie service reservoirs and Drumchapel by the summer of 1953.

VALVES FOR GAS MAINS.

The sluice valves shown in Figs. 1 and 2, above, are for use in crude gas mains, where much dust may be present in the gas, and are made by Zimmermann and Jansen, G.m.b.H., of Bochum, Germany, whose British agents are D.M.M. (Machinery), Ltd., 119, Victoria-street, London, S.W.1. The design is such that, whether the valve is open or shut, no dust can penetrate into the housing. The slide of the valve is a casting *a*, having a circular hole in its lower part, corresponding to the designated bore of the valve. The slide is raised or lowered by the screwed spindle, which is accommodated in a cylindrical hole in the upper part of the casting. The slide works between the faces of two joint-plates *b*, one of which is attached rigidly to the housing while the other is held in close contact with the slide by spring plungers, equally spaced to maintain a uniform pressure. This is the design employed for one-way gas flow; if the flow is reversible, spring plungers are fitted on both sides, as in Fig. 2. Adjusting screws enable the pressure to be regulated as required; this can be done from outside the housing. The joint plates *b* are provided with centring rings, fitting into corresponding recesses in the valve body, so that the plates can move slightly in an axial direction while remaining concentric with the valve bore. Flexible sealing rings *c* are fitted between the valve body and the joint plates. A gastight seal is maintained by spring-loaded steel scraper rings *d*, which, as the slide is operated, scrape off any dust adhering to it.

In the valves shown, the operating spindle is enclosed in the upper part of the housing and is held by a thrust collar *e* between two grease-lubricated ball-bearings; but the valves are made also with external spindles and, in both types, may be designed for operation either by hand or by electric motor, compressed air, or hydraulic power, with remote control if desired. At the bottom of its travel, the slide rests on a central stud attached to the hand-hole cover plate.

AIR-CONDITIONING PLANT FOR DEPARTMENTAL STORE.

Fig. 1. Inlet Side of Air Filters.

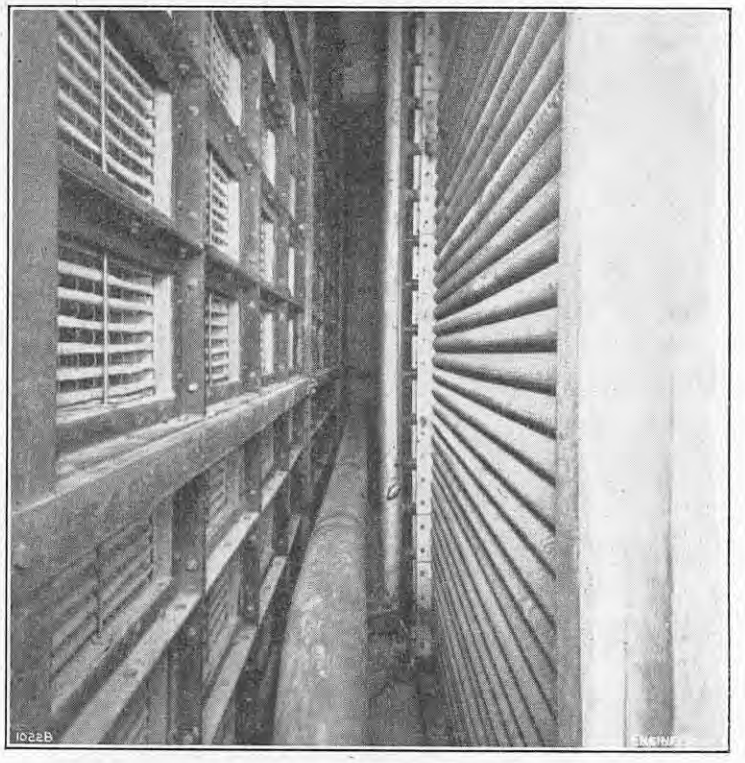


Fig. 2. Outlet Side of Air Filters.

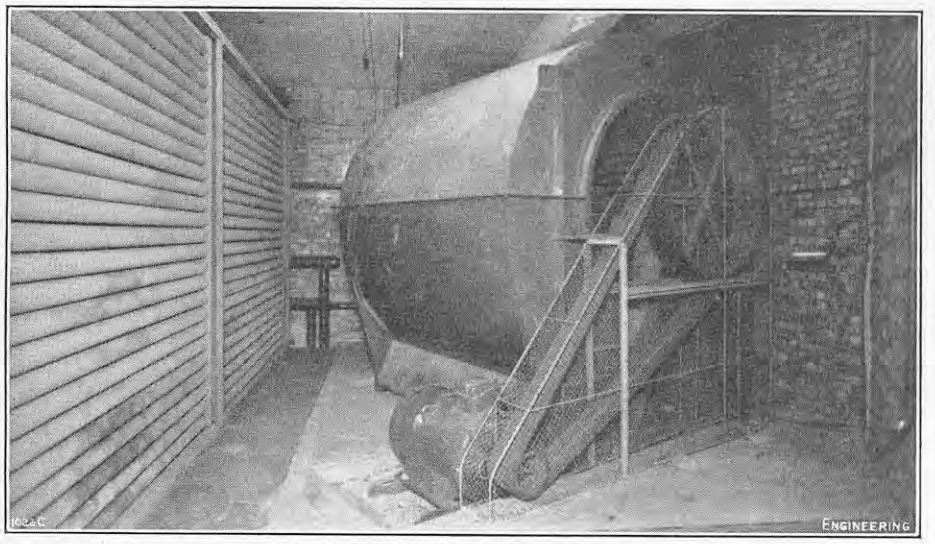


Fig. 3. Main Delivery Fan.

AIR-CONDITIONING PLANT FOR A DEPARTMENTAL STORE.

Increasing use is being made of air-conditioning systems in departmental stores, since, in addition to providing a better atmosphere for the customers and workpeople, the conditioned air is beneficial for the merchandise and furnishings. Several stores are equipped in this way, including one built at Southampton by Messrs. Bovis, Limited, Stanhope Gate, London, W.1, for Messrs. E. Mayes and Son, Limited, and provided with air-conditioning plant by the Andrew Machine Construction Company, Limited, Woodbank Works, Stockport.

The conditioned air is circulated through the building by a Dynaflow fan of the double-inlet type, driven by V-belts from a 38-h.p. motor and capable of delivering up to 80,000 cub. ft. of air per minute. The fan, which is illustrated in Fig. 3 above, is installed on isolated foundations and delivers the air into ducts incorporated in the main fabric of the building. These lead the air to the three floors to be air-conditioned, subsidiary sheet-metal ducts arranged at ceiling height subsequently delivering it to the various departments. To prevent undue air pressures within the building, a Dynaflow extraction fan of the single-inlet type is arranged at roof level and is connected through suitable ducting to the first and second floors. This fan is capable of extracting 54,000 cub. ft. of air per minute and connections are provided at the outlet which enable the air to be recirculated when conditions permit, thus saving the heating, or cooling, load. A separate extraction fan is also provided for the basement. This, like the main extraction fan, is arranged at roof level and is capable of extracting 9,000 cub. ft. of air per minute.

Two further extraction plants are incorporated in the system, one of which serves the beauty parlour and is designed to balance the input of conditioned air to this section of the building and prevent the spread of odours to the main part of the floor. The other extraction plant is used to maintain good conditions in the two kitchens on the third floor, one of which serves the main restaurant and the other the staff canteen. This plant consists of two Dynaflow fans each capable of extracting 24,000 cub. ft. of air per minute. Each fan is connected to a system of sheet-metal ducts on the roof of the kitchens.

All air entering the building passes through a bank of filters; these were supplied by Messrs. Vokes, Limited, Guildford, Surrey, the complete installation being built up from a number of their K600 Kompak-type filters. They are illustrated in Figs. 1 and 2, on this page, Fig. 1 showing the inlet side and Fig. 2 the outlet side. After being filtered, the air passes through a cooling battery; this operates on the direct-expansion principle and forms part of the refrigeration plant supplied by Messrs. J. and E. Hall, Limited, Dartford. The plant is designed to extract 1,800,000 B.Th.U. per hour when cooling a mixture of fresh and recirculated air to 60 deg. F. (dry bulb) and consists of two compressors capable of performing one-third and two-thirds of the total duty respectively. The machines work in conjunction with a common shell-and-tube condenser provided with cooling water from a forced-draught cooler situated on the roof. An interesting feature of the plant is the system used for controlling the air temperature, coarse adjustment being provided by the number, and size, of compressors in operation and fine adjustment by regulation of the evaporation temperature within the cooler. The number of compressors at work is regulated by the temperature in the building, which, on rising to a predetermined value, automatically starts the plant. At first, however, only the smaller compressor is brought into operation, the fine-control mechanism regulating the cooling effect. When the air temperature rises to such a value that the smaller machine is no longer able to accomplish the duty, it is automatically cut out and the larger machine brought into operation. Should the temperature rise still further, then the smaller compressor again comes into operation.

To cater for the periods when the air entering the store has to be warmed, a heating battery is installed. This is of the gilled-tube type and operates on hot water, being capable of an output of 2,400,000 B.Th.U. per hour. To give even conditions in the basement, a secondary heating battery is provided. This is installed in the duct leading to the basement and is controlled by a thermostat which operates in conjunction with a diaphragm valve fitted in the hot-water supply line to the heater. The control equipment for both the cooling and heating sections of the plant is of the pneumatically-operated type and was supplied by Messrs. Negretti and Zambra, Limited, 122, Regent-street, London, W.1. The heating and cooling systems are selected manually, but thereafter the automatic controls function.

HIGH-VOLTAGE LABORATORY AT LOUGHBOROUGH.

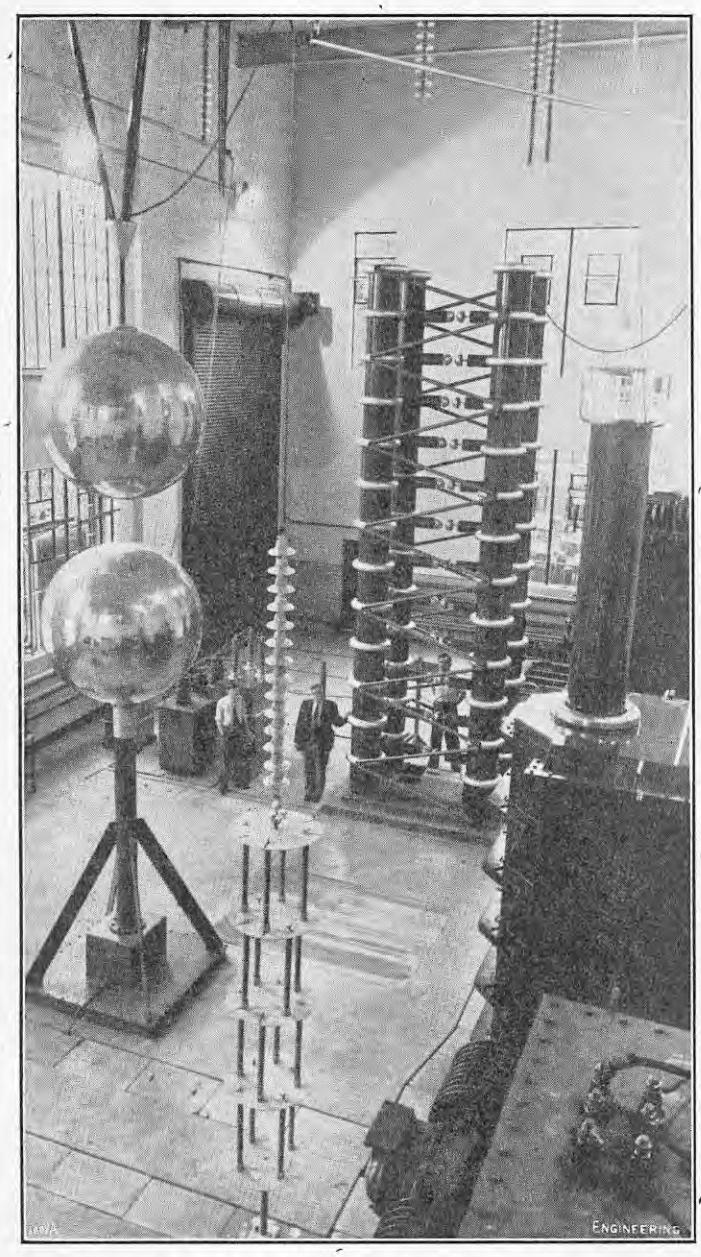


Fig. 1. General View of Laboratory.

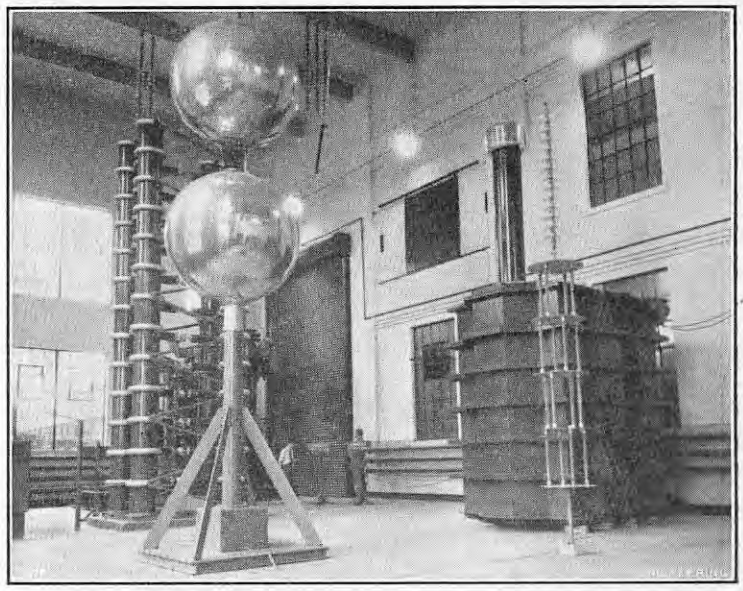


Fig. 2. 1,500-KV Impulse Generator and Sphere Gap.

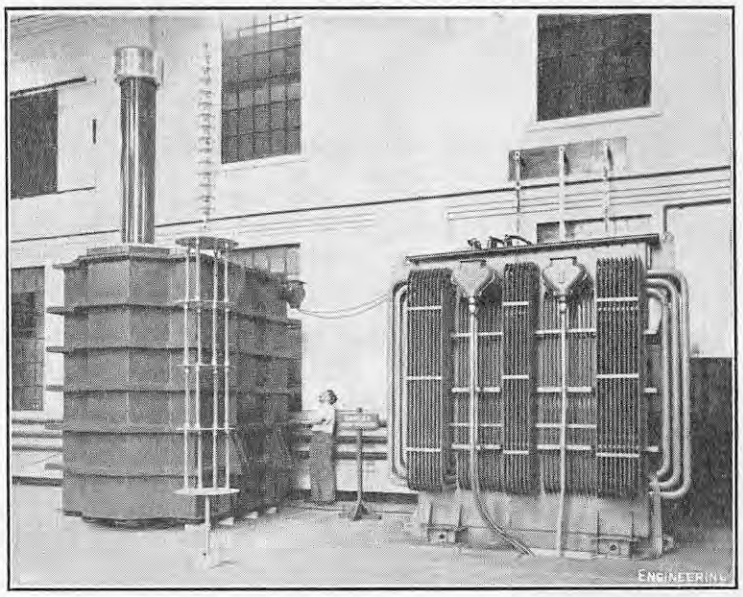


Fig. 3. 600-KV Flash-Testing Transformer.

HIGH-VOLTAGE LABORATORY OF THE BRUSH ELECTRICAL ENGINEERING COMPANY.

The objects of the high-voltage laboratory which was formally opened by Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research, at the Loughborough works of the Brush Electrical Engineering Company, on Tuesday, July 29, are to carry out tests on completed transformers and to enable investigations to be made into the properties of insulating materials. So far, the capacity of the transformers built by the company has not exceeded 30 MVA at 132 kV, and these have been tested by the National Physical Laboratory at the 640/750-kV impulse level. The expansion of the demand for their products and the increasing voltages used in electric power transmission have, however, caused the company to instal equipment which will enable 275-kV, and eventually higher voltage, transformers to be tested.

A general view of the new laboratory, which is housed in an extension of an existing building, and is 80 ft. long by 40 ft. wide by 40 ft. high, is given in Fig. 1. At one end there is a rail track running the full width of the building, so that large transformers can be brought in. At each end of this track is a roller shutter door one of them, shown in Fig. 2, gives access to the production bay, and the other opens on to an off-loading area outside the building. At the other end of the building is a two-storey administrative block, on the first floor of which is a 50-cycle control room, an impulse-generator control room, and a records room. On the floor above are an office, conference room and dark room, as well as an observation gallery extending the full width of the laboratory.

The equipment comprises a 1,500-kV impulse generator with a 150-cm. sphere gap, which can also be seen in Fig. 2. This generator has twelve stages, each comprising two 0·12 microfarad condensers connected in parallel, so as to give an output capacitance of 0·02 microfarads. The charging voltage is 125 kV per stage, and is obtained from a Cockcroft-Walton double circuit. The stored energy at peak voltage is 22·5 kilowatt-seconds. The circuit is arranged so that the stages can be connected in various series-parallel groupings, while the main tripping gaps are mechanically coupled and are driven through eccentric cams and gearing by a remotely-controlled motor. The gap setting is also remotely indicated on the main control board. The auxiliary tripping circuit is of the Miller needle gap type and has an overall delay range of 0·5 to 25 microseconds. The capacitors were supplied by the Telegraph Construction and Maintenance Company, Limited, 22, Old Broad-street, London, E.C.2.

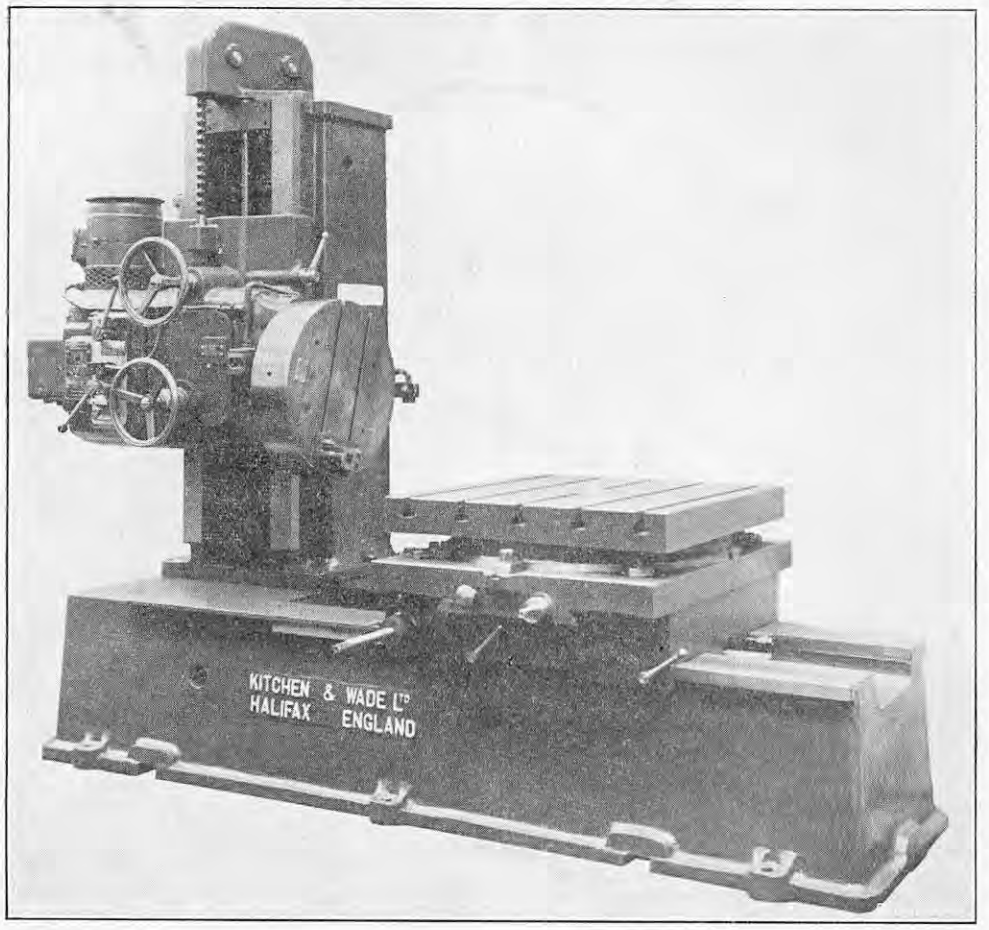
The voltage is recorded by a matched resistance capacitance voltage divider, the low-voltage arm of which is connected to the main control board. The voltage is measured by the sphere gap visible in Fig. 2, the spheres for which were supplied by the London Aluminium Company, Limited, Birmingham. The insulated sphere forming this gap is fixed and is suspended from the roof girders by three insulated rods, which terminate in a stress cone. The earthed sphere is movable and is driven through gearing by a motor through a range up that is about 90 cm. The gap setting is remotely indicated on two indicators on the control board, with ranges of 0 to 120 cm. and 0 to 10 cm., respectively.

High voltages at power frequency can be obtained from the 2,000-kVA 3·3/500-kV oil-immersed double-wound transformer, which can be seen on the left of Fig. 3. The 3·3-kV winding of this unit is supplied from a 2,000-kV alternator outside the building, while the high-voltage winding is arranged in cascade, so that a test voltage up to 1,000 kV can be obtained in future. The high-voltage bushing on this transformer was supplied by Micanite and Insulators Company, Limited, Walthamstow. On the right of Fig. 3 is a 5,500-kVA 100-kV multi-ratio test supply transformer, which also forms part of the equipment of the laboratory.

All the apparatus is connected by a 'bus-bar system consisting of aluminium tubes with an external diameter of 1¼ in These tubes are suspended from the strings of glass insulators, visible in Fig. 1, which can be raised or lowered by small hand winches to facilitate inter-connection. The main operating panel is installed in the impulse

PIPE-FLANGE FACING MACHINE.

KITCHEN AND WADE, LIMITED, HALIFAX.



generator control room, mentioned above, and carries all the indicating circuits, master "make-dead" and "make-alive" switches, a switch controlling the polarity change-over switch, the voltage regulating circuit for the transformer supplying the impulse generator and the control switches for raising and lowering the sphere gap. The length of the gap is also indicated. The recording equipment includes four high-speed oscillographs, each of which comprises a 10-kV cathode-ray tube and a camera with f 1·5 lens for recording on a 35-mm. film with seven speeds from 0·5 to 250 microseconds. Each of these recorders is mounted in a portable rack, so that it can be used in any part of the laboratory. Each separate circuit group is also mounted on an individual chassis, which is fitted into its rack on runners and is interconnected at the back by plugs, so that it can be withdrawn for servicing. The "make-dead" and "make-alive" buttons are duplicated on each section of the control panel and there is also a "make-dead" switch on the observation gallery, thus ensuring safety in operation. For the same reason, all the main doors of the laboratory are electrically interlocked so that when they are opened the impulse generator is switched out and earthed.

The entire installation was designed by the members of the transformer department of the Brush Electrical Engineering Company after discussion with the staffs of the National Physical Laboratory, the British Electrical and Allied Industries Research Association, and Queen Mary College. Industrial equipments in this country and abroad were also visited.

Incorporated Plant Engineers.—A new branch of the Incorporated Plant Engineers is being formed at Blackburn. The inaugural meeting will be held on Thursday, September 4, at the Golden Lion Hotel, Church-street, Blackburn, commencing at 7.45 p.m. The honorary secretary of the organising committee for the new branch is Mr. A. C. Smith, 271, Burnley-road, Accrington, Lancashire.

PIPE-FLANGE FACING MACHINE.

By designing a machine specially for facing cast-iron and steel pipe flanges, Messrs. Kitchen and Wade, Limited, Arundel-street, Halifax, have been able to eliminate some of the features of the horizontal drilling, boring and facing machines that are normally used for this work, and have thereby produced a machine tool which is comparatively simple and therefore less in first cost and maintenance cost. Pipe-flange facing work can be done on this machine, which is illustrated above, by unskilled operators, yet high output is achieved by the use of tungsten-carbide tools. Flanges up to 30 in. in diameter can be machined and the work-table can be indexed at four 90-deg. positions. The machine is available with either of two sets of facing-head speeds, namely, 30 and 50 r.p.m., or 15 and 25 r.p.m., and the facing-slide feeds are $\frac{1}{32}$ in. and $\frac{1}{24}$ in. per revolution. The work-table is 3 ft. square, and a power feed, in the direction towards the table, can be provided if required, with a rate of feed of either 0·5 in. or 0·8 in. per minute. The facing slide has a 9-in. length of feed; the maximum vertical distance between the table and the centre of the facing head is 2 ft.; and the horizontal distance between the face of the tool-holder and the edge of the table is 2 ft. 6 in. maximum and 7 in. minimum. The cross traverse of the work-table is 24 in.

The bed is of box section, ribbed and provided with sloping exit chutes for the swarf. The slide-ways for the compound table are completely covered between the facing head and the table at all positions of the latter. The table is adjusted by quick-pitch screws in the longitudinal and transverse directions, the handles for both being arranged at the front of the table for convenience. A jacking device enables the joint between the table and the top slide to be broken, when the table can be rotated freely on ball bearings for indexing. The column of the machine is bolted and dowelled to the bed; it incorporates slide-ways for the head, the balance weight for which hangs inside it. The head is a box casting enclosing all running mechanism and supporting a 5-h.p. motor. A hand-wheel is used for vertical traverse and the head is locked by means of a lever.

The facing slide, of Meehanite cast iron, is actuated by an enclosed screw. It has a taper gib for taking up wear, and two T-slots which allow alternative positions for the tool-holder for facing large or small pipes or for facing inwards or outwards from the centre of the facing head. The tool-holder takes $1\frac{1}{4}$-in. square-shank tools. The facing head, which carries the slide, is 24 in. in diameter, and its long spindle runs in a phosphor-bronze bearing at the working end and a ball-bearing at the rear. The driving gears are of hardened nickel-chromium steel, and they and the bearings and feed gears are lubricated by means of a built-in oil pump. The machine occupies a floor space 11 ft. 1 in. by 6 ft. 3 in., and its net weight is 6 tons.

HYDRO-ELECTRIC DEVELOPMENTS IN SCOTLAND.

The extensive development of the water-power resources of Scotland, which is being undertaken by the North of Scotland Hydro-Electric Board, includes both large and small schemes, the latter providing a much-needed source of power in the more sparsely inhabited districts of the country. Among these smaller schemes, mention may be made of the Storr Lochs project, which involves the use of the waters of Loch Fada and Loch Leathan in the north-east of the Island of Skye. The level of the latter lake has been raised to that of the former by the construction of a gravity dam, 179 ft. long and 36 ft. high, and the water is taken thence through a pipe-line, 2,800 ft. long, to a power station on the seashore near the mouth of the Bearreraig River, thus utilising a catchment of 5·2 sq. miles in which the average annual rainfall is 75 in. The power station, a view of which is given in Fig. 1, on page 176, is equipped with three 800-kW Francis turbines, which operate under a gross head of 147 ft. It is manually controlled, but operates with fully-automatic protection. An interesting point is that it is worked in parallel with the 1,000-kW Lochalsh station on the mainland. The distance between the two stations is 52 miles and they are connected by submarine cable and a 22-kV overhead line. The estimated annual output of the station, which went into service at the end of May, is $5\frac{1}{2}$ million kWh.

Fig. 2, on page 176, shows the regulating weir across the River Kerry at the outlet of Loch Bad-an-Sgalaigh. This forms part of the Gairloch scheme, which has been constructed to supply electricity to the Gairloch-Aultbea coastal district of Wester Ross and thus to utilise the water in a catchment area of 13 sq. miles with an annual rainfall of 76 in. From the regulating weir a pipe-line has been laid in the bed of the river to facilitate the flow of water to an intake weir about three quarters of a mile farther down stream. The water is then led into a 48-in. diameter pipeline, 4,600 ft. long, to a power station near the Gairloch-Achnasheen road. This power station contains one 400-kW Francis turbine, which operates under a gross head of 400 ft., and it is estimated that the annual output will be 3 million kWh. After passing through the turbines, the water is returned to the River Kerry.

Noise at London Airport.—On July 31, the Minister of Civil Aviation received a deputation of residents from Harmondsworth, Cranford, Heston, and South Harlington, led by Mr. Reader Harris, M.P., to discuss methods for alleviating noise at London Airport. Mr. R. Maudling, M.P., Parliamentary Secretary to the Ministry of Civil Aviation, after hearing the views of the deputation, said that it was hoped that the erection of the first acoustic wall at London Airport would commence shortly. As regards noise in the air, there was little likelihood of a satisfactory silencer being developed in the near future. Mr. Maudling explained that he fully appreciated the problem that had arisen in connection with the development of the airport, and although London had to be developed as the main airport in the United Kingdom, every practicable effort would be made to reduce the inconvenience.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Demand for Steel.—Local steelworks resumed work this week, heartened by bright prospects so far as home demand is concerned. With the shipyards assured of about four years' capacity production, power-plant firms occupied with contracts for the next ten years or even longer, and other steel users supplied by the Scottish works certain of steady employment, the requirements for all kinds of steel will be heavy. Only in the lighter branches of the steel-consuming industry are there less hopeful signs.

Television in Scotland.—Nearly 21,000 television licences were current in Scotland on June 30, according to Mr. L. D. Gammans, Assistant Postmaster-General, speaking in the House of Commons on July 30. The British Broadcasting Corporation had informed him, he added, that even with a high-power transmitter it would not be possible to guarantee reliable reception of television programmes throughout Scotland. A high-power transmitter, however, would give better service than at present, and the Corporation expected to fix a date shortly for bringing this into operation.

Radio Research in Australia.—Sir Edward Appleton, Principal and Vice-Chancellor of Edinburgh University, said on his arrival at Fremantle, Western Australia on July 30, that the decision of the International Scientific Radio Union to meet in Sydney and Canberra next month was a tribute to the brilliant work Australian radio scientists had carried out in recent years. It will be the first time that the union has met outside Europe or America. Australia, he added, had become one of the world's outstanding research centres for scientific radio work and radio astronomy. Sir Edward will represent Edinburgh University at the centenary celebrations of Sydney University.

Rapid Cargo Discharges at Glasgow.—A cargo of 8,000 tons of iron ore was discharged at Glasgow last week at an average rate of 62 tons per gang per hour, and 3,000 tons of steel tubes were loaded at an average of 20 tons per gang per hour, which is regarded as a remarkable achievement for such material. West Canadian timber was recently discharged at an average rate of 28 tons per gang per hour. A port official, quoting these examples, said that these results were an answer to the publicity given to complaints regarding the slow turn-round of shipping.

Newmains Foundry.—On July 30, Mr. Duncan Sandys, Minister of Supply, was urged by a deputation of Lanarkshire M.P.'s and employees' representatives to intervene with the Coltness Iron Company over the threatened closing of their foundry in Newmains, and, if necessary, to take over the undertaking. In reply, the Minister said that, though his powers were limited, he was prepared to investigate the position and to consider the possibility of helping with materials and orders. He pointed out, however, that he had no power to compel any private company to continue operations which, in their view, might be unprofitable.

Forth Purification Campaign.—A Forth River Purification Board consisting of 20 members, of whom 13 would be appointed by interested town and county councils, the remaining seven to be appointed by the Secretary of State for Scotland to represent industry, agriculture, fisheries and other interested parties, has been proposed as a result of the initiation by the Department of Health for Scotland of a river-purification campaign for Central Scotland.

Oil Deposits on Lerwick Foreshore.—Masses of oily yellow sludge have been driven along half a mile of the Lerwick foreshore by northerly winds this week. It lay inches deep on the esplanade and stuck to fishing-boat hulls and mooring hawsers. A salvage vessel has been collecting the sludge and discharging it out at sea. The harbour trustees are endeavouring to trace the parties responsible for the nuisance.

CLEVELAND AND THE NORTHERN COUNTIES.

The Need for Skilled Tradesmen.—Presenting prizes to apprentices employed by his firm, Sir Claude D. Gibb, chairman and managing director of C. A. Parsons & Co., Ltd., Newcastle-on-Tyne, said that the shortage of skilled men was now more serious than the shortage of materials. He stated that his firm had the biggest order book in their history and could employ another 300 fitters, turners, welders, moulders and pattern makers. Sir Claude presented the "Highest Merit Apprentice" Cup to John Russell, the senior apprentices' vocational prize to J. W. E. Carlson, and the junior vocational prize to L. H. Teasdale.

Centenary of Hawthorn, Leslie & Co.—A brochure entitled "Our Ships at Work" has been published by R. and W. Hawthorn Leslie & Co., Ltd., Hebburn-on-Tyne, to mark the firm's centenary. The brochure traces the type of ships built by the firm since it was founded in 1952 by Mr. Andrew Leslie. Since the war, the firm have completed, or have orders in hand, for ships or machinery for 48 British and foreign shipping concerns. Noteworthy vessels built in recent years have included the tanker Auris, now fitted with a gas-turbine engine, the tanker Auricula, designed to use heavy boiler fuel in her Diesel engines, and the aircraft carrier Triumph.

The Outlook in Shipbuilding.—Mr. F. C. Pyman, managing director of William Gray & Co., Ltd., the West Hartlepool shipbuilders, writing in that firm's *Joint Production Committee Journal*, states that a cargo ship which could command a freight of 180*s*.per deadweight ton a year ago is now getting only 100*s*. Shipowners were finding it difficult to obtain remunerative charters, and there was more tonnage offering for employment than there were cargoes to carry. The demand for tankers continued strong and experts did not expect a recession for some years. Mr. Pyman added that it was fortunate that plenty of work was in hand, but that purchasers were already showing apprehension and would react violently to any increase in the bill which they would finally have to face.

Sale of the M.V. "African Queen."—The African Queen, a fish factory ship owned by the Colonial Development Corporation, which has been lying in the Tyne at North Shields since 1951, has been sold to Alpha West (England), Ltd. The purchase price is reported to be 80,000*l*. The African Queen was equipped for catching and processing shark, tunny and crawfish off West Africa, but after six months' trial it was found that the venture was not profitable.

Labour Adjustments at Billingham-on-Tees.—Further adjustments in labour have been necessary at the Billingham-on-Tees works of Imperial Chemical Industries, Ltd., as a result of a reduction in demand. The production of sulphate of ammonia has fallen by 25 per cent. There has been a decline also in the demand for organic compounds, such as acetone, in the plastic and paint industries. The restrictions rendered necessary, however, involve only a small portion of the total outputs at Billingham Works.

Projected Oil Plant at Tweedmouth.—Scottish Oils and Shell-Mex, Ltd., have decided not to proceed with their plan for installing oil tanks and other plant at Tweedmouth, Northumberland. It is understood that the firm have found that the site is not large enough.

Water Supply in the Tees Valley.—At the annual inspection of the Tees Valley Water Board's undertakings this week, Mr. T. W. Allison, chairman of the Board, intimated that another 32,000,000 gallons a week for home and industrial purposes would be available in the Board's distributing area when the new 708,000*l*. plant was completed at Broken Scar near Darlington. He said that the expansion of the water undertaking was largely due to the vast increase in water required for industrial use, and he hoped the industrial consumers would guarantee the Board for 63 per cent. of the increased consumption which the industries were expected to take. The Board were grateful to Darlington Corporation for supplying, so far, a total of 520 million gallons of water to tide over an emergency. At present, the Board had power to take from the River Tees 60 million gallons a week, and when the new plant became available this would be increased to 92 million gallons.

THE MIDLANDS.

Manufacture of Motor Cars in Australia.—The Standard Motor Company, Ltd., Coventry, are to establish in Australia a new company, Standard Motor Products, Ltd., to undertake there the assembly of Standard and Triumph cars. Tractors will also be made, for Harry Ferguson, Ltd. The Coventry company will provide all the technical assistance necessary under a 25-years agreement.

Industrial Holidays.—Industrial activities in the west Midlands have been reduced temporarily by the annual summer holidays which started when many factories closed down on July 26. For the first time, employees in the engineering industry have been given two weeks paid holiday, as a result of agreements reached last autumn. Between 300,000 and 400,000 were affected by the new arrangements in the Birmingham, Wolverhampton and Black Country area, and this number was increased on August 1, when most of the remaining factories closed.

Over-Driving of Cars During Delivery.—The Austin Motor Company, Ltd., have taken steps to prevent the over-driving of new cars which are being delivered under their own power. There have been numerous reports that new cars were being driven to distributors' premises, and to ports for shipment overseas, at speeds greatly in excess of those recommended by the manufacturers for the first 500 miles. The Austin Company now display in the rear window of each new car leaving their works a notice calling attention to the fact that it should not be driven at more than 30 m.p.h. The notice asks the public to report any instances of cars being driven at greater speeds, quoting the trade registration number and the time and place, so that offending drivers can be traced.

Radio-Controlled Gas Repair Vans.—The West Midlands Gas Board have introduced a repair service operated by radio-controlled motor vans in the West Bromwich, Oldbury and Smethwick districts. Three vans working in these adjacent towns have been equipped with two-way short-wave radio, and there is a control point similarly fitted at the West Bromwich service depot. Requests for attention to any form of gas appliance can be passed immediately to the van nearest to the point where service is required. The vans provide service over an area of 20 square miles, in which there are about 45,000 consumers.

Proposed Rural Water Supply.—A public inquiry was held at Bridgnorth, Shropshire, on July 29, into the proposal by Bridgnorth Rural Council to improve water supplies over a large area in south Shropshire. The Council's scheme, to which Birmingham Corporation have agreed, involves tapping Birmingham's Elan aqueduct at several places, and piping the water to 21 parishes. An area of 60,000 acres, with a population of 8,000, is involved, and the cost is estimated to be 353,000*l*. It was stated at the inquiry that only 35 per cent. of the houses in the area had a piped water supply, and that, in some cases, water had to be carried several miles.

Pit-Head Baths.—Mr. S. McKee, manager of Desford Colliery, Bagworth, Leicestershire, opened new pit-head baths at the colliery on July 6. The baths, which cost 130,000*l*., will accommodate 2,000 miners. A medical centre also is being built.

Flooding from an Underground Stream.—An underground stream at Lower Gornal, near Dudley, Worcestershire, has caused flooding in a group of houses. The existence of the stream was previously unknown, but analysis shows that the water is from natural sources. Extensive mining operations in the past caused considerable subsidence in the district, and it is surmised that the channel in which the water flows has been affected by a recent settlement. Efforts to trace the course of the stream have proved unsuccessful so far.

LANCASHIRE AND SOUTH YORKSHIRE.

Easing of Australian Import Restrictions.—When the Australian Prime Minister, Mr. R. G. Menzies, was in Sheffield, he promised to give special consideration to cases of hardship among tool and cutlery exporters who had surplus stocks, made for Australia, for which there is now no market. Every case is being investigated and, where hardship is proved, licences to permit the goods to be imported into Australia are being issued. One Sheffield manufacturer has 7,000*l*. worth of surplus stock made specially for Australian buyers.

Heavy Machinery Sent by Road.—On July 30, there reached Hull from Sheffield, by road, a 93-ton load of machinery, part of the equipment of a steel sheet and strip mill for Sweden. To avoid bridges and narrow roadways, 120 miles had to be traversed, about double the length of the direct route.

Miners' Holidays.—Yorkshire miners received three weeks' pay on going for their annual holidays. Underground employees drew 9*l*. for each of the two weeks' holiday in addition to their usual week's wages. Surface employees received smaller sums. Some 70,000 miners, who took their holidays a week earlier than the majority, agreed to cut their holiday short and returned to work last Tuesday.

Scrap Recovery from River Don.—An accumulation of steel grindings is being recovered from the River Don, adjoining a Sheffield steelworks. They are of tool steel and include a proportion of tungsten. Over a period of years, the grindings have drained

from the grinding department into the river, and until the present shortage, have not been considered of sufficient value to justify recovery. During a recent fortnight, about 30 tons a day were recovered.

HECLA WORKS PROJECT.—Millspaugh Ltd., a firm formed by Hadfields Ltd. when that company was nationalised, are seeking the permission of the Ministry of Supply to reconstruct the original Hadfields' site at Hecla Works, Sheffield. Recent contracts for paper-making machinery, placed with the firm by Canadian interests, amount in value to over a million dollars. Millspaugh Ltd. is now the parent company of a group of eight.

SOUTH-WEST ENGLAND AND SOUTH WALES.

INCREASE IN WELSH COAL EXPORTS.—To release more Welsh coal for export, the National Coal Board have decided to reduce supplies to domestic consumers in Wales. After August 11, consumers in South Wales will have to accept about half of their requirements in English coal. As a result of this step, about 5,000 tons of Welsh coal will be released each week for shipment, while a similar quantity of West Midland coals will be brought into the area to make good the loss. The export demand for the best-quality Welsh coals has continued to exceed the available supplies.

STRIKE OVER FARES INCREASE.—On account of the introduction of increased omnibus fares by the Merthyr Corporation, 1,600 miners have come out on strike in protest at the Tirherbert and Tower Collieries, Hirwaun. Moreover, attempts have been made to involve the 10,000 miners in the Aberdare and Merthyr Valleys in the dispute. The decision to seek support in their protest was made after the Merthyr Corporation had announced their intention to apply to the licensing authority for a suspension of the new fare structure, but that until a decision was made the present fares must operate. The strikers claimed that 450 men were affected and that the old standard fare of 1*s.* 3*d.* had been increased to 1*s.* 11*d.* and 2*s.* 8*d.*

NEWPORT SHIPYARD PROJECT.—The site of the proposed new shipyard on the banks of the River Usk at Newport has been inspected by Sir Graham Cunningham, the independent chairman, and five members of the Shipbuilding Advisory Committee. They also inspected test borings at the site. The committee are advisers to the First Lord of the Admiralty and the Ministry of Transport. The chairman said that the committee would have to consider the matter from the point of view of labour and material resources, expense, the strategic position, and the manner in which the scheme would serve the country.

WELSH PORT TRADE STATISTICS.—Trade of the Welsh ports in the first half of this year was 15 per cent. above the level reached in the corresponding period of 1951. Returns issued by the Docks and Inland Waterways Executive showed that, up till July 13 this year, a total of 12,085,964 tons were handled, against 10,519,592 tons a year ago. Imports rose from 4,833,679 to 5,190,678 tons, and exports from 5,685,913 to 6,895,276 tons. On the outward side, coal and coke shipped to foreign destinations rose from 1,431,655 to 1,914,977 tons, and patent fuel from 162,581 to 225,284 tons. Tin-plate shipments increased from 115,826 to 136,077 tons, while the expansion at the oil refinery, near Swansea, was reflected in a jump from 499,991 to 1,047,812 tons in oil and spirit shipped to foreign destinations. Imports of oil and spirit rose from 1,899,898 to 2,378,761 tons, and iron ore arrivals increased from 948,653 to 1,095,674 tons.

RE-ARMAMENT ORDERS.—Since the re-armament programme was commenced two years ago, firms in Wales and Monmouthshire have received Government orders worth 26,000,000*l.*, it was reported after a meeting of the Welsh Board for Industry at Cardiff. In addition, other orders worth 16,000,000*l.* had been placed with Royal Ordnance and Ministry of Supply agency factories.

NOTICE OF MEETING.

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.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 9, 2.30 p.m., Neville Hall, Newcastle-upon-Tyne, 1. (i) "Automatic Mine Winding Practice," by Mr. O. T. Evans and Mr. P. H. Harvey. (ii) "Coal Ploughs in the Durham Coalfield," by Mr. H. E. Collins.

ANNUALS AND REFERENCE BOOKS.

National Union of Manufacturers: Descriptive and Classified List of Members, 1951-1952.

Offices of the Union, 6, Holborn Viaduct, London, E.C.1. [Gratis to members; price 20*s.* to others.]

THE National Union of Manufacturers was formed in 1915 to provide an organisation which would represent on a national basis the interests of Britain's manufacturing industry as a whole. Membership is restricted to manufacturers and comprises more than 5,400 firms, in addition to 75 affiliated trade associations. A list of members is published each year, which, besides being supplied free of charge to firms belonging to the Union, has a wide circulation in Britain and overseas. It is divided into two parts, in the first of which the names of the member firms are listed alphabetically. This section contains the full addresses of each firm's head office and works, their products, telegraphic and cable addresses and telephone numbers. Details of the manufactures and specialities of the firms concerned are included. In appropriate instances, other information, such as the names of agents and directors, codes used, branch addresses and particulars of subsidiary companies are also given. The second part consists of lists of the firms belonging to the Union arranged according to their trades and products. This classified section contains several thousand trade headings spread over the whole industrial field.

An Explaining and Pronouncing Dictionary of Scientific and Technical Words.

By W. E. FLOOD, M.A., Ph.D., and MICHAEL WEST, M.A., D.Phil. Longmans Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 12*s.* 6*d.* net.]

ONE of the results of the continued expansion of scientific knowledge is a steady increase in the number of newly-coined scientific terms, some of rather curious derivation. It may be supposed that persons in direct contact with the sciences concerned learn these terms in the course of their work, but there is a growing proportion of relative laymen who also require to know of such terms, and occasionally to use them, and who desire that their knowledge, however superficial, shall be correct. To such users, presumably, this book will have its widest appeal. The only way to ascertain its usefulness, obviously, is to use it. Taking a selection of engineering terms at random, by way of a test, we can say that, in general, it stands up well to the investigation, but it would have been still better if one or more practising engineers had been consulted. Then the authors might have learned, e.g., that "caisson" is commonly (however incorrectly) pronounced "cassoon" and has other meanings than that of a "water-tight box for building under water"; that "tube" does not mean only a radio valve; that "the water seen flowing out from a ship's side" is not necessarily what they term "condenser water"; that their definitions of, e.g., "peak load" and "centrifuge" and "scale effect" could be improved upon; and they might not have countenanced the term "gasometer" while omitting "gasholder."

The Colliery Year Book and Coal Trades Directory, 1952.

The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30*s.* net.]

IN the 30th year of publication of this annual, the editor has given fuller details of the opencast work which is now the responsibility of the National Coal Board, and of the Board's brickworks. It contains brief details of relevant Government, professional, trade-union, technical and industrial organisations; the National Coal Board, its headquarters, divisions, etc.; an index of mines; briquetting plants, by-product coke-oven plants and blast furnaces; the British Electricity Authority and the Gas Council; coal-trade firms and associations; and a "Who's Who" in the coal industry. There are also numerous statistical tables, analyses of typical British coals, a review of the coal-mining industry in 1951, a list of relevant British Standards, significant parts of the Coal Industry Nationalization Act, 1946, Coal Industry Act, 1949, and Mines Regulations, a personal index, and a directory of makers of colliery plant and stores.

Power Transmission Directory and Trade Names Index, 1952-54.

Trade and Technical Press, Limited, 65-66, Chancery-lane, London, W.C.2. [Price 6*s.* 4*d.*, postage included.]

THIS guide to the makers of mechanical power-transmission equipment is now in its ninth edition. It contains an index to trade and brand names (with the name of the manufacturer or supplier), a classified index to manufacturers, an alphabetical list of manufacturers and suppliers, a similar list arranged by geographical areas, and a table for determining the lengths of V-belts when the distance between the sizes and centres of the pulleys are known.

PERSONAL.

HER MAJESTY THE QUEEN has been graciously pleased to grant her patronage to the INSTITUTION OF NAVAL ARCHITECTS, 10, Upper Belgrave-street, London, S.W.1, in continuation of that granted by King Edward VII, King George V, and King George VI.

The Shipbuilding Conference, 21, Grosvenor-place, London, S.W.1, announce that the offices of chairman and deputy chairman of the Conference are to be discontinued, and that two new appointments have been created, namely, director and controller. MR. R. B. SHEPHEARD, C.B.E., is to be director and will take up his duties as from October 1. MR. ALEXANDER BELCH, C.B.E., hitherto deputy chairman of the Conference, will be controller.

MR. J. A. JAMESON, C.B.E., and MR. F. G. C. MORRIS have relinquished their positions on the board of the Anglo-Iranian Oil Co., Ltd. MR. J. M. PATTINSON, C.B.E., and MR. H. E. SNOW, C.B.E., have been elected to fill the resulting vacancies on the board.

MAJOR R. A. BELCHAM SMITH, M.C., A.M.I.C.E., M.I.Struct.E., M.Inst.T., has been appointed by the Minister of Transport to be a member of the Special Panel of the Transport Tribunal in succession to the late MR. E. S. SHRAPNELL-SMITH, C.B.E.

MR. W. H. F. MEPSTED, commercial superintendent, Railway Executive, Southern Region, has been nominated by the British Transport Commission to be a member of the Transport Users' Consultative Committee for the London area, in place of MR. K. W. C. GRAND, who has resigned.

MR. R. R. C. RANKIN, O.B.E., A.M.I.E.E., has been appointed technical manager of the equipment division of Mullard Ltd., Century House, Shaftesbury-avenue London, W.C.2. He also holds the corresponding position in Mullard Equipment Ltd.

MR. L. DE WYNTER has been appointed manager of the Ipswich branch of British Insulated Callender's Cables Ltd., with effect from August 1, in succession to MR. A. R. DRIESSEN, who has been appointed commercial manager of the Indian Cable Co., Ltd.

MR. D. B. COLLETT, vice-president and general manager of the Dunlop Tire and Rubber Goods Co. Ltd., Toronto, Canada, is returning to England to join the main board of the Dunlop Rubber Co. Ltd., as an executive director. MR. J. P. ANDERSON, C.B.E., is succeeding Mr. Collett at Toronto, and MR. L. J. W. BAILEY, general manager, Dunlop Plantations Ltd., has been appointed chief purchasing agent in succession to Mr. Anderson.

MR. P. J. TAYLOR, of Bromley, Kent, and MR. R. V. MAGLIONE, M.I.E.E., of Southport, have been appointed by the Colonial Office to serve in Tanganyika, the former as a surveyor and the latter as an electrical engineer.

DR. H. L. MAXWELL, of E.I. du Pont de Nemours & Co., Wilmington, Delaware, U.S.A., has been nominated President of the American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. MR. N. L. MOCHEL, of Westinghouse Electric Corporation, Philadelphia, has been nominated vice-president.

THE NORTH BRITISH LOCOMOTIVE CO., LTD., Glasgow, have purchased the whole of the issued share capital of the CARNTYNE STEEL CASTINGS CO., LTD., Renfrew. Directors appointed to manage the affairs of the company are MR. J. B. MAVOR (chairman), MR. T. A. CROWE, MR. R. ARBUTHNOTT and MR. J. GIBB (general manager).

THE INTERNATIONAL TIN RESEARCH AND DEVELOPMENT COUNCIL have resolved to be known, as from August 1, as the INTERNATIONAL TIN RESEARCH COUNCIL. The change, it is pointed out, will not affect the policy or activities of the Council.

AUSTIN AND LANG (SALES) LTD., Heather Park-drive, Wembley, Middlesex, have appointed A. A. JONES AND SHIPMAN LTD., Narborough-road South, Leicester, to be the sole distributing agents in Great Britain and overseas for their "Lunzer" rotating centres. These will be marketed under the name "J & S-Lunzer."

BROMHEAD AND DENISON LTD. have taken over the business previously carried on by BROMHEAD AND DENISON. New warehouse and office premises have been taken at 48, Gowers Walk, Commercial-road, London, E.1, to which all correspondence should be addressed. (Telephone: ROYal 3864.)

THE D.P. BATTERY CO., LTD., Bakewell, Derbyshire, announce that their London office has been transferred to 66, Victoria-street, London, S.W.1. (Telephone: VICtoria 9661-2.)

The London sales office of BRITANNIA BATTERIES LTD. has been transferred from No. 66 to 53, Victoria-street, S.W.1. (Telephone: ABBey 6168-9.)

ELCONTROL LTD., industrial electronic manufacturers, have moved into larger factory premises at Wilbury Way, Hitchin, Hertfordshire. Their sales headquarters remain at 10, Wyndham-place, London, W.1. (Telephone: AMBassador 2671.)

HYDRO-ELECTRIC DEVELOPMENTS IN SCOTLAND.

(*For Description, see Page* 173.)

Fig. 1. Storr Lochs Power Station, Island of Skye.

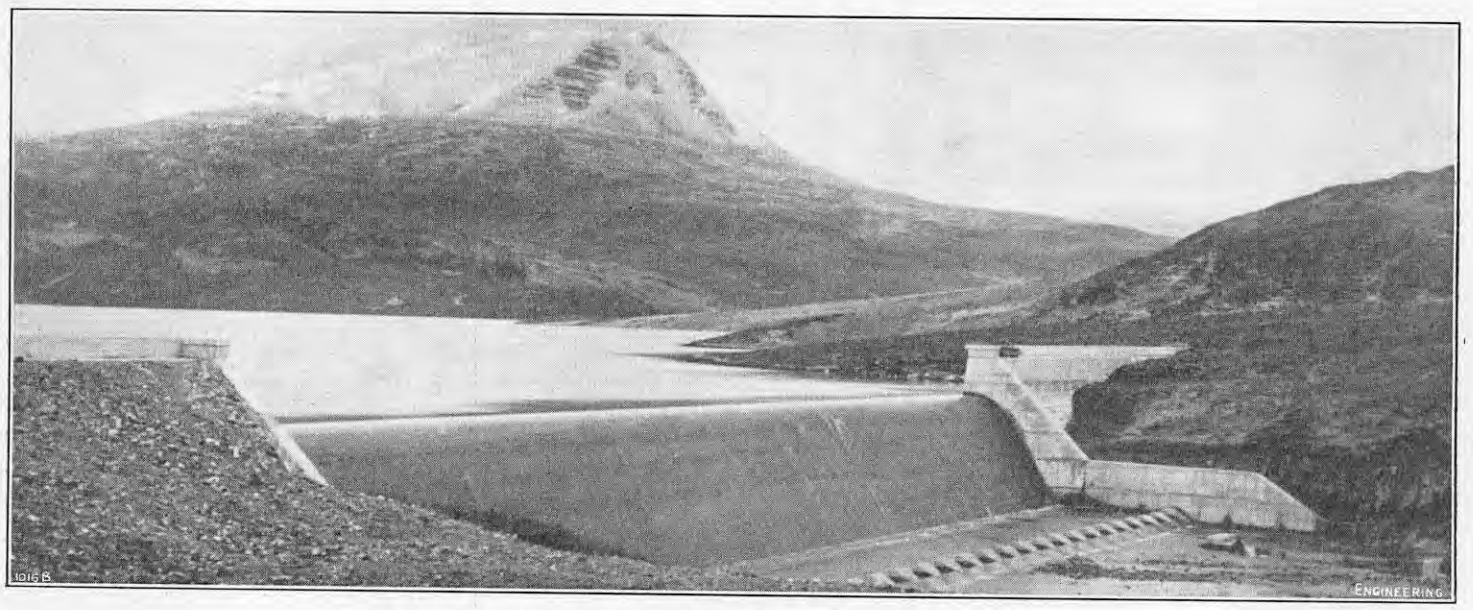


Fig. 2. Regulating Weir for Kerry Power Station, Wester Ross.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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

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

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

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

INDEX TO VOL. 172.

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

CONTENTS.

ENGINEERING

FRIDAY, AUGUST 8, 1952.

VOL. 174. No. 4515.

EDUCATION FOR RESEARCH.

THE annual reports of the various research stations maintained by the Department of Scientific and Industrial Research usually contain statements to the effect that shortage of trained personnel is limiting the range of work which can be undertaken. The same lack of an adequate supply of scientific workers is also frequently mentioned in the reports of industrial companies engaged in engineering and other highly technical occupations. This state of affairs is not peculiar to Great Britain; for instance, it is reported that, in the United States, the shortage of "trained scientific researchers" is "very real and very serious right now." This statement would appear to carry the implication that a "trained scientific researcher" is a different individual from a "trained scientific worker." In the document from which this remark is quoted, the following statement also appears: "It is sometimes said of factory workers that practically any of the men can be trained to do almost any of the jobs. This is certainly not true in research."

The validity of this remark clearly depends on what is meant by "research." Obviously, no matter how adequate his scientific education, a man of mediocre mental capacity cannot be "trained" to the point at which he is able to make fundamental advances in scientific theory or application. None the less, he may be a valuable and hard-working "laboratory technician" (this phrase is again quoted from the document above-mentioned). In his presidential address to the Royal Society in 1859, Sir Benjamin Brodie said: "Physical investigation, more than anything besides, helps to teach us the actual value and right use of the Imagination—of that wondrous faculty . . . the source of poetic genius, the instrument of discovery in Science, without the aid of which Newton would never have invented fluxions, nor Davy have decomposed the earths and alkalies." Possibly neither Newton nor Davy would have described their activities as "research," but Sir Benjamin's statement emphasises the fact that major scientific advances are made only by workers of exceptional capacity who, in addition to their scientific attainments, have a quality which he termed "imagination."

The majority of those engaged in research, scientific or industrial, are not distinguished by exceptional scientific imagination; they are trained scientific workers, with adequate knowledge of the subject with which they are concerned. Some few have a quality which has been defined as "creative mentality," but it is likely that they are born with this endowment; it can hardly be created by training, though it may be developed in a suitable environment. Apart from exceptional men, however, it may reasonably be asserted that certain mental characteristics and, possibly, specific training are useful, and even essential, in the rank and file of research workers. This is evidently believed in the United States, as was made clear at a conference on industrial research held at Columbia University last year. The proceedings at the conference have now been made available in a report.*

A number of the papers read at the conference were concerned with such matters as the organisation of research staffs and the relations between the leader of a research team and his assistants. There were, however, papers entitled "The University's Rôle in Training Research Workers" and "Training of Young Researchers." The second of these, by Dr. H. A. Leedy, Director of the Armour Research Foundation, contained what may be called a specification of the desirable qualities in a research worker and the statement that those who "fall by the wayside" probably lack one or more of these qualifications. The "aptitudes or personality traits" laid down are imagination, perseverance, experimentalism, optimism, ability to co-operate, curiosity, courage, aggressiveness, capacity for effective expression in writing and speech, and, finally, scientific integrity. The college graduate who thinks that research might prove an interesting and profitable career may be intimidated by this list of qualifications, but actually most of them would be of value in any walk of life. "Scientific integrity" does not appear to be of a different type from any other kind of integrity, and it was remarked some time ago that honesty is the best policy. The only qualification which appears to bear direct relation to research is "experimentalism," defined as "the ability to test and check ideas and opinions." Dr. Leedy admitted that, while it was easy to specify desirable qualifications, it was not so easy to determine which applicants possessed them. Indeed, he said that "the best we can hope for is that in a few cases the men will live up to our expectations." He is evidently inclined to rely mainly on school and college records, and impressions gained in personal interviews, in selecting men for training.

The programme of training at the Armour Research Foundation is primarily designed for men who have just obtained a degree. They are encouraged to take an interest in the proceedings of professional institutions, and facilities are granted

* *Selection, Training and Use of Personnel in Industrial Research. Proceedings of the Second Annual Conference on Industrial Research, June*, 1951. King's Crown Press, 1145 Amsterdam-avenue, New York 27, U.S.A. [Price 4.50 dols.]; Oxford University Press, Geoffrey Cumberlege, Amen House, Warwick-square, London, E.C.4. [Price 36*s.* net.]

for the continuation of academic studies, but essentially the training in research is obtained by doing research; the section leader under whom a beginner works has much influence in directing his interests in the desirable direction. There is no reason to suppose that the rank and file of research workers in, say, an engineering laboratory are in any material way different, in their essential qualifications, from their colleagues in the design department or shops, but their environment and activities naturally turn their interests towards new problems.

The paper entitled "The University's Role in Training Research Workers" was the only one read at the Conference which was concerned with the raw material from which research graduates are made. It was read by Dr. H. K. Work, Director of the Research Division, College of Engineering, New York University, and confirmed what has been said above. The way to teach research methods and to inculcate a research mentality in a university is to arrange for the students to participate in research work. This process has apparently been facilitated in the United States by the placing of sponsored contracts with some of the universities. These demand the setting up of research teams in which undergraduates can take part. There was some discussion in connection with this paper about the relation between applied research, with which these sponsored contracts are concerned, and basic research, usually held to be the university's proper field. It is doubtful, however, if the distinction between these two types of activity is important in the training of students. The purpose is to impart instruction in research method and outlook.

Two recent publications* by the Institute of Physics have a bearing on the subject of education for research. The book on careers, by Mr. Norman Clarke, who is deputy secretary of the Institute of Physics, has a good deal to say about research posts, but neither in it nor in that on education is any suggestion made that a research physicist requires a training any different from one who takes up a teaching post or a position in one of the national or local government services which have scientific staffs. What is required is a sound scientific education. Some stress is laid on "personal qualities," which may be taken to be an omnibus expression embodying the items of Dr. Leedy's specification, and Mr. Clarke's insistence on the need to cultivate clarity of expression usefully supplements the reference to this attribute in the Institute's brochure.

Professor W. E. Curtis, President of the Institute of Physics, in his foreword to Mr. Clarke's book, lays particular stress on this qualification, remarking very truly that "Few university students, and by no means all graduates, are capable of saying exactly what they mean in the fewest words possible." How true this is, editors of technical and scientific periodicals, and of the transactions of institutions, are better aware than most. "It seems," says Professor Curtis, "that more attention should be paid to this matter by physics teachers of all grades"; but while so many physics teachers are deficient in literary exposition, usually without realising their deficiency, it is difficult to see how any general improvement can be initiated. To introduce teachers of English composition, to expound that subject purely, is no solution unless they also have some knowledge of physics. Fundamentally, the question is probably one of home background, early training and extra-collegiate environment; but the compilers of the reports and monographs we have quoted may be forgiven for not having pursued that debatable thesis to its conclusion.

* *The Scientific Education of Physicists*, and *Physics as a Career*, by Norman Clarke, B.Sc., F.Inst.P. The Institute of Physics, 47, Belgrave-square, London, S.W.1. Prices, respectively, 2*s.* and 6*s.*]

ELECTRICAL PLANT IN MINES.

In the year 1950, a total of 493 persons were killed at mines coming under the Coal Mines Act, 1911; 2,020 were reportably injured. As there were 55,299 electric motors installed underground, with a total capacity of 1,752,620 h.p., and 37,200 with a capacity of 1,318,005 h.p. on the surface, it may be taken as a tribute to the safety of electrical plant that in that year there were only five fatal electrical accidents and 67 cases of serious injury. It might be argued, of course, that these comparative figures do not fairly represent the position. Much plant with which accidents occur never would have been installed underground had the electric drive not been available, though this can hardly be debited against the use of electricity; but there are accidents of a mechanical nature which should have been prevented by the operation of electrical safeguards, but were not. In the report of H.M. Chief Inspector of Mines for 1950, which was reviewed in our issue of February 22, 1952, there is a section dealing with accidents due indirectly to the use of electricity.

One of the matters there mentioned is the question of fires at underground belt conveyors, which are stated to occur with "alarming frequency." A fire of this type at the Old Boston colliery, Lancashire, a safety-lamp mine, was described and the case is dealt with in somewhat more detail in the report* of H.M. Electrical Inspector of Mines, which has just been published. A 45-h.p. 440-volt motor driving a 26-in. belt conveyor had been running for about 20 minutes when the attendant noticed smoke coming from the brake and found that coal dust round the coupling brake had ignited. He extinguished it with stone dust and prevented the development of what might have been a serious fire.

The conveyor carried ripping stone up a slope of 1 in 5. To prevent running back when the current was switched off, the brake was controlled by a 440-volt flameproof solenoid; the motor and the solenoid were connected to a gate-end switch. The duty of the solenoid was to lift the brake, but examination after the incident showed that the solenoid plunger was jammed by a piece of stone which had apparently fallen through a gap in the metal shroud; presumably, a cover plate had been removed and not replaced. The result of this state of affairs was that the brake remained hard on and sufficient heat was generated to ignite the coal dust. The solenoid was supplied by a small-section cable from the terminal box of the 45-h.p. motor and the whole arrangement was protected by the gate-end circuit-breaker, set at 80 amps. The load imposed by the motor running with the brake in the "on" position was apparently not sufficiently large to trip this breaker, but the main point made in the Principal Electrical Inspectors' report is that the breaker did not provide adequate protection for the small-section cable and solenoid winding.

It is stated that the general practice is to connect the small cable of such apparatus as solenoids directly to the terminals of the main driving motor. This procedure does not appear to be in accordance with clause 128(*c*) of the Coal-Mine Regulations, of which a revised issue† has just been published. This clause states that "efficient means shall be provided in respect of each separate circuit for cutting off all pressure automatically from the circuit or part or parts of a circuit affected in the event of a fault." The report states that fuses are sometimes provided on the solenoid, but this does not protect the small cable and, in any case, "one of the three fuses might blow and any intended protection be lost." It is suggested that a small automatic circuit-breaker, electrically interlocked with the circuit-breaker for the main motor, would appear to be the best arrangement, the interlocking providing that the use of the solenoid was dependent on the motor being used. Further, the solenoid should have top and bottom limit-switches so that failure of the plunger to complete its travel will cut off pressure from the motor and braking device.

This particular matter has been referred to at some length as it forms an illustration of cases in which electrical operation can have unexpected mechanical reactions. We do not suggest, of course, that electrical plant in general has other than a remarkable record of safety; the comparative figures of mechanical and electrical accidents are evidence of that. Electrical apparatus, however, must be used with knowledge and with care. Four accidents described in the electrical report emphasise this; they were responsible for the death of one man and injury to three others. In each case the trouble arose because a shot-firing cable was connected in error to a live signalling system. The accident at Usworth Colliery, Durham, in which a stoneman was killed, arose during roof ripping by sheathed explosives, detonated electrically. The shot-firing cable, laid along the floor, was connected to 20 yards of similar cable which had been used to extend the bare-wire signalling system. In this, and the other cases, the accidents resulted from failure to realise that, presumably for convenience, shot-firing cable had been inserted in the signalling system. The Inspector recommends that the use of such cable for signalling wires should be prohibited.

The record of colliery accidents in any individual year does not, at any time, give a correct idea either of progress or retrogression in safety measures. One year may be fortunate; in another, general overall improvement may be masked by a single serious disaster. The table given in the report, which lists accidents and their causes for the years 1941 to 1950, is therefore of interest and value. The most common type was "electric shock and/or burns," the total for which over the ten years was greater than all other types of accident added together. Of fatal accidents, the next type in order of importance was "ignition of firedamp or coal dust," but among non-fatal accidents, "fires arising from electrical defects" took second place. "Electrical defects" are clearly a matter of design, workmanship and maintenance and it would be satisfactory if a steady fall in this type of accident could be recorded. On the credit side, only one fatal accident is debited against this cause, but in non-fatal accidents no sign of a general fall in numbers is indicated. The yearly totals vary between 6 and 12, and the figure for 1950 had not been reached since 1942. In connection with these figures, it has to be remembered that the total amount of electrical plant in, and at, mines is continually increasing.

The type of apparatus most commonly involved in fatal accidents, 28 in ten years, was flexible cables and plugs, followed by switchgear and fuses. This latter type of apparatus, however, headed the list for non-fatal accidents, 281 in ten years; flexible cables and plugs were responsible for 196 non-fatal accidents. These two types of plant were the dominant agents in the accident record, the only other piece of apparatus coming anywhere near their totals being "armoured cable and accessories," with three fatal and 80 non-fatal accidents. Coal-cutting machines have an excellent record and in ten years were responsible for only one fatal and five non-fatal accidents, none of these was in 1950.

* *Report of H.M. Principal Electrical Inspector of Mines for the Year* 1950. H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

† *Coal Mines Act*, 1911. *Regulations and Orders Relating to Safety and Health.* 1951 Edition. H.M. Stationery Office. [Price 4*s.* net.]

NOTES.

ECONOMY IN BUILDING MATERIALS.

THE general need for economy in the use of materials—especially imported materials and those requiring a significant expenditure of fuel or labour for their production—led to the appointment by the Government, at the end of 1951, of an interdepartmental committee to examine the possibility of increased economy in the use of materials, more particularly steel, cement, bricks and softwood, in that order of urgency. The inquiry was to cover building, heavy civil engineering, maintenance, airfields, mechanical and electrical engineering, and steel economy generally, the first five of these being delegated to sub-committees, while the last was to be studied by the main committee. The programme was drawn up by the Ministry of Works in conjunction with the Admiralty, the Air Ministry and the War Office, whose representatives were, respectively, Sir Charles J. Mole, M.V.O., F.R.I.B.A., Director-General of Works in the Ministry of Works, who was chairman of the Committee; Sir F. Arthur Whitaker, K.C.B., M.I.C.E., Civil Engineer in Chief, Admiralty; Mr. G. H. Fretwell, C.B., M.I.C.E., Director-General of Works, Air Ministry; and Major-General L. D. Grand, C.B., Director of Fortifications and Works, War Office. The report of the main committees, embodying the reports made under the six headings given above, has now been published; it is entitled *Economy of Building Materials* and is obtainable from H.M. Stationery Office at the price of 2*s*. net. The first three sections of the report constitute a guide to building and civil-engineering practice from the standpoint of economy in the classes of materials indicated and, in fact, has been adopted as a mandatory code of practice in the Works Directorates of the four Departments which have contributed to its compilation. The remaining three sections are more technically specialised, but follow the same general pattern in their recommendations. These include recommendations that buildings should be classified as permanent or temporary, with an intermediate category to cover certain cases, and should be constructed and equipped accordingly; that plans should allow only for the minimum requisite circulating space, and for floor heights no greater than the particular user needs; that basement accommodation should be eliminated where possible, and that foundations should be constructed in mass concrete or brickwork rather than reinforced concrete; that prestressed concrete should be used for certain applications, as being more economical; that welding should be used in steelwork in place of riveting or bolting; and that, in road formations and heavy structures, savings shoud be made by using soil stabilisation and by making use of the findings of soil mechanics. The possibilities of considerable savings in copper, lead and steel are also indicated.

HEAVY ELECTRICAL PLANT CONSULTATIVE COUNCIL.

Mr. Duncan Sandys, the Minister of Supply, announced on August 1, in a written answer to a Parliamentary question, that he had set up a Heavy Electrical Plant Consultative Council, which would act under his chairmanship. He stated that the Council's terms of reference would be "to provide a means of regular consultation between the Government and the heavy electrical plant industry on matters affecting the well-being of the industry and its contribution to the national economy." The new body will replace the former Heavy Electrical Plant Committee, which discontinued its meetings in July, 1950. In all, there will be 17 members of the Council, apart from the Minister. Representatives of electrical-plant manufacturers who will serve on the Council will be Sir Claude Gibb, C.B.E., F.R.S., Sir George Nelson, Sir Harry Railing, Mr. E. H. Ball, Mr. I. R. Cox, D.S.O., and Colonel B. H. Leeson, O.B.E. Water-tube boiler manufacturers will be represented by Mr. C. K. F. Hague, Mr. F. G. Mitchell, Mr. F. G. Penny, Mr. E. W. Thompson, Mr. W. E. Young and Mr. K. J. McKillop. Sir John Hacking, Sir Henry Self, K.C.B., K.C.M.G., and Mr. I. A. Park will serve on behalf of the British Electricity Authority, and Mr. F. Foulkes and Mr. E. J. Hill on behalf of the Confederation of Shipbuilding and Engineering Unions. Mr. Sandys stated that representatives of the North of Scotland Hydro-Electric Board and of Government Departments would attend meetings of the Consultative Council, when it was appropriate for them to do so.

FLYING DISPLAY AT FARNBOROUGH.

The annual display and exhibition of the Society of British Aircraft Constructors is to be held from Monday, September 1, to Sunday, September 7, at the aerodrome of the Royal Aircraft Establishment, South Farnborough, Hampshire. Some 50 British aircraft will be displayed, including the six "super-priority" machines: the Vickers-Armstrongs Valiant four-engine bomber aircraft; the English Electric Canberra twin-engine medium bomber; the Hawker Hunter and Vickers-Armstrongs Supermarine Swift single-seat single-engine fighter aeroplanes; the Gloster GA-5 delta-wing twin-engine all-weather fighter (to which the Air Council have given the name Javelin); and the Fairey Gannet anti-submarine aircraft for carrier operation. With the exception of the Javelin and the Supermarine Swift, which was prevented by a mishap from appearing at last year's display, aircraft of these types have been seen in previous years. The de Havilland 110 all-weather fighter will also be seen in public for the first time and, as usual, there are a number of aircraft and engines still on the secret list which, it is hoped, will appear at Farnborough. It is possible that two new air liners may have completed their maiden flights in time to appear in the display—the Bristol Britannia, a progress report on which is summarised on page 166, and the Saunders-Roe Princess flying boat. It is also hoped to demonstrate the Bristol 173 twin-engine helicopter. There will be, as in previous years, a comprehensive exhibition of equipment and accessories. Monday, September 1, is a preview for technicians and the Press, and on Tuesday, Wednesday and Thursday the show is open only to guests invited by the Society. The public will be admitted to the display on Friday, Saturday and Sunday, from 10 a.m. Tickets may be obtained in advance from Auto-Parks, Limited, 1-31, Maclise-road, Olympia, London, W.14.

ENGINEERING TRAINING MISSION TO LATIN AMERICA.

Sir Arthur Fleming, on his return recently from a mission to Latin America, said "We were greatly impressed by these young Latin-American republics and their importance from the point of view of future British export trade. Their economic progress depends very largely on the work of the engineer to provide facilities for transportation, communication and power supply, and for the general development of their natural resources. There is, in fact, in these countries, a great need for fully trained engineers." Sir Arthur, who is chairman of the Overseas Scholarships Committee of the Federation of British Industries, had led the Federation's British Engineering Training Mission to Latin America, the other members of which were Mr. F. R. Livock, a member of the committee, and Mr. W. V. Jenkins, who administers the F.B.I. overseas scholarship scheme. The chief purposes of the mission were to investigate the technical training arrangements for young engineering graduates in Latin-American countries, with a view to providing a selected number of them with scholarships for practical training in Britain; and to make known to all concerned, including Government departments, industrialists and universities, the exceptional training facilities which Britain can offer. A full report of the findings of the mission will be published later. Meanwhile, the F.B.I. state that the scholarships to be offered to Latin-American countries are an extension of the general overseas scholarship scheme which was established two years ago as part of a long-term export-trade policy, and to assist overseas countries in process of economic development. Sir Arthur confirmed that the offer of practical training in Britain was received with great interest and enthusiasm and that there was no doubt that young engineers trained in Britain would be "our best trade ambassadors in these countries in the future." The mission had succeeded in reviving interest in Britain generally. It was, he said, for British industry to seize this advantage and, by training young Latin-American engineers in increasing numbers, to turn to practical account the priceless assets of traditional skill in craftsmanship, organisation and invention which Britain possesses. The mission left England on April 29 and visited Colombia, Venezuela, Cuba, Mexico, Peru, Chile, Argentine, Uruguay and Brazil.

LETTERS TO THE EDITOR.

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

TO THE EDITOR OF ENGINEERING.

SIR,—We have been most interested to read the letter on page 84 of your issue of July 18, from Mr. J. W. Fox and Mr. E. M. Lewis, whose accomplishments are well known in the practical development of ultrasonic testing of welds. It seems to be generally agreed that one of the important limitations of ultrasonic testing is the extreme sensitivity of the method, and consequently the difficulty of interpreting the signals received. It is for this reason that we consider ultrasonic methods require further development in application in order that weak signals which may emanate from important defects are not disregarded.

We can appreciate the simplification which would result from the incorporation of a filter in the amplifier, as used by Mr. Fox and Mr. Lewis, to reject all signals of low amplitude. For the type of inspection in which we are most keenly interested, a defect may be so orientated as to produce only a small signal; the operator is nevertheless alerted and by re-scanning the area, perhaps from a different position, is not denied the opportunity of assessing the importance of the indication. Furthermore, signals of low amplitude which would be concealed by a filter circuit may be of real importance should they emanate from a continuous line defect.

The development work at Renfrew on the application of the shear-wave technique to pipe butt welds has been mainly directed towards ease of operation and maintenance of adequate contact between probes and steel surface. In the case of the direct transmission method, the object is not necessarily to provide a permanent record, but to produce a method of inspection as rapid and convincing as radiography can be in those cases where the fluorescent-screen technique may be used; this, of course, is prohibited by the dimensions of the welds common in boiler construction practice.

Yours faithfully,
H. HARRIS,
Works Metallurgist.
T. B. WEBB,
Chief Research Engineer.

Babcock and Wilcox, Limited,
Renfrew,
Scotland.
July 29, 1952.

FOURTH INDUSTRIAL PHYSICS CONFERENCE, GLASGOW.

TO THE EDITOR OF ENGINEERING.

SIR,—I am rather concerned with the interpretation which might be placed upon one paragraph of the otherwise accurate account of my contribution to the discussion on the training of physicists for industry which was held during the recent Institute of Physics Conference in Glasgow. This paragraph suggested that research in physics at Glasgow University is restricted to nuclear physics and the study of elementary particles owing to lack of funds and facilities. I hope that you will allow me to make it clear that since 1945, when I was elected to the chair of natural philosophy at Glasgow, the most generous encouragement and support have been provided not only by the University, but also by the Nuffield Foundation and the Department of Scientific and Industrial Research. Considerable

funds made available by these bodies for the provision of staff and facilities, in addition to a large modern research building, have enabled us to meet to the full the programme which was envisaged for the development of a research school in nuclear physics at Glasgow. The point which I wished to make in my lecture was that it is essential to have many persons working in collaboration in one connected field of studies rather than upon a diversity of unrelated topics if rapid progress is to be made in modern physical researches. I did also remark that most present-day researches in physics are necessarily elaborate and costly, and that the resources both of personnel and facilities prohibit most universities from engaging in more than one major field of study. This, of course, is quite different from the possible implication of your report, and I am anxious to make it clear that the restriction of researches in physics at Glasgow to one particular field is due to no considerations of limitation of resources or finance, but is highly desirable for the reasons which I have stated above, and also because there is a limit, in my opinion, to the possible size of a healthy research department.

Yours truly,
P. I. Dee,
Professor of Natural Philosophy.

The University,
Glasgow.
July 25, 1952.

THE DOWLAIS FOUNDRY OF GUEST KEEN BALDWINS IRON & STEEL CO., LTD.

To the Editor of Engineering.

Sir,—May I draw your attention to a small error in the article on the Iron Works, Dowlais, in your issue of July 11 ? You state, on page 33, *ante*, that the works were founded in 1759 for producing puddled iron. Cort's process—the first of the two major puddling processes—was patented in 1784 (No. 1420, of February 13, 1784). There had been earlier patents, but the first of the two, which were very similar to Cort's, was also too late for Dowlais to have used it at the date stated. In any case, there is no evidence known to me that either of the two earlier patents was ever used, except experimentally; Cort's is accepted as the first successful one. Dowlais certainly made very large quantities of puddled iron in later years—they had 161 puddling furnaces in 1873—but, if they made wrought iron at all in the early days, it could not have been done by puddling. They probably used the finery at first, though they may have used Wright and Jesson's "stamping and potting" process after 1773.

Yours faithfully,
W. K. V. Gale.

63, Wolverhampton-road,
Sedgley, Dudley,
Worcestershire.
July 19, 1952.

Concrete Jetty on River Ouse.—The Docks and Inland Waterways Executive announce that, with the approval of the British Transport Commission, a new concrete jetty is to be built at a cost of 175,000*l.* at Blacktoft, on the River Ouse, for the mooring of vessels proceeding to and from Goole Docks. The new jetty, which will replace an old wooden structure, will be 654 ft. long and 35 ft. wide, and will have a mean depth of 15 ft. of water alongside at low spring tides. The commencement of the work will be subject to the obtaining of necessary Parliamentary powers and to the approval of the Minister of Transport.

Aircraft Carrier for Royal Canadian Navy.—The Admiralty announce that arrangements have been completed for the purchase by Canada from the United Kingdom of an aircraft carrier to replace H.M.C.S. Magnificent, at present on loan to Canada from the Royal Navy. The new ship, one of the Majestic class of light fleet carriers laid down at the end of the war, is under construction by Harland and Wolff, Ltd., at Belfast, and will be equipped to handle jet aircraft. The vessel is to be modified by strengthening the flight deck and elevators and by improvements in the deck arrester gear, and will be fitted with the new British steam catapult, which is capable of launching both jet and heavy types of aircraft.

OBITUARY.

SIR WILLIAM GRIFFITHS.

Engineers and metallurgists on both sides of the Atlantic will receive with regret the news of the death of Sir William Griffiths, which occurred on July 30. William Thomas Griffiiths, who will be remembered chiefly for his long connection with the Mond Nickel Company, was the son of the Rev. Caradoc Griffiths, of Cardiff, and was born on April 19, 1895. He received his technical education at University College, Cardiff, where he graduated B.Sc. in pure science in 1915. He then entered the Army and served with distinction with the Royal Engineers, in France, until 1918. Upon demobilisation, Griffiths returned to University College, Cardiff, where he took up the study of metallurgy and was awarded the degree of M.Sc. (Wales) in that subject. He served for a short time on the staff of the Metallurgy Department of his College, and, in 1921, was appointed to the metallurgical branch of the Research Department,

The Late Sir William Griffiths.

Woolwich, under Dr. Harold Moore, C.B.E. Griffiths remained at Woolwich until 1926, when he joined the staff of the Mond Nickel Company.

In 1929, Griffiths was made head of the Mond Nickel Company's research and development organisation, and did a great deal of work in connection with the promotion and development of iron-nickel, copper-nickel and related alloys in engineering and allied spheres. For his researches on nickel alloys he was awarded the degree of D.Sc. (Wales) in 1938. During the war of 1939-45, Dr. Griffiths served on various Government technical committees and undertook several missions to Canada and the United States on matters connected with alloy steels and other metallurgical questions. In August, 1945, he was appointed chairman and managing director of the Mond Nickel Company, in succession to the late Mr. D. Owen Evans, M.P., and also became vice-president of the International Nickel Company of Canada, Limited. He was knighted in 1946. In 1950, he relinquished his positions with the Mond and International Nickel Companies, but continued to take an interest in metallurgical research as a member of the Advisory Council of the Department of Scientific and Industrial Research and in other ways. Sir William was a Fellow of the Royal Institute of Chemistry, the Institute of Physics and the Institution of Metallurgists, a member of the Iron and Steel Institute, and was President of the Institute of Metals from 1944 to 1946.

MULTIPLY-LOADED AND CONTINUOUSLY-LOADED STRUTS.

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

The main object of this article is to give an exposition of some approximate methods for calculating the critical loadings of slender struts when the loads are applied at more than one point or continuously. For the sake of comparison, a sketch of the "exact" method for calculating the critical loadings is also included. While the strut problem is a relatively simple one, the methods here discussed, when suitably generalised, are applicable to elastic structures in general. Hence this article could be regarded as providing an introduction to the study of the critical loading of structures.

Characteristics of the State of Neutral Static Stability.—When a structure or system of any kind in equilibrium is in a state of neutral static stability the application to it of an exceedingly small force suffices to cause a slow creep away from the original position or, if the system is set moving with a very small velocity, it will continue to move until there is a considerable displacement. During such a slow displacement the forces are always in balance, the kinetic energy is vanishingly small, and the total work done by all the forces is zero. Thus, any gain in the internal potential energy of the system is exactly equal to the work done upon the system by the forces external to it. This fact is the basis of the method for the determination of critical conditions by the principle of energy.

Usually, the displacement in the neutral state can occur only in one definite mode, which we may call the neutral mode. The magnitude of the displacement of a given point in this mode is indefinite but the displacements of all points vary together in strict proportionality; this is exactly analogous to the state of affairs in any free mode of oscillation of the system. In exceptional cases there may be two or more independent neutral modes which can be blended in any proportions. This can be exemplified by the bowing of a symmetrical strut where the two independent neutral modes can be taken to be bowing displacements in a pair of perpendicular planes.

Whenever the neutral mode is known, the quantitative critical condition can be determined at once (and accurately) by the principle of energy. In the absence of exact knowledge of the neutral mode it is still possible to apply the principle of energy by means of special techniques which are explained below. When the differential equations governing the displacements of the system are strictly linear, the displacements in a neutral mode may have any magnitude but, if the exact equations are non-linear, the displacements will be restricted to be so small that the non-linear terms in the equations are negligible.

"*Exact*" *Treatment of Strut Problems.*—Although the main purpose of this article is to give useful approximate methods for calculating the critical loadings of struts, it will be well to give a brief account of the "exact" treatment and to record some useful results. We consider an elastic beam or strut which is perfectly straight when unloaded and we shall suppose that all the loads parallel to the undeflected axis of the beam are applied exactly at the centroid of the section (zero eccentricity). The beam will be supposed thin, so the deflections due to shear are negligible and the Bernoulli-Euler theory of bending is applicable. For the sake of generality the fundamental equations will be established for the case where there are transverse loads and distributed bending couples, as well as axial loads.

In Fig. 1, opposite, where the curvature of the loaded beam is greatly exaggerated for the sake of clearness, consider the equilibrium of the element E E′ of length ds and let O X be parallel to the axis of the beam when it is unloaded.

Let

W = total load in the direction OY applied to the right of E.

* Department of Aeronautics and Fluid Mechanics in the University of Glasgow.

P = total load in the direction XO applied to the right of E.
M = bending moment at E (positive when clockwise).
n = applied distributed bending couple per unit length.

The loads applied to the element are then as shown in the figure, but to avoid confusion the distributed normal and axial forces are not shown. Take moments about E′ and neglect second-order terms. We get

$$P dy + W dx + M + dM + n ds = M$$

or

$$\frac{dM}{dx} + P\frac{dy}{dx} + n\frac{ds}{dx} + W = 0. \quad . \quad (1)$$

When the deflections are small we may take $\frac{ds}{dx}$ to be unity and then (1) becomes

$$\frac{dM}{dx} + P\frac{dy}{dx} + n + W = 0. \quad . \quad (2)$$

When the problem is statically determinate and P is constant for a segment of the strut, it will be possible to integrate this equation once and so obtain an equation which may be written

$$M + Py = L$$

or, since

$$M = EI\frac{d^2y}{dx^2}, \quad . \quad . \quad . \quad (3)$$

$$EI\frac{d^2y}{dx^2} + Py = L, \quad . \quad . \quad . \quad (4)$$

where L is a known function of x. In statically-indeterminate problems it may be convenient to use the equation obtained by differentiating (2) with respect to x, namely

$$\frac{d^2M}{dx^2} + P\frac{d^2y}{dx^2} - p\frac{dy}{dx} + \frac{dn}{dx} - w = 0, \quad . \quad (5)$$

where

$$p = -\frac{dP}{dx} \quad . \quad . \quad . \quad (6)$$

is the intensity of the distributed compressive loading and

$$w = -\frac{dW}{dx}, \quad . \quad . \quad . \quad (7)$$

is the intensity of the distributed normal loading. Some illustrative examples will now be given.

Take first a uniform cantilever strut of length l with a compressive load P_1 at the tip and a second compressive load P_2 applied at a distance h from the root, but otherwise unloaded (see Fig. 2). For the segment BC we have, by equations (2) and (3),

$$EI\frac{d^3y}{dx^3} + P_1\frac{dy}{dx} = 0,$$

while for A B, we obtain, similarly,

$$EI\frac{d^3y}{dx^3} + (P_1 + P_2)\frac{dy}{dx} = 0.$$

Let

$$\left.\begin{aligned} \mu_1^2 &= \frac{P_1}{EI} \\ \text{and} \\ \mu_2^2 &= \frac{P_1 + P_2}{EI}. \end{aligned}\right\} \quad . \quad . \quad . \quad (8)$$

Then the first of the foregoing differential equations becomes

$$\frac{d^3y}{dx^3} + \mu_1^2\frac{dy}{dx} = 0,$$

and the general solution of this can be written

$$y = a + b \sin \mu_1 (x - k)$$

where a, b and k are constants of integration. But the bending moment and curvature vanish at the tip, so we get

$$y = a + b \sin \mu_1 (x - l) \quad . \quad . \quad . \quad (9)$$

Similarly, the general solution for A B can be written

$$y = A + B \sin \mu_2 x + C \cos \mu_2 x$$

and the conditions at the root are

$$y = \frac{dy}{dx} = 0.$$

Hence we obtain

$$y = A(1 - \cos \mu_2 x). \quad . \quad . \quad . \quad . \quad (10)$$

Both the slope and curvature are continuous at B ($x = h$). Hence

$$\mu_2 A \sin \mu_2 h = \mu_1 b \cos \mu_1 (h - l)$$

and

$$\mu_2^2 A \cos \mu_2 h = -\mu_1^2 b \sin \mu_1 (h - l).$$

These equations can be satisfied in two ways. First, μ_1 and μ_2 may be unrestricted and then A and b must be zero, which implies that the strut is not bowed. Second, A and b may not be zero, so the strut is bowed, and then μ_1 and μ_2 must satisfy the following equation obtained from the last equations by division and rearrangement :—

$$\tan \mu_2 h \tan \mu_1 (l - h) = \frac{\mu_2}{\mu_1} \quad . \quad . \quad . \quad . \quad (11)$$

The same equation holds when the thrust P_2 is replaced by a tension $T_2 = -P_2$, provided that A B is in compression, i.e., provided that $P_1 > T_2$.

As a numerical case of (11) let us suppose that $P_1 = P_2$ and that $h = \frac{l}{2}$. For convenience, put

$$\mu_1 = \mu,$$

so that

$$\mu_2 = \sqrt{2}\,\mu,$$

and

$$\alpha = \frac{\mu l}{2}.$$

Then (11) becomes

$$\tan \alpha \tan \alpha \sqrt{2} = \sqrt{2}.$$

Fig. 1. FORCES AND MOMENTS ON ELEMENT E E′.

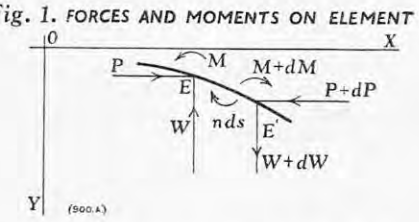


Fig. 2. DOUBLY-LOADED CANTILEVER STRUT.

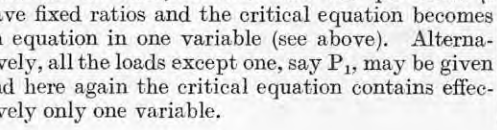


Fig. 3. DOUBLY-LOADED PIN-JOINTED STRUT.

The smallest root of this is found to be 0·7189 radian and the critical loading can now be calculated from

$$P_1 = P_2 = \frac{4\alpha^2 EI}{l^2} = 2{\cdot}067\left(\frac{EI}{l^2}\right) \quad . \quad (12)$$

In a similar manner we can show that when the thrust P_1 is replaced by a tension $T_1 = -P_1$ the critical equation is

$$\tan \mu_2 h \tanh \mu_1 (l - h) = -\frac{\mu_2}{\mu_1} \quad . \quad . \quad (13)$$

where

$$\mu_1 = \sqrt{\frac{T_1}{EI}}$$

and

$$\mu_2 = \sqrt{\frac{P_2 - T_1}{EI}}.$$

This holds so long as AB is in compression ($P_2 > T_1$). When A B is in tension, the whole column is in tension and there can be no instability. Again, if P_2 is replaced by a tension $T_2 (= -P_2)$ which is greater than P_1, so that A B is in tension while B C is in compression, the critical equation is

$$\tan h\mu_2 h \tan \mu_1 (l - h) = \frac{\mu_2}{\mu_1}. \quad . \quad . \quad . \quad (14)$$

Equations (13) and (14) can be derived from equation (11) by the following rule : substitute $i\mu$ for μ when the segment to which μ relates is in tension and use

$$\tan i\mu = i \tanh \mu.$$

The constant a in the expression for y can be found from the condition that y is continuous at B but its value is not required for the formulation of the critical equation.

In this and similar problems we may be given the ratios of the loads, in which case the quantities μ have fixed ratios and the critical equation becomes an equation in one variable (see above). Alternatively, all the loads except one, say P_1, may be given and here again the critical equation contains effectively only one variable.

Take next a uniform cantilever strut of length l having a compressive load P_1 applied at the tip and compressive loads P_2, P_3 applied at distances h_2, h_3 respectively from the root. Let

$$\mu_1^2 = \frac{P_1}{EI}, \ \mu_2^2 = \frac{P_1 + P_2}{EI} \text{ and } \mu_3^2 = \frac{P_1 + P_2 + P_3}{EI}.$$

By an easy extension of the method used for the doubly loaded strut we can show that the critical equation is

$$\begin{aligned} &\mu_3 [\mu_2 - \mu_1 \tan \mu_1 (l - h_2) \tan \mu_2 (h_2 - h_3)] \\ &= \mu_2 \tan \mu_3 h_3 [\mu_2 \tan \mu_2 (h_2 - h_3) \\ &\qquad + \mu_1 \tan \mu_1 (l - h_2)]. \quad . \quad (15) \end{aligned}$$

As a numerical example of (15) let us suppose that the loads are equal while $h_2 = \frac{2}{3}l$ and $h_3 = \frac{1}{3}l$. Also write μ for μ_1 so that $\mu_2 = \sqrt{2}\,\mu$ and $\mu_3 = \sqrt{3}\,\mu$, also put $\alpha = \frac{\mu l}{3}$. Then the equation becomes

$$\begin{aligned} &\sqrt{3} [\sqrt{2} - \tan \alpha \tan \alpha \sqrt{2}] \\ &= \sqrt{2} \tan \alpha \sqrt{3} [\sqrt{2} \tan \alpha \sqrt{2} + \tan \alpha]. \end{aligned}$$

The smallest root of this is found to be 0·4310 radian and the critical loading is accordingly

$$P_1 = P_2 = P_3 = 9\alpha^2\left(\frac{EI}{l^2}\right) = 1{\cdot}672\left(\frac{EI}{l^2}\right).$$

Multiply-loaded pin-jointed struts are conveniently dealt with by employing the expression for the bending moment and as an example (see Fig. 3) we shall take such a strut with a compressive load P_1 applied at the end and a second compressive load P_2 applied at a distance h from the support A. The strut is uniform, the end A has a frictionless pivot and the end C slides without angular constraint in a frictionless guide. Let the strut be critically loaded and let the deflection of B be y_2. Since the strut is in equilibrium we find by taking moments about A that the normal reaction F of the guide upon the strut at C is given by

$$F = \frac{P_2 y_2}{l}.$$

Hence the bending moment at any point in the segment B C is

$$M = -P_1 y - \frac{P_2 y_2 (l - x)}{l}.$$

Accordingly,

$$EI\frac{d^2y}{dx^2} + P_1 y = \frac{P_2 y_2 (x - l)}{l}.$$

A particular integral of this differential equation is

$$\frac{P_2 y_2 (x - l)}{P_1 l}$$

and the complete solution is

$$y = a \sin \mu_1 (x - k) + \frac{P_2 y_2 (x - l)}{P_1 l},$$

where a and k are arbitrary constants.

The end conditions are

$$y = 0 \text{ when } x = l$$
$$y = y_2 \text{ when } x = h.$$

Accordingly we get, after some reduction, for points in B C

$$\begin{aligned} \frac{y}{y_2} &= \frac{[(P_1 + P_2)l - P_2 h] \sin \mu_1 (x - l)}{P_1 l \sin \mu_1 (h - l)} \\ &\qquad + \frac{P_2 (x - l)}{P_1 l}. \quad . \quad (16) \end{aligned}$$

The bending moment at any point in A B is

$$\begin{aligned} M &= -P_1 y - P_2 (y - y_2) - \frac{P_2 y_2 (l - x)}{l} \\ &= -(P_1 + P_2) y + \frac{P_2 y_2 x}{l}. \end{aligned}$$

Accordingly,

$$EI\frac{d^2y}{dx^2} + (P_1 + P_2) y = \frac{P_2 y_2 x}{l}$$

and this has the particular integral

$$\frac{P_2 y_2 x}{(P_1 + P_2) l}.$$

The complete solution is

$$y = A \cos \mu_2 x + B \sin \mu_2 x + \frac{P_2 y_2 x}{(P_1 + P_2) l}$$

while the end conditions are

$$y = 0 \text{ when } x = 0$$
$$y = y_2 \text{ when } x = h.$$

After some reduction we obtain for points in A B

$$\frac{y}{y_2} = \frac{[(P_1 + P_2)l - P_2 h] \sin \mu_2 x}{(P_1 + P_2) l \sin \mu_2 h} + \frac{P_2 x}{(P_1 + P_2) l}. \quad . \quad (17)$$

At B we already have continuity of deflection and of bending moment or curvature, and the only further condition to be met is continuity of slope (at $x = h$). We get from (16) and (17), after some reduction, as the critical equation

$$\mu_1 \cot \mu_2 h + \mu_2 \cot \mu_1 (l - h) = \frac{(\mu_2^2 - \mu_1^2)^2}{\mu_1 \mu_2 [\mu_1^2 h + \mu_2^2 (l - h)]}. \quad . \quad (18)$$

To obtain from this the critical equation for the case where P_1 is absent involves a tricky investigation of a limit and an independent solution is to be preferred. It can be shown without difficulty that the critical equation is now

$$\cot \mu h = \frac{1}{3} \mu (l - h) - \frac{2}{\mu (l - h)} - \frac{h}{\mu (l - h)^2}, \quad (19)$$

where $\mu^2 = \frac{P_2}{EI}$. If we put $\mu l = \alpha$ and $h = pl$ this can be written

$$\cot p\alpha = \frac{\alpha^2 (1 - p)^3 + 3p - 6}{3\alpha (1 - p)^2}. \quad . \quad (20)$$

When $p = 1$ this yields $\cot \alpha = \infty$,

and the smallest root is π. Hence

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

which is the usual result. When $p = \frac{1}{2}$ the equation becomes

$$\cot \frac{\alpha}{2} = \frac{\alpha^2 - 36}{6\alpha}.$$

It is found that the smallest root is 4·320 so

$$P = 4 \cdot 32^2 \left(\frac{EI}{l^2}\right) = 18 \cdot 66 \left(\frac{EI}{l^2}\right)^*. \quad . \quad (21)$$

Rayleigh's Principle and the Influence of Constraints.†—When a "conservative" structure or dynamical system is performing small oscillations about a position of equilibrium the frequency can always be calculated exactly by applying the principle of energy when the mode of oscillation is known. Thus, the potential energy at the end of a swing (when the system is at rest), measured relative to the value in the position of equilibrium, is equal to the kinetic energy at mid-swing and this contains the square of the frequency as a factor. According to Rayleigh's Principle, every natural frequency is a stationary value of the "energy quotient" in the sense that if the mode of oscillation used in calculating the frequency is in error by small quantities of the first order, the frequency obtained from the quotient is in error by a small quantity of the second order. Moreover, the square of the fundamental frequency is an absolute minimum value of the quotient. Thus, if we assume a fundamental mode of oscillation which differs from the true one, we can be sure that the frequency as calculated from the energy quotient is greater than the true fundamental frequency.

The foregoing has a very useful application to the calculation of the critical loads of struts and of structures in general. A critically loaded structure has a fundamental natural frequency equal to zero. Thus if we use the true neutral mode we shall obtain a zero value for the energy quotient when the structure is critically loaded. Hence the increment of the total potential energy in a displacement in the neutral mode is zero, as we have already seen. However, if the true neutral mode is not used in the calculation, the calculated frequency will not be zero and the system will still appear to be statically stable. Thus, any error in the assumed neutral mode must result in an over-estimate of the fundamental critical load. However, in consequence of Rayleigh's Principle, the error in the critical load is of the second order when the errors in the assumed modal ratios are of the first order. Accordingly, the energy method provides a very convenient means of calculating critical loads and the results are of satisfactory accuracy provided that the calculations are properly conducted (see further below).

There is another way of looking at the matter which is instructive and useful. Instead of thinking of the assumed mode of neutral displacement as being in error, we may suppose that the structure is so constrained that the neutral mode agrees with that assumed. Thus, any kinematical constraint raises the fundamental critical load unless the constrained mode happens to agree with the natural one, when the effect is zero. There are, however, elastic constraints as well as kinematic ones and these also, in general, increase the fundamental critical loading. For example, a strut might be provided with elastic supports at midspan and these would raise the critical load since the potential energy for a given bowing displacement would be increased.* We can thus make the general statement that any constraint increases the fundamental critical loading unless, exceptionally, it is so applied that it is ineffective. The important proviso must be added that the constraint must not alter the configuration of equilibrium. For example, the supports must not be applied to the strut in such a manner as to pull it to one side.

Calculation of the Critical Loadings of Struts by the Energy Method.

When a strut bows, its axial length is reduced and the applied compressive loads do positive work upon it. In the critical state this is exactly equal to the elastic energy associated with the bowing.† Let the bowed form of the line of centroids of the strut be

$$y = f(x).$$

Then the length of an element of arc of this line is

$$ds = dx \sqrt{1 + \left(\frac{dy}{dx}\right)^2}.$$

The corresponding shortening of the strut is

$$ds - dx = \tfrac{1}{2} \left(\frac{dy}{dx}\right)^2 dx$$

by the binomial theorem, when $\left(\frac{dy}{dx}\right)$ is small. Let the fixed end of the strut be the origin and let the axial shortening at a current point be $u(x)$. Then, by the last equation

$$u(x) = \tfrac{1}{2} \int_0^x \left(\frac{dy}{dx}\right)^2 dx. \quad . \quad . \quad (22)$$

Let the compressive loads be $P_1, P_2, \ldots P_n$ applied at $x_1, x_2, \ldots x_n$ respectively. Then the total work done by these loads in the bowing displacement is

$$W = \sum P_r u (x_r). \quad . \quad . \quad . \quad (23)$$

or

$$W = \int_0^l p(x) u(x) dx. \quad . \quad . \quad . \quad (24)$$

for a distributed compressive load of intensity $p(x)$. The elastic energy of bending is

$$V = \tfrac{1}{2} \int_0^l EI \left(\frac{d^2 y}{dx^2}\right)^2 dx \quad . \quad . \quad (25)$$

and in the critical condition

$$W = V \quad . \quad . \quad . \quad . \quad . \quad (26)$$

When the modal function $f(x)$ has been chosen we can thus easily calculate the critical load system.

Provided that $f(x)$ is a fair approximation to the true modal function the relation (26) will be sufficiently accurate for practical purposes. We can refine the approximation to any extent by making use of the minimum property of the fundamental critical load. Now let us assume that

$$y = \sum q_r f_r(x) \quad . \quad . \quad . \quad . \quad (27)$$

and take all the applied loads to be proportional to one of them, say P_1. Equation (26) will then give P_1 as a function of the parameters q_r and the best approximation to the true value of P_1 will be the minimum value obtained from the equation. This minimum can be found in any convenient manner. The functions $f_r(x)$ must always be so chosen as to satisfy the end conditions for the strut and, even for highly acurate work, it will seldom be necessary to use more than two functions.

The method of Galerkin is often convenient in the treatment of the stability of struts, especially when they are tapered. When properly applied, it is equivalent to the energy method.*

(To be continued.)

* For further information on the exact treatment of strut problems the reader may consult *The Theory of Elastic Stability*, by S. Timoshenko (New York, McGraw-Hill, 1936).

† Lord Rayleigh: "Some General Theorems Relating to Vibrations," *Proc. Lond. Math. Soc.*, vol. 4, 1873; also "Scientific Papers," vol. I, page 170, and "Theory of Sound," vol. 1. Lord Rayleigh: "General Theorems Relating to Equilibrium and Initial and Steady Motions," *Phil. Mag.*, vol. 49 (1875), page 218, and "Scientific Papers," vol. 1, page 232. R. V. Southwell: "On the General Theory of Elastic Stability." *Phil. Trans. Roy. Soc.* (A), vol. 213, page 187, (1914). G. Temple and W. G. Bickley: *Rayleigh's Principle and Its Applications to Engineering*, Oxford, 1933. This book gives a very good introduction to the theory and many illustrative examples.

* An elastic constraint has a double influence: (*a*) it changes the mode of deflection, in general, and thus provides, in effect, a kinematic constraint; (*b*) it provides its own quota of potential energy.

† The already existing elastic energy of compression is unaffected by a small amount of bowing and is therefore irrelevant to this discussion.

* W. J. Duncan: "Galerkin's Method in Mechanics and Differential Equations." Reports and Memoranda of the Aeronautical Research Committee (R. and M.), No. 1798 (1937); also "The Principles of the Galerkin Method." R. and M., No. 1848 (1938)

CREEP-RESISTING ALLOY FOR GAS TURBINES.

In order to meet the steadily increasing demands of gas-turbine engineers for materials which will withstand still higher temperatures and higher stresses than the alloys employed in current-production engines, investigations in the field of precipitation-hardening nickel-chromium alloys have been continued in the research laboratories of the Mond Nickel Company, Limited. We have already dealt with such of the company's alloys as Nimonic 75, 80 and 90, and the latest outcome of the firm's investigations is the alloy Nimonic 95. The new alloy is similar to Nimonic 90 (which contains 62 per cent. of nickel, 20 per cent. of chromium, 18 per cent. of cobalt and small quantities of titanium, aluminium and other elements), but the creep resistance of Nimonic 95 has been improved by increasing the content of the hardening elements. All alloys which have a high creep resistance at high temperatures are unavoidably difficult to hot-work, and one of the principal problems in the development of a new alloy is to retain sufficient forgeability to enable the material to be worked to the required form. Any increase in the maximum temperature at which an alloy is serviceable necessarily involves a reduction in the temperature interval within which hot-working must be carried out. Nevertheless, by careful control of the proportions of the hardening elements and of the methods of melting and casting the ingots, as well as by improvements in the technique of hot-working, it has been found possible to maintain adequate forgeability in the new alloy for practical purposes.

Since the alloy has been developed only within the last few months, it has not yet been possible to determine its creep properties in long-time tests or over a wide range of temperatures, but its properties for the relatively short periods which are of interest to designers of jet engines show a considerable improvement over those of other alloys in the Nimonic series. Thus the stress required to produce fracture of the new material in 100 hours, at 750 deg. C., is 22 tons per square inch; at 815 deg. C., it is 14 tons; at 870 deg. C., 9 tons; at 900 deg. C., 6·5 tons; and at 925 deg. C., 5 tons per square inch. Furthermore, the approximate minimum creep rates for tests at these stresses are 0·002 to 0·005 per cent. per hour at temperatures between 750 deg. and 870 deg. C., and 0·005 to 0·01 per cent. per hour at temperatures between 900 deg. and 925 deg. C. Tests on the new material are being continued, but in the meantime, it is being produced by Messrs. Henry Wiggin and Company, Limited, Sunderland House, Curzon-street, London, W.1.

HYDRAULIC COPYING ATTACHMENT FOR LATHES.

S. N. BRIDGES AND COMPANY, LIMITED, LONDON.

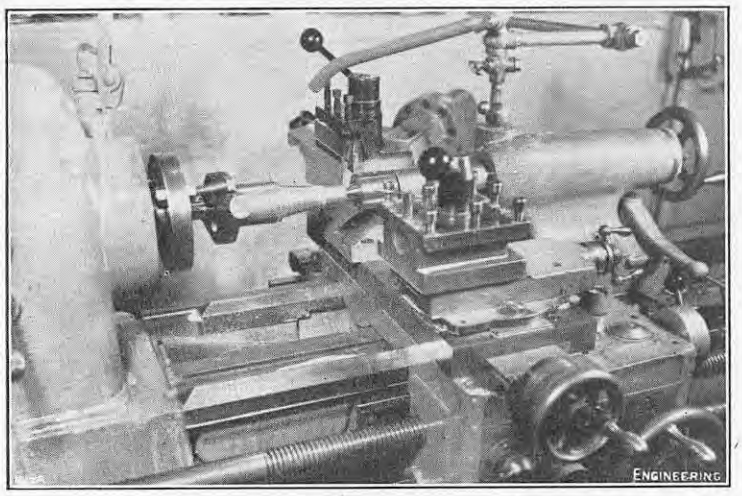


FIG. 1. ATTACHMENT FITTED ON SLIDE-REST.

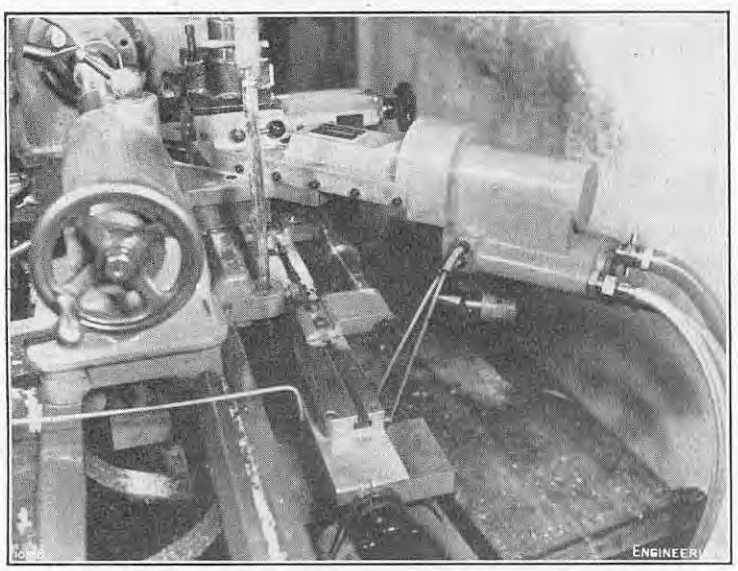


FIG. 2. 45-DEG. TOOL SLIDE.

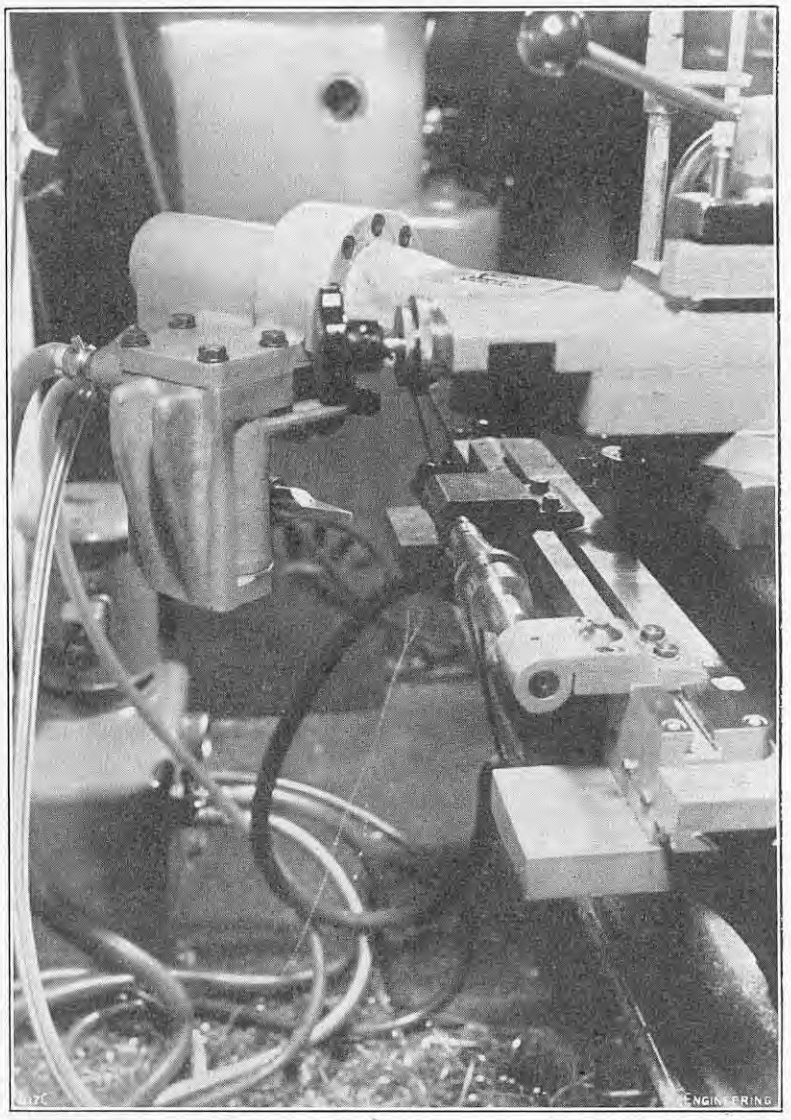


FIG. 3. TRACER FINGER AND MASTER WORK-PIECE.

HYDRAULIC COPYING ATTACHMENT FOR LATHES.

THE hydraulic copying attachment shown in Figs. 1 to 3, above, is particularly useful for repetition production, by unskilled labour, of complicated turned parts that, on a normal lathe, would require a skilled turner. It also facilitates screwcutting right up to a shoulder, since it automatically and rapidly withdraws the tool just before it reaches the shoulder. The attachment can be fitted to a lathe (with a main motor of not more than 12 h.p.) in a few hours, and it does not interfere with the normal operation of the machine when the attachment is not in use. It is suitable for turning work-pieces in which the greatest diameter does not exceed the least diameter by more than 6 in., and the slide which supports the template or master work-piece is supplied in five sizes to suit parts up to 16 in., 40 in., 60 in., 80 in. and 100 in. in length. The makers of the attachment claim that work-pieces can be produced to within $\pm$ 0·001 in. or even less, and that, once the lathe has been set up, work of this accuracy can be turned out by ordinary shop labour, without the operator having to refer to the drawing of the part. The attachment is made by Messrs. S. N. Bridges and Company, Limited, Bridges-place, Parson's Green-lane, London, S.W.6, and has been given the trade name Copyrite.

The attachment comprises three main components: a 45-deg. tool slide, with a hydraulic actuating cylinder and tracer finger; a longitudinal slide and supports for the template or master work-piece; and a hydraulic pump unit with electric-motor drive. The tool slide is fixed to the back of the lathe cross-slide with the tool upside down, as shown in Fig. 1, and its movement towards or away from the longitudinal centre-line of the lathe —but at 45 deg. to this centre-line—is controlled by the tracer finger, which is visible in Figs. 2 and 3, below the tool-slide cylinder. The master work-piece is fixed between a pair of centres on the longitudinal slide which is bracketed to the back of the lathe bed (Fig. 3). A template would be bolted to the slide, the centres being dispensed with, but whichever is used it is located accurately parallel to the lathe axis.

When the attachment is brought into use, the lathe slide-rest is traversed continuously along the bed in the normal way from right to left by the lead-screw. From the moment the tracer finger makes contact with the master, it automatically remains in contact by causing the 45-deg. tool slide to move in or out, as necessary, so as to follow the profile of the master. So long as a parallel portion is being turned the tool slide does not come into play, since the lead-screw feed of the slide-rest provides the necessary longitudinal feed; but if, for example, the finger reaches a square shoulder, it causes the tool slide to move away from the work-piece at such a rate that the longitudinal component of its velocity is opposite in direction, but otherwise exactly equal to, the lead-screw feed. The transverse component of the top-slide velocity is now the only motion of the tool relative to the lathe bed; it is, in fact, a facing feed away from the work-piece, and it produces the desired shoulder. Any other form of profile is generated by a combination of these two basic motions—the longitudinal feed of the slide-rest and the 45-deg. feed of the tool slide. The attachment is quite capable of dealing with an enlargement of diameter (such as a shoulder) while the slide-rest is travelling towards the headstock of the lathe, but reductions in diameter must not be more abrupt than 20 deg. to the axis of the work-piece. The work-piece, and the template, can however be turned end for end between centres to complete any turning which cannot be done at the first setting. This procedure is common enough in turning practice, and with the copying attachment a batch of parts is finished at one setting before the master or template is reversed for turning at the other setting.

The advantage of the attachment for screwcutting derives from the difficulty a turner experiences on an ordinary lathe in allowing the tool to remain in the thread right up to a shoulder. It will be obvious that, if a template with a shoulder is fitted to the slide at the back of the lathe bed, the operator can concentrate on the actual screwcutting, with the assurance that the 45-deg. slide will move at the critical moment. The template is arranged so that it controls only this movement; while screwcutting is taking place the tracer finger is not in contact with it, and the turner uses the cross-slide of the slide-rest in the normal way to give the required depth of thread. Tapered threads can, however, be cut by using a tapered template or master work-piece.

A few points relating to the construction and fitting of the attachment are worth amplifying. The 45-deg. slide is readily fixed to the ordinary lathe cross-slide where the latter is provided with T-slots for a rear tool-post; where it is not, there is often sufficient space to allow holes to be drilled and tapped for securing the attachment. If neither

of these courses is practicable an extended cross-slide can be made. The template or master work-piece carrier embodies a longitudinal slide for setting-up purposes, and the nearest centre bracket shown in Fig. 3 is fitted with an eccentric screw and locking screws for adjusting the parallelism of the master to the lathe axis.

Hydraulic power is provided by a gear pump which is driven by a ¾-h.p. motor and operates at a pressure of between 150 lb. and 175 lb. per square inch. The hydraulic system includes two filters which keep the oil clean and ensure trouble-free service, especially as the oil serves also as a lubricant. The pump unit is usually mounted on a baseplate on the floor, and the oil is delivered through a flexible metallic hose to the slide of the copying unit and through a plastic hose to the tracer finger. A larger-diameter plastic hose is used to return both oil flows to the pump. The pressure exerted by the finger on the template is light and resilient, so that wear is virtually absent. The supply of oil to the double-acting piston which controls the tool slide is regulated by a valve that is coupled to the tracer finger. The tool and the finger cannot be advanced towards the lathe axis, by turning the lathe cross-slide handwheel, beyond the point at which the finger contacts the template, since at that point the tool slide comes into operation automatically. A hand adjustment on the tool slide, however, allows the operator to adjust the position of the tool relative to the finger, for setting up, after which the slide is locked. A quick hydraulic feed controlled by a three-position lever enables the tool to be rapidly advanced towards, or retracted from, the work-piece, when starting and finishing machining.

When setting up it is only necessary to ensure that one dimension of the finished component is accurately established; thereafter, the hydraulic copying mechanism, in conjunction with the template, controls the other dimensions. Internal profiles can be produced by using a template which is set up at 180 deg. to the workpiece, and concave faces can also be turned. Whatever the shape of the components, if the quantity to be produced is large, it is economical to make a hardened and ground master. If the component is bulky, a ⅜-in. or ⅜-in. flat template is used; in all other cases a prototype is first produced by normal turning methods and is then used as the master. Setting-up time for a work-piece weighing, say, 4½ lb., is about five minutes. For specially accurate work, a roughing cut, leaving about 0·010 in. for a final skim using the template, is recommended. Points to be watched in the lathe itself and in setting up are slackness of the headstock spindle, inaccuracy of the lathe, and the correct level of the tool, i.e., it should be in the horizontal plane of the lathe axis.

Permanent-Way Maintenance.—The Railway Executive have issued a booklet entitled "Codes of Practice for Gangers, Sub-Gangers and Lengthmen" to the 50,000 members of their permanent-way staffs.

An International Coal Classification.—The Information Centre of the European office of the United Nations, at Geneva, has announced that after three years of study in Geneva and in numerous laboratories in nine European countries and the United States, agreement has just been reached by a working party of the United Nations Economic Commission for Europe (E.C.E.) on a sound and practical system for describing European coal by its essential characteristics. It was decided to seek agreement upon a system for classifying coal according to intrinsic properties and grade properties, thus including classes, groups and sub-groups according to volatile matter, calorific value, caking and coking properties, ash content, etc. One element in reaching agreement on such a system was the elimination of differences of view concerning the importance of the various characteristics and qualities of the coal. Several hundreds of coal samples were exchanged among the co-operating countries for tests in their laboratories. Various testing methods were used, and progress was steadily made towards eliminating differences between sets of test results. Thousands of analyses had to be made in this process. A particularly difficult task was that of fitting the infinite varieties of coal into a reasonable number of family groupings with carefully defined limits, taking into account the commercial and practical needs of each country. Such a draft table, with 62 groupings of coal by properties and characteristics, has now been agreed upon.

LABOUR NOTES.

The wage claim for an increase of 2*l.* a week for all adult male manual employees in the engineering industry was rejected outright on July 31, at a joint meeting in London between representatives of the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions. Sir Alexander Ramsay, the director of the Federation, informed the trade-union representatives that their demand had had to be rejected because it would be against the national interest to accept it in the present circumstances. In spite of the Confederation's contentions to the contrary, the demand was not justified by the profits of the industry, which were already heavily taxed. Furthermore, it was not warranted by the rise in the cost of living, against which there had been compensations, such as reductions in income tax and an increase in family allowances. If employees in other industries were to present wage claims on a corresponding level, the cost to the nation might well amount to two thousand million pounds in a full year. This would be a severe blow to the country's solvency and standard of living.

On the other hand, the Confederation representatives were informed, engineering employers would not be unwilling to reward increased effort by individual workpeople, but to increase the costs of production was a sure way to create depression and unemployment. Britain was now faced with a revival of producing power, particularly in Germany and Japan, which had again become challengers for world markets, and at very competitive prices. To safeguard this country's future, a whole-hearted effort was needed in every industry to produce more goods at less cost. The present standard of earnings in the engineering industry compared very favourably with those obtaining in other industries. Mr. J. Tanner, President of the Amalgamated Engineering Union, in a brief reply on behalf of the Confederation representatives, expressed acute disappointment at the complete rejection of the wage claim.

It is estimated that nearly 2,500,000 persons are affected, directly or indirectly, by this wage claim and that it would cost the engineering industry well over 200 million pounds per annum to grant the two-pounds-a-week increase in full. Another claim, in respect of adult male manual employees in the shipbuilding and ship-repairing industries was rejected outright by the Shipbuilding Employers' Federation on Wednesday. The replies of both employers' Federations were considered at a meeting of the executive council of the Confederation of Shipbuilding and Engineering Unions yesterday. Delegates to the annual conference of the Amalgamated Engineering Union and leading officials of the Electrical Trades Union will hold meetings tomorrow to discuss the situation. Final decisions regarding the rejection of the claims are not likely to be taken, however, until the annual conference of the Confederation, which is due to begin at Southsea on Tuesday next. In connection with these wage claims, it may be recalled that all adult male employees in the engineering and allied industries were granted an increase of 11*s.* a week and an additional week's annual holiday with pay, as recently as November last.

Meetings between Sir Walter Monckton, the Minister of Labour, and members of the Trades Union Congress economic committee and of the employers' side of the Retail Distributive Trades Conference, were held in London on July 31, at which general discussions took place on the Minister's decision to refer back wage proposals from twelve Wages Councils covering the distributive and allied trades. The meetings were held separately and Sir Walter assured both parties that he had no intention of interfering with the functions of the Wages Councils or of attempting to undermine their authority. He informed the delegates that the proposals for wage increases had been referred back to the Councils because he felt that it was his duty to make certain that these bodies had taken into account the statement on wages made by the Chancellor of the Exchequer on May 15. In this, Mr. Butler appealed for moderation in the presentation of wage claims and deprecated demands for large amounts.

Meetings of the Wages Councils concerned, for the reconsideration of their proposals for wage increases, in the light of Sir Walter's suggestions, began on Wednesday last and will continue until August 28. The first to re-open its discussions was the Retail Food Wages Council for England and Wales. It appears to be generally accepted by the Councils that such proposals for increases in wages as they may now decide to submit to the Minister will not be questioned a second time. Owing to administrative requirements, however, it is considered to be unlikely that any new wage rates decided upon by the Councils could be brought into operation earlier than mid-September.

On July 30, Sir Walter announced in the House of Commons that the board of arbitration set up to consider the dispute between the Durham County Council and certain professional organisations had decided that the County Council's regulation, requiring applications for extended sick pay to be made through a trade union or similar body, conflicted with the principle of voluntary membership of a trade union and that the regulation should be withdrawn. After a meeting of the joint emergency committee of the professions in London on the same day, it was stated that the committee welcomed the award, which it regarded as the closing of an unhappy chapter in the relations between the Council and its professional employees.

There are other aspects of the closed-shop problem, however, apart from those raised in connection with the dispute with the Durham County Council, and attention is directed to some of these in the July issue of *The Journal of the Engineers' Guild*. The assistant secretary of the Guild, in an article in that issue, states that the National Association of Women Civil Servants and the Association of Ex-Service Civil Servants, both unions of long standing which can in no way be termed breakaway organisations, have been refused representation on appropriate National Whitley Councils. Their arbitrary removal from Whitley Councils with which they have been associated for many years creates a serious problem. Members of these organisations must, if their voices are to be heard, join a "recognised" organisation.

Maintaining that the denial of the rights of minorities to be heard is contrary to article 20 of the Charter of Human Rights and to the British sense of justice, the Guild's assistant secretary continues, members of the two organisations have asked the Prime Minister to take steps to ensure that minority bodies of civil servants shall have the right of consultation with the Treasury in the same way as the larger organisations and the right of representation on the Whitley Councils of Government Departments. A similar situation exists in the recently created nationalised industries, where, in many instances, only certain specified organisations are recognised as being able to speak to the management on matters affecting salaries and conditions of employment. If professional engineers are to have proper representation at the correct level, instead of being out-voted by non-professional colleagues in organisations which represent the mass rather than the individual, they must unite, the Guild's assistant secretary maintains, to form a strong body which can speak with authority on their behalf.

Changes in full-time rates of wages, which came into operation in the United Kingdom during June benefited more than 609,000 workpeople, and the total cost of the increases is estimated by the *Ministry of Labour Gazette* for July to amount to approximately 146,000*l.* a week net. The principal increases affected persons employed in the iron and steel industry, and in baking and milk distribution in England and Wales, hosiery manufacture in the Midlands, and in rubber manufacture. During the first six months of the current year, some 4,959,000 employees have received increases in their net wages, amounting to about 1,971,900*l.* a week.

MOBILE CARGO CRANE.

STEELS ENGINEERING PRODUCTS, LIMITED, SUNDERLAND.

Fig. 1. Crane in Use.

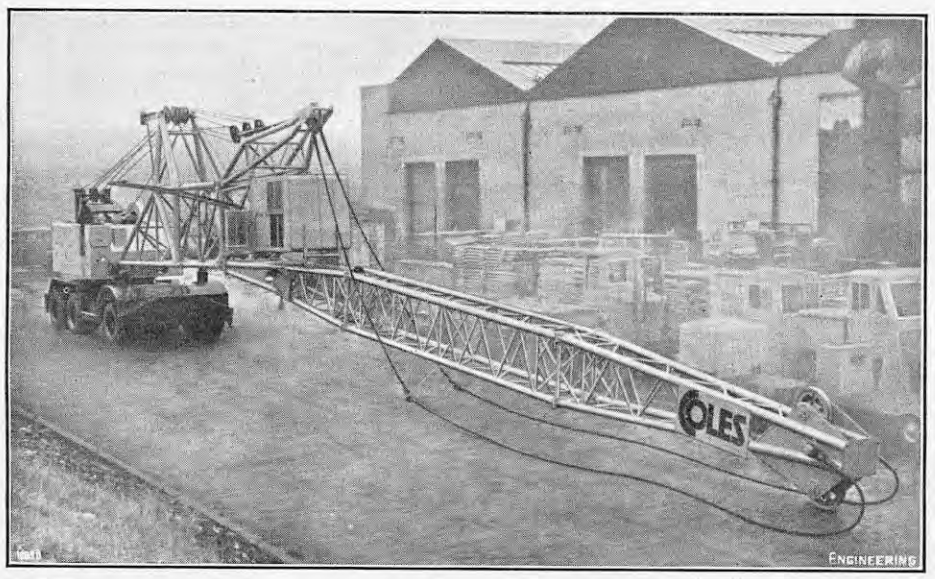


Fig. 2. Jib Lowered to Ground.

MOBILE 3-TON CARGO CRANE.

On page 125, *ante*, we described and illustrated a self-erecting tower crane of Swiss design, now in use on the site of an office building which is to be constructed near London Bridge station. In Figs. 1 and 2, herewith, we illustrate a British design of mobile self-erecting crane, intended primarily for discharging cargo from ships lying alongside quays which are not provided with permanent cranage facilities or where the existing quay cranes are already fully occupied. It is known as the Coles mobile cargo crane, and is made by Messrs. Steels Engineering Products, Limited, Crown Works, Sunderland, who are also the makers of the "Electric Eel" industrial tractor and various other types of handling plant.

The crane is of tubular steel construction and consists of a tower, of square section in plan, mounted on, and hinged to, a chassis which travels on six large pneumatic-tyred road wheels. Hinged to the tower is a jib 50 ft. long, giving sufficient reach to plumb the holds of medium-sized cargo vessels. The crane-driver's cabin is mounted on top of the tower, so that the driver is about 36 ft. above ground level and has a clear view of the ship's deck and the far side of the hatch opening. When handling loads, the crane is provided with a fixed base by extending, from the front and rear of the chassis, four telescopic girder stabilisers, fitted with jacks at their extremities. The crane will lift 3 tons at a radius of 30 ft., to a height of 63 ft. above quay level and from a depth of 50 ft. below that level. A 2-ton load can be handled at a radius of 40 ft., to a height of 55 ft. above the quay and from 58 ft. below it; or 1½ tons at 50 ft. radius to 40 ft. above the quay and from 73 ft. below quay level. Hoisting speeds up to 150 ft. per minute can be provided, with 1½ tons on the hook, and a free barrel can be incorporated, if desired, for gravity lowering. The crane can travel at speeds up to 4 miles an hour, with the tower erected; but if obstructions prevent this, or considerable distances are to be covered, the tower can be lowered to give a clearance height of only 17 ft. 9 in. The crane can lower and erect its own tower without external aid and is designed to give full-circle slewing in either direction, without limit.

The Coles cargo crane is electrically-operated and generates its own electric power, the generator being driven by a Diesel or petrol engine. It has four motions—hoisting, derricking, slewing and travelling—with an individual electric-motor drive for each, the control being by the Coles variable-voltage system. Two or more motions can be carried out simultaneously. The safety devices include automatic limit switches on the hoisting and lowering motions, and, to prevent the jib from being derricked beyond the prescribed positions, a safe-load indicator, automatic electromagnetic brakes, and automatically-reversing steering, so that normal steering can be effected by the driver, irrespective of whether the jib is projecting to the front or rear of the chassis when travelling. The road-wheel brakes are power-assisted, and the crane is equipped with electric lighting and an electric starter. It is thought that the crane will be of particular service in facilitating the rapid turn-round of ships by enabling a harbour authority to concentrate additional cranage capacity on any desired quay, without the heavy capital cost of providing extra fixed cranes, which might be required only occasionally and in special circumstances.

Evening Course on Prestressed Concrete Theory and Design.—A course of lectures on prestressed concrete theory and design is to be held at the University of Leeds on Tuesday evenings, beginning in October, 1952, and ending in March, 1953. The series will cover 20 periods and will include lectures and tuition in design calculations. There will also be laboratory demonstrations of the behaviour of prestressed-concrete beams. The lecturers will be Professor R. H. Evans, D.Sc., M.I.C.E., M.I.Mech.E., and Mr. E. W. Bennett, M.Sc., A.M.I.C.E. A fee of three guineas will be payable. Applications should be made to Miss M. Spink, assistant to the director of extra-mural studies, The University, Leeds, 2, not later than August 16.

CONCRETE SHELL ROOF CONSTRUCTION.

(*Concluded from page* 106.)

The third and final day of the symposium on concrete shell roof construction, organised by the Cement and Concrete Association, was held on Friday, July 4, at the Institution of Civil Engineers, and was concerned with the actual construction of shell roofs. The first paper of the session dealt with the costs of this type of roof and the other three papers with descriptions of methods used in the construction of particular buildings.

Costs of Construction.

Mr. H. G. Cousins began his paper on the economic aspect by briefly indicating the advantages of shell roofs and suggesting that although shells could be the cheapest form of roof for large spans, for spans less than 60 ft. considerable repetition was essential for economical construction. The value of repetition had been demonstrated during the war, when the War Office had roofed storage sheds at reasonable cost with shells of only 30 ft. span, but over a total area of several acres. Among the many variables affecting the cost could be included the span, type of lighting and form of shell roof adopted, the clear height over floor and, most important of all, the degree of repetition which could be achieved. Of recent figures quoted from tenders he had received, Mr. Cousins mentioned 4*s*. per square foot of floor space where factors had been extremely favourable, 8*s*. to 12*s*. per square foot as a typical figure, rising to 20*s*. in cases of extreme complexity and difficulty. The figures quoted were the cost to the client of the roof alone, taking no account of supporting columns and their foundations. The relative costs of labour and materials suggested that the saving of labour might be more important than the direct saving of material in reducing overall costs. For example, the use of fabric mesh, although requiring a greater weight of steel, due to the less economic distribution of the steel and the need for overlaps, was far easier to fix, so giving a reduction in costs.

The thinness of concrete shell roofs, 2½ in. to 3 in., prohibited any saving being made by reducing the amount of concrete used, and the only economy factor in the designer's hands for a given roof was the efficient use of steel reinforcement and its careful disposition to reduce the cost of fixing. The costs of auxiliary treatments—insulation, lighting, waterproofing and decoration—were dependent upon the purpose for which the building was intended and upon the standard of finishes specified, and, as such, were fixed. It was in the actual construction of the shell that the greatest savings could be effected, particularly by progressive methods of shuttering and by paying attention to the arrangement of concrete plant. Some attempts had been made with spraying the concrete on to the roof but these had proved very expensive. Some economy could be expected from prestressing, so long as dead weight was not increased by thickening up the concrete to cover the cables.

In presenting his paper to the meeting, Mr. Cousins referred to a number of points that he had made in his paper and emphasised that, at present, shell roofs were a luxury except for large buildings, and that the greatest reduction in costs would have to come from the contractor. He suggested that a possible source of economy might be found in the judicious use of pre-casting sections of the structure.

Mr. Dudley Harris referred to the congested reinforcement often found in shell roofs and pointed out that this compelled the use of a plastic concrete involving a high sand content, which forced up costs. In connection with Mr. Cousins' suggestion that fabric mesh should be used, Mr. Harris pointed out that sheet fabric must be specified, as opposed to rolls which would have to be straightened before use.

Examples of Concrete Shell Roofs.

In the first paper describing particular completed works, Mr. H. E. Manning gave an account of the methods used to construct shell roofs at Skelton Grange power station and at a food factory for Messrs. Fropax (Ware), Limited, at King's Lynn. An aerial photograph of Skelton Grange during construction has already appeared in Engineering, vol. 171, page 404 (1951). The turbine room at Skelton Grange, Mr. Manning said, was a reinforced-concrete framed structure with a thin barrel vault roof stiffened by ribs. The building measured nearly 750 ft. long by 79 ft. wide and was divided into 24 bays, each 31 ft. long, by portal frames, of which the main roof ribs formed a part. At a height of 60 ft. above ground level the portal frames carried the rails for a 150-ton travelling crane; the soffit of the barrel roof crown was another 28 ft. above the crane rails. The roof was constructed from a carriage travelling on the crane rails; a method which left the floor clear of scaffolding, enabling work below to proceed unhampered. The carriage comprised two steel frames, 32 ft. apart, spanning the width of the turbine house and braced together by rolled-steel joists which carried the working platform and the light steel frame supporting the centering for one complete bay. The whole carriage was able to pass below the completed roof ribs after the dismantling of the shutter panels, made from 5 ft. by 4 ft. battened plywood. Dismantling the centering, hauling the carriage forward by winch and tackle and re-erection of the shuttering could be accomplished in eight hours. Ten days were allowed to elapse to permit the concrete to harden before striking the shutter, but a steel tie shackled to the columns was provided on the forward portal frame, just below the springing, to reduce the stresses after removal of the shutter. Since the portal frames were 31 ft. apart and the carriage frame 32 ft., the carriage could be moved forward without interfering with the tie.

Secondary roof ribs were provided at the middle of each bay; at every third intermittent rib there was an expansion joint, the two half-bays of the roof shell either side of the joint being cantilevered out from the adjacent bays. During construction, the two half-bays were cast as one, temporarily connected across the gap of the expansion joint by steel dowels passing through pre-cast concrete blocks. When a sufficient number of bays had been erected for the half-bays to act as cantilevers, the superfluous concrete was cut away and the steel dowels burnt out. Each bay of the roof contained an opening 32 ft. by 15 ft. divided by precast ribs that supported the skylights. The roof was finally covered externally by two layers of mastic asphalt and internally with ¾ in. of asbestos, which was sprayed on to the roof from the shutter carriage, run back through the completed building for that purpose.

The factory at King's Lynn was of considerable interest, since it was among the first shell-roofed concrete buildings to be prestressed in this country. Situated close to the River Ouse, it was essential to pile under every column and any reduction that could be made in columns, and therefore in piles, represented a marked saving in cost. The roof was designed as a series of seven bays, each 28 ft. wide and spanning 112 ft., giving a clear floor area of 196 ft. by 112 ft. Edge beams, each 8 in. wide, were provided between each vault, and post-tensioned by means of Magnel-Blaton cables, which were threaded into holes formed by rubber cores withdrawn a few hours after the concrete had been placed. As the rubber cores could only be obtained in lengths up to 60 ft., the edge beams had to be constructed in two parts; a slight crack could afterwards be discerned at the joint but this closed up completely after prestressing. In order to keep the cables straight—to ease the difficulties of threading—the whole roof, beams and shells, was haunched 38 in. in the span of 112 ft. The end frames were constructed in normal reinforced concrete. All the roof construction was supported by tubular scaffolding, which carried plywood shutter panels held to the correct profile by either curved timber battens or curved scaffold tubes.

During the course of the discussion on this paper, Mr. A. W. Hill, of the Cement and Concrete Association, asked if any figure could be given for the number of repetitions possible with the plywood sheets. In reply, Mr. Manning indicated that they were each used between 30 and 40 times on the original job, and went on to say that the centre of each board was good for many more usages if the edges, which inevitably got turned up, were trimmed off. Mr. A. Goldstein took the opportunity to draw the attention of those concerned to the dangers involved if extra concrete were put into the roof. Pointing out that the thickness of the concrete was usually determined by the steel fixers and the need to obtain the minimum cover over the reinforcement, Mr. Goldstein expressed the opinion that the shell was frequently constructed thicker than specified, with a resultant increase in dead weight. Mr. Manning agreed that an extra ¼ in. might be placed in the shell.

The shutter used for the erection of a factory at Greenford formed the subject of the next paper, given by Mr. H. F. Rosevear. The area covered by the roof construction was 150 ft. 6 in. by 400 ft. 6 in., divided into 45 bays, each 51 ft. 6 in. by 26 ft. 8 in. The concrete stiffening diaphragms were pre-cast near their final position on the floor slab between the columns, so doing away with all but the edge shuttering. Two transverse expansion joints ran the full width of the building, and the central bays adjacent to these joints were provided with upstand stiffening beams in the valleys, so that the propping could be quickly removed from these localities thereby providing passage-way for the travelling shutters.

The programme for the completion of the work required that five barrels should be concreted at one time, which meant that the five sets of shutters each had to be used nine times. Design of the vault shuttering raised three problems: it had to be capable of being lifted into its working position and yet be able to pass under the stiffening diaphragms, of being adjustable at the ends to give the clearances necessary during these movements, and of being able to pass in any direction inside the clear

Fig. 6. TRAVELLING SHUTTER USED AT GREENFORD FACTORY.

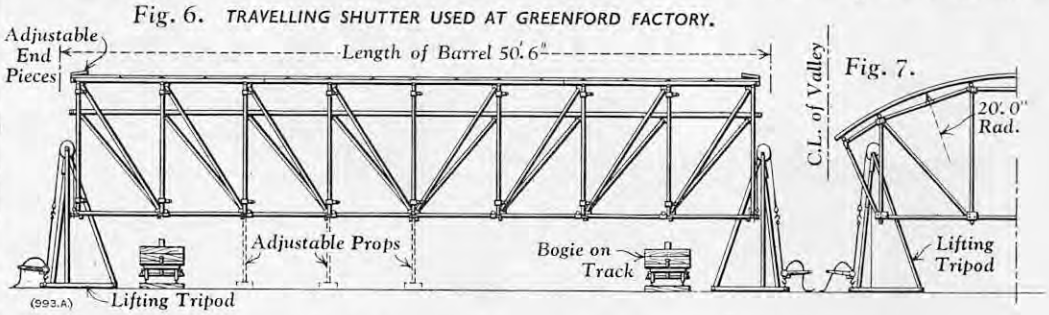
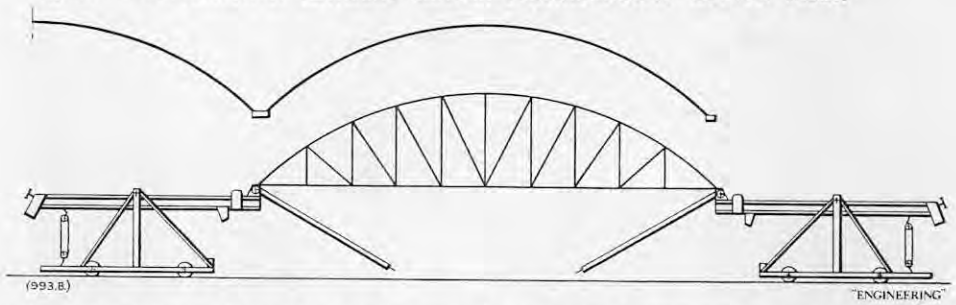


Fig. 7.

Fig. 8. MANIPULATION OF CENTERING UNITS IN CONSTRUCTION OF ANTWERP SHEDS.



FLAME-FAILURE CONTROL FOR OIL BURNERS.

RHEOSTATIC COMPANY, LIMITED, SLOUGH.

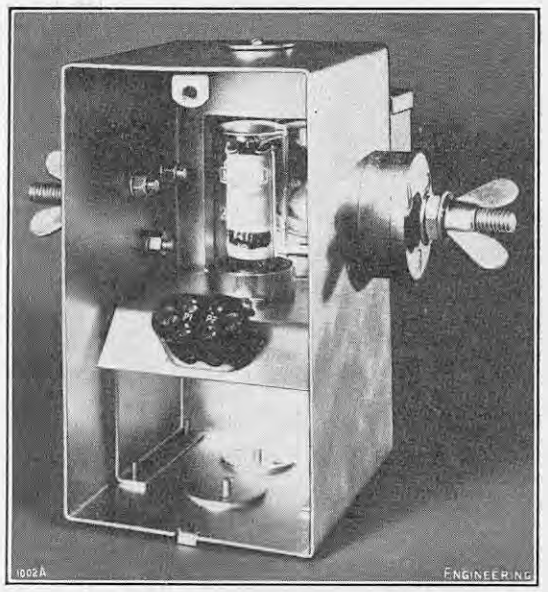


FIG. 1. PHOTOCELL HEAD.

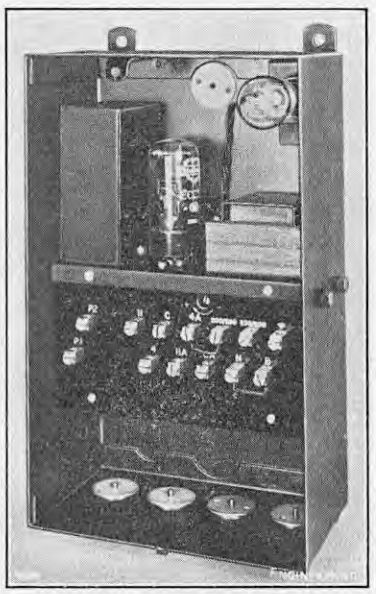


FIG. 2. AMPLIFIER-RELAY UNIT.

distances between the faces of the columns. The arrangement adopted was shown in two drawings (reproduced in Figs 6 and 7, opposite). The framework was constructed from steel tubing; all the vertical members were adjustable props, the feet being lifted clear of the floor when the shutter was carried on the bogies for travelling. The shutter skin was made from 20-gauge steel sheet stiffened by V-ribs, welded to the sheet steel at about 8-in. centres and running in the longitudinal direction of the barrel. This stiffened skin proved to be sufficiently flexible to be fitted to any reasonable curve and capable of supporting wet concrete over a span of about 3 ft. At 3-ft. intervals, curved ribs, made of 2 in. by 2 in. by ¼ in. mild-steel T-sections, rolled to the appropriate radius and fixed to the main frame, held the shutter to the required profile. The complete frame and shutter skin for one bay weighed just under 6 tons. For raising and lowering the shutters, one set of four tripods, of the type shown in Figs. 6 and 7, were provided; these tripods could be moved easily about the site and used on any of the five barrel shutters that required moving. These arrangements had enabled the 45 barrels to be completed at an average rate of one in three days and at a competitive price.

The final paper of the symposium, by Mr. André Paduart, described the construction of some extensive self-supporting concrete vaults at Antwerp Docks, with particular reference to the travelling formwork used. The buildings, which were now used as transit sheds, had an overall length of 465 m. and a width of 60·4 m. As constructed, the roofs were formed in 31 vaults, each 15 m. wide by 60·4 m. long, supported intermittently by columns at 17·87 m. centres along their length, without stiffening from either edge beams or tie frames. Openings for skylights 40 m. long by 3 m. wide had been left along the crowns of the vaults; the thrusts from the two half-shells so formed were carried by pre-cast reinforced-concrete struts at approximately 4·5m. centres. Although subjected only to direct thrusts, these struts had been curved to follow the profile of the vaults, so preserving the architectural features of the roof and easing the problem of shuttering.

Contrary to general practice, the thrusts of the vaults were not taken by tie-rods connecting the springings, but were absorbed by four reinforced-concrete counterforts at each corner of the building. It had been verified that, in the event of one vault disappearing, as the result of an accident, the building would not collapse; nevertheless, it was essential to ensure the stability of the structure during building operations. Since the 31 vaults leaned against each other and the thrusts were finally to be carried back to the counterforts—it was out of the question to concrete the entire roof in a single operation—special precautions had to be taken to absorb the thrusts during construction. Before shifting the centering from one bay to the next, the heads of the outermost columns were guyed back to the feet of the adjacent columns, so taking up the thrust from the last-built shell. The guys were, of course, finally removed with the construction of the last counterforts. The formwork was composed of 14 units of centering each about 4 m. in width; the remainder of the length of the vault was shuttered by plates spanning between adjacent units of centering. Each time the formwork was shifted, each unit had to be lowered about 3·5 m. so as to allow it to pass beneath the valley gutter, hauled 15 m. along the length of the building and raised again to its final position. The method employed, shown in Fig. 8, opposite, used two travelling carriages.

The vault concrete had a thickness of 8 cm. at the crown and was thickened to 12 cm. at the springings. Bar reinforcement was used in those areas where there were tension stresses, due to the vaults acting as continuous beams over the supporting columns, but mesh reinforcement was used elsewhere to afford some protection against shrinkage, temperature variations and incidental loading from wind or snow. Such was the flexibility of this form of construction—thin parabolic arches—that it was possible to design and to construct a building 465 m. in length without a single expansion joint. Watertightness of the roof was ensured by a coating of asphalt.

In the discussions that followed the last two papers, many speakers congratulated the respective authors on the development of travelling shutters by which means alone barrel vault roofs could be rendered fully economical methods of construction. Mr. W. E. J. Budgen, M.I.C.E., closed the symposium with a brief review of the papers and discussions of the previous three days, and by thanking the Cement and Concrete Association for the very successful arrangement of the symposium.

THE LATE MR. A. S. WINDSOR.—We report with regret the death of Mr. Arthur Simeon Windsor, of Ealing, which occurred in a nursing home on July 9. Mr. Windsor, who was in his 80th year, was for a long period an engineer with the Blue Circle Cement Group, but will be remembered chiefly for his pioneer work for the cast-stone and cast-concrete products industry. He was a former secretary of the Cast Concrete Products Association, the National Association of Cast Concrete Products Manufacturers, and the British Concrete Federation. In 1942, these three bodies were amalgamated, under his secretaryship, into the British Cast Concrete Federation. Mr. Windsor had also been secretary of the British Concrete Corporation, Ltd.

FLAME-FAILURE CONTROL FOR OIL BURNERS.

To prevent the accumulation of unburnt air-fuel mixtures in oil-fired furnaces in the event of flame failure, a photo-electric flame-failure control, known as the Satchwell type PER, has been introduced recently by the Rheostatic Company, Limited, Slough, Buckinghamshire. It is designed to shut off the flow to the burners immediately the flame fails, either when starting up the furnace or during normal running. The control will also shut down the furnace if any component or circuit in the flame-failure mechanism itself should fail. This type of control, which has a higher rate of response than a thermal detector installed in the flue, is particularly suitable for large burners and for multiple-burner installations sharing a common flue.

The Satchwell control comprises two units: a photo-cell head, which is designed for mounting on the front plate of the furnace so that the photo-electric cell can be focused on the flame, and an amplifier-relay unit in a separate housing. When the photo-electric cell, which is of the vacuum-emissive type, receives light from the burner flame, it transmits a signal to the amplifier unit. The amplified signal operates a telephone-type relay in the amplifier unit, which, in turn, sends an appropriate signal to the circuit of the main controller of the oil burner.

If the signal from the photo-cell is interrupted, by failure of the flame or of the photo-cell itself, the relay moves to the "cold" position, shutting off the main controller.

The photo-cell head is illustrated, with its cover removed, in Fig. 1. In order to prolong the life of the photo-electric cell, the head is designed to keep the temperature of the photo-cell as low as possible. The attachment wing nuts and fixing bolts are thermally insulated from the casing, and the sight tube on the head is provided with spacing ribs which allow the passage of a small flow of fresh air, for cooling and for keeping the face of the outer lens free from dust deposits. Three lenses are provided in the sight tube, two of them mounted in a common slide which can be raised in order to clean the lenses. The inner lens, i.e., that closest to the flame, and the middle lens, which acts as a condenser, are of heat-resisting glass. The outer lens acts as a filter, absorbing a high proportion of heat rays but not appreciably reducing the intensity of the light falling on the photo-electric cell. The head also has provision for air-blast cooling, should this be required on installations with a high intensity of radiation.

The amplifier-relay unit can be seen, with its cover removed, in Fig. 2. On the upper part of the chassis are carried a double-triode amplifying valve, a transformer, and the post-office relay. The internal wiring and a resistor-capacitor network are housed below. The relay has a double-pole change-over switch, one pole for use with the main controller circuit; the other is available for operating a warning lamp or for interlocking where complex control circuits are employed. A sensitivity adjustment, comprising an adjustable rheostat operated by a knob with a screw-driver slot, is provided so that the rate of response of the relay to the flame-failure signal can be adjusted to suit the particular installation.

The instrument is normally arranged for operating from a 200-250 volt, 50-cycle supply, but it can be supplied for use with other alternating voltage ranges if desired. The photo-electric cell is designed to work at a maximum temperature of 170 deg. F.; in general, it can be used in an ambient temperature of 120 deg. without air-blast cooling.

B.O.A.C. "STRATOCRUISER" FLEET.—British Overseas Airways Corporation have announced that their fleet of ten Boeing Stratocruiser air-liners, which went into service on the North Atlantic routes in December, 1949, have now completed 3,120 Atlantic crossings. During the six summer months of 1951, the average daily utilisation was 7 hours 32 minutes. In the first four months of this year, higher utilisations were achieved, but owing to the recent strike in the American oil refineries, it was not possible to maintain this high average.

ALUMINIUM MOTOR YACHT "TONQUIN."

The motor yacht Tonquin, recently completed by Grimston Astor, Limited, Bideford, North Devon, for a private owner, is of more than usual interest, as she is believed to be the largest all-aluminium vessel of her class to be built so far in the United Kingdom. The general appearance of the Tonquin will be apparent from Fig. 1, herewith. She has been constructed to the requirements, and under the supervision, of the Ministry of Transport and has a length overall of 60 ft. and on the water line of 57 ft. 6 in., a breadth of 14 ft. 9 in. and a draught of 2 ft. 9 in. The displacement is 14 tons and the registered tonnage 20.20. The vessel has a maximum speed of 15 knots, a service speed of 12 knots and a range of from 650 to 800 miles.

The design of the hull is based on that of the survey vessel Ain-Al-Bahr which the builders delivered last year to the Pakistan Government for river survey work; but whereas the accommodation specified for the Ain-Al-Bahr was austere in the extreme, the Tonquin has been fitted out to an exceptionally high standard. The accommodation includes two double-berth cabins, one single-berth cabin and a large saloon arranged to provide additional sleeping facilities when required. The builders' "two-way tension" method was adopted for the construction of the hull. This method was described at length in our article, published on page 188 of our 171st volume, in connection with the Ain-Al-Bahr. In brief, the system entails the fabrication of the shell of the craft in a flat, unstressed condition, the shape of the flat surface corresponding to the developed form of the complete hull. The gunwales, stringers, bilge keels, etc. are riveted to the cladding while it is still in the flat condition, and the hull form is obtained by flexing the prefabricated skin upwards about the centre line so that it encompasses the transom, the flexing being continued until the two parts forming the stem are joined. This process is illustrated in Fig. 2, herewith, which shows the hull of the Tonquin under construction at the builders' yard. The framework previously secured to the flat sheet is located so that, during the flexing process, it controls the movement of the skin and ensures that it automatically assumes the designed form. The aluminium sheet, which, in its original flat form, was flexible, now forms a tensioned shell or stressed envelope which can be strengthened by by the insertion of athwartship frames and bulkheads to withstand wringing strains. Normally, the bulkheads employed to subdivide the craft into the various parts are sufficient for this purpose.

Due to the fact that the hull is not built from shaped plates riveted to frames, but has a skin stressed by double curvature to a spring-like tension, there is a considerable reduction in weight over a hull constructed in the traditional manner; in some cases, this may be as much as 60 per cent. In the case of the Ain-Al-Bahr, which also is 60 ft. overall, the displacement is only 11 tons, whereas a sister vessel built from teak has, according to reports, a displacement of from 70 to 75 tons. Furthermore, the draught of the Ain-Al-Bahr is 2 ft. 9 in. against the teak vessel's 4 ft. 6 in., and requires only 130 h.p. to achieve a speed of 12 knots, whereas the teak vessel requires 260 h.p. to reach this speed. It is understood that the first cost of a craft built on the two-way tension system is considerably less than that of a similar wooden or steel vessel, as fabrication of the parts requires no expensive presses or machine tools, standard hand tools being quite adequate in most cases. Most of the materials used in constructing the Tonquin were supplied by the British Aluminium Company. The hull is clad with 10-s.w.g. quarter-hard aluminium-alloy plate to specification N.S.5. A feature of the hull construction is the provision of twin keels and skegs, thus enabling the vessel to remain upright when aground. The two skegs can be seen in Fig. 3.

The vessel is propelled by twin screws, each driven by a Foden F.D.6 two-stroke Diesel engine. These engines have six cylinders with a bore and stroke of

ALUMINIUM MOTOR YACHT "TONQUIN."

GRIMSTON ASTOR, LIMITED, BIDEFORD.

Fig. 1. "Tonquin" on Trial.

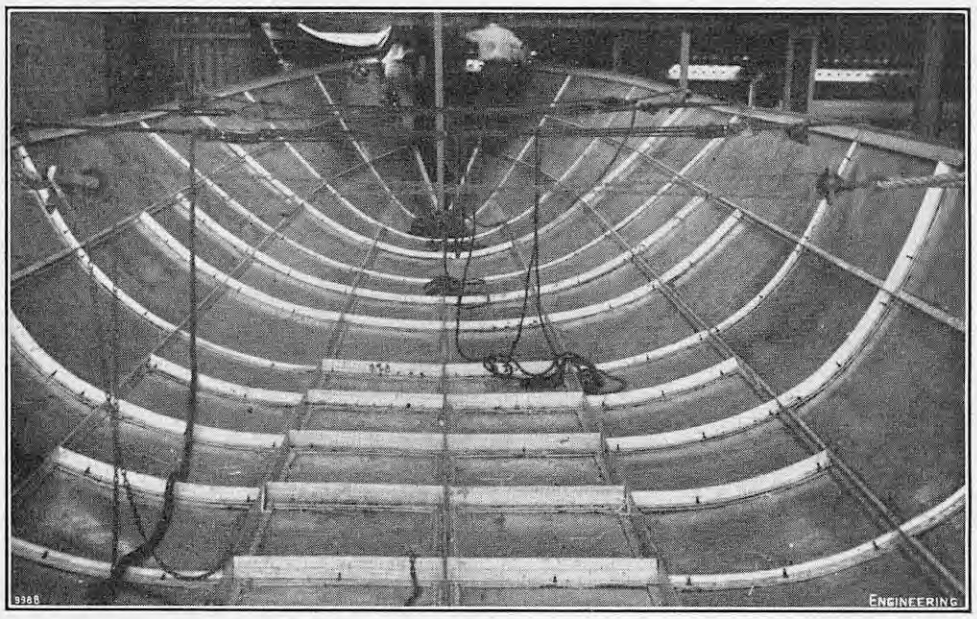


Fig. 2. Hull in Process of Being "Moulded."

Fig. 3. Vessel Resting on Twin Skegs.

85 mm. and 120 mm., respectively, and have a maximum continuous rating of 104 h.p. each at 1,800 r.p.m. and a maximum intermittent rating of 120 h.p. at 2,000 r.p.m. The Foden F.D.6 engine was described on page 406 of our 172nd volume (1951). It is a supercharged two-stroke compression-ignition unit, with uniflow scavenging, operating on the Kadenacy principle, a low-pressure Root's-type blower delivering the scavenging air to a common air chest from which it flows into the cylinders through ports in the cylinder liners. Exhaust valves are located in the cylinder head, there being two valves to each cylinder, operated by push-rods and rocking levers. Considerable use has been made of light alloys in the construction; the cylinder block and combined crank-case, for example, is cast in aluminium alloy.

The two engines fitted in the Tonquin are arranged for fresh-water cooling, the fresh water being circulated through a heat exchanger supplied with sea water by an engine-driven pump. The propellers rotate at engine speed, but a gearbox made by the Self-changing Gear Company, is incorporated in each shaft drive to give astern movements, Silentbloc flexible couplings being fitted to the transmission shafting. Corrosion-resistant light-alloy propellers of the three-bladed type are used; these have a diameter of 17 in., a pitch of 14 in., and are fitted to 1¾-in. diameter chromium-plated shafts. The shafts and propellers were supplied by Parsons Engineering Company, Limited, Southampton, and the stern brackets, made from a heat-treated aluminium alloy to specification L.M.10.W, by Messrs. Victor Moyle and Company, Kingston-on-Thames. Twin rudders are fitted.

The engines are situated in a compartment immediately below the wheelhouse, and are supported on Silentbloc flexible mountings. Electric starters are fitted, current for this purpose and for the vessel's lighting system, etc., being provided by batteries which, with the switchboard, are located at the after end of the engine room. Provision has been made for a small generating set to be fitted, together with an air compressor for the yacht's siren, at a later date, should this be required. All the engine controls, gauges, etc., are grouped together on a panel situated in front of the helmsman and there is no necessity, therefore, for any of the crew to remain in the engine compartment during manœuvring. A small hatch is provided in the deck of the wheelhouse to give access to the engines for routine maintenance, and the complete deck is designed in the form of two portable hatches, which can be removed when it is required to carry out major overhauls to the engines.

The crew are accommodated in the forepeak, which at present has a single berth on the starboard side and an upholstered settee on the port side which can be converted into a second berth. A large teak hatch gives access directly to the deck. A door at the after end of the crew's cabin leads into the galley; this is situated at the starboard side, the equivalent space to port being occupied by the forward two-berth cabin. Access to this cabin is from a small vestibule aft of the galley. Steps at the after end of the vestibule lead up to the main saloon, which measures 15 ft. by 11 ft. 6 in. The furnishings of this compartment include an L-shaped settee which can be used as a berth and two easy chairs designed so that they can be converted into beds. The space below the saloon floor is taken up largely by the fuel and fresh-water tanks, but there is stowage space of about 90 cub. ft. for stores. A door at the after end of the saloon leads into the wheelhouse, whence access is provided to the after accommodation. The single-berth cabin is located at the starboard side of a central passage and the double-berth cabin at the after end. At the forward end of the passage, on the port side, are two linen lockers, heated by the exhaust from the port engine.

The navigating equipment includes a universal Sestral Minor compass, a Consol 66 wireless set with loop aerial, a Walker's patent yacht log, compressed-air and hand-operated sirens, and oil and electric navigation lights. Other items include a double-acting Moyle winch, 35-lb. and 55-lb. anchors, and foam and carbon-tetrachloride fire extinguishers. A 12-ft. launch is carried, and this also is constructed from light alloys on the two-way tension system. It is driven by a 6-h.p. Norman engine and can carry six persons at a speed of over 10 knots. The Tonquin can maintain the cruising speed of 12 knots with an overall fuel consumption of less than 10 gallons an hour, equivalent to 1·2 nautical miles per gallon. An outstanding feature of the vessel is her quick response to the helm, it being possible to turn her in less than two lengths at full speed.

SIGNALS RESEARCH AND DEVELOPMENT ESTABLISHMENT.

(*Concluded from page* 154.)

The wide diversity of work undertaken at S.R.D.E. naturally requires first-class workshop facilities. Well-equipped light-engineering workshops serve the needs of the research and development laboratories and are capable of producing prototypes of all the equipment under development, apart from specialised components such as radio-valves. The work undertaken covers a wide variety of machining operations, sheet-metal working, electrical work, tool and pattern making, foundry work, and rubber and plastic moulding. An apprentice-training scheme is in operation, in which both craft and engineering apprentices are given a thorough practical training; they are also allowed up to two days per week to attend classes in theory at Bournemouth College of Technology. Full-time university-degree courses are offered to selected apprentices who have passed the necessary preliminary examinations.

Important considerations, such as the stability and physical size of electronic equipment, depend to a large extent on the properties and dimensions of their component parts. At the present time, the aim in design is toward reduction in size, proofing against tropical climatic conditions, and improvement of performance which would not be possible without the greatly improved components which are being developed. The attainment of the objectives mentioned, and improvements in the stability, reliability and tropical performance of components, is the responsibility of the Components Development Group at S.R.D.E. A considerable reduction in the size of most components has been achieved in recent years, and improved performance under tropical conditions has resulted from the introduction of new materials and methods of sealing and enclosing components. Dynamic components, such as relays or vibrator units, are generally enclosed in cans, but in the case of static components, such as coils and capacitors, potting or impregnation with suitable compounds has provided a good solution to the problems. Resins of the polyester and epoxide groups are at present under investigation in this connection.

As regards the proofing of equipment, an alternative to protecting the individual components is the sealing of the complete instrument. This has necessitated the development of new types of plugs and sockets, switches, control spindles and similar externally-mounted components. Improvements in components, such as vibrators for producing high-tension supplies from low-voltage batteries, have resulted in greater reliability, increased power and a longer life for the equipment. In the case of fixed capacitors, efforts are being made to produce components of high precision by the use of artificial dielectric materials, such as glass and ceramics, instead of mica.

In radio communication, various factors, such as the increasingly heavy demands for communication channels and the impracticability, in some instances, of quartz-crystal control of frequency, have made the development of stable oscillator and tuned circuits urgent. The main cause of frequency drift in oscillator circuits is the variation of the capacitance and inductance of the circuit elements with temperature. Because of the wide range of temperature (— 40 deg. C. to 55 deg. C.) over which Service equipment is required to operate, the control of frequency presents a serious problem. Present work at S.R.D.E. is directed main to the development of capacitors and inductances which are little affected by temperature changes, and the production of capacitors with known coefficients of temperature variation which can be used to compensate for temperature changes in the electrical values of other components. The Service requirements are that a change in temperature of 1 deg. C. should not cause the frequency to change by more than about 15 parts in a million. In order to be able to measure frequency variations, apparatus has been developed at S.R.D.E. which is capable of measuring the changes accurately to within approximately 2 parts in a million per 1 deg. C.

A long-term stability of components, such as trimming capacitors, is also important, and the Components Development Group has also developed apparatus which is capable of assessing long-term changes in capacitance or inductance to a high degree of accuracy. Changes in capacitance resulting from mechanical instability have also been investigated. The study of components is aided by the use of microscopes, X-ray equipment, a spectrograph and chemical apparatus. These are employed mainly for the examination of materials and for locating faults in sealed or enclosed components.

Reference has already been made to the severe conditions, both mechanical and climatic, which communications equipment used by the Army must be capable of withstanding and under which it may be required to operate. Before any new component is approved for Army use, therefore, it is subjected to a series of stringent tests to ensure reliability. The nature of these tests and the performance required of the component are decided by a number of inter-Service sub-committees of the Radio Components Standardisation Committee.

The standardisation of components is also an important matter since, in the event of war, large numbers of components would have to be produced. It is, therefore, highly desirable that the variety of components should be kept at a minimum. Considerable progress has been made towards achieving this result. The design of thermionic valves and batteries is the responsibility of the radio and electrical industry, who do such work for the Services under Government contracts. The testing and approval of valves and batteries, however, is done at the establishment concerned, on lines similar to those adopted in the case of components. S.R.D.E. is fully equipped with all the apparatus required for these tests. In climatic testing, the temperature range from — 60 deg. C. to 70 deg. C. can be covered, and humid tropical conditions can be simulated. Reduced-pressure chambers are installed, in which conditions in aircraft flying at altitudes up to 60,000 ft. can be reproduced. There is also equipment for simulating tropical rain and dust storms. For assessing durability, there is a bumping machine which simulates transport in a vehicle travelling over rough ground, and drop-testing equipment for packages. A vibration-testing machine covers all frequencies from 10 to 150 oscillations per second and the vibrations of the equipment and its component parts can be studied stroboscopically. Tests of this kind are always made in the early stages of the development of new equipment so that any weaknesses and faults in its construction can be corrected before the design work has proceeded too far. It will be clear, therefore, that everything is done to ensure that the communications equipment provided for the Army will give satisfactory service under the most severe conditions.

BUSINESS EFFICIENCY EXHIBITION, GLASGOW.—In connection with the silver jubilee celebrations of its incorporation, the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4, is holding an exhibition of "business efficiency" equipment at Kelvin Hall, Glasgow, from Tuesday, November 4, to Friday, November 14. This will be the second large-scale exhibition organised by the Association in 1952, the first having been held at Birmingham in February last.

STEEL FOR MERCHANT SHIPBUILDING.—In answers to Parliamentary questions on July 30, Mr. J. P. L. Thomas, the First Lord of the Admiralty, stated that the steel allocation for merchant shipbuilding would be increased from October next. The precise increase had not been settled, but it would not be less than 5 per cent. None of the steel being imported from the United States was being specifically earmarked for shipbuilding.

ELECTRICAL TRAINING AND FUTURE DEVELOPMENTS.*

By Sir John Hacking.

There is a great need for the maintenance of close contact between those responsible for the manufacture and use of electrical equipment of all types. It is to further this ideal that the British Thomson-Houston Company have organised this series of lectures. Such a conference enables the educational side to keep informed of the latest actual and potential developments, and helps to ensure that the standard of graduates from the universities and colleges is adequate for the requirements of manufacturers and users. On looking through the syllabus, subjects and lecturers, I note that, in fact, there is only one lecture which deals with the study of electrical engineering, but 20 which deal with specified new developments, covering a very wide field. As the emphasis of the course is, therefore, more on advanced developments in engineering technique, perhaps I may speak on the general question of technological and technical education; a matter in which the Institution of Electrical Engineers has a great interest and, indeed, as the guardian of the standards of the profession, a great responsibility. The Council, and particularly the members of the Education and Training Committee, are watching with interest two important educational developments which have been made possible by the close collaboration between the B.T.H. Company and the Rugby College of Technology and Arts; I refer to the courses for student apprentices reading for the London external degree and to the advanced courses for graduates. The student or engineering apprentice course is an interesting and valuable alternative to the sandwich course advocated by our Education and Training Committee. Its shape leads me to describe it as a Scandinavian sandwich rather than the ordinary accepted British article.

You may be interested if I outline briefly the views of the Council of the Institution on the broad pattern of the future provision of higher technological education in this country, and particularly of electrical engineering education. The Council are convinced that more effective and wider facilities for technological education should be developed rapidly, as this will have a profound influence on the level of productivity in the United Kingdom; for the rate of increase in productivity is delayed if new scientific discoveries cannot be brought quickly to the stage of effective large-scale application. It is in the detailed engineering steps that lie between scientific discovery and its widespread application in industry that the professional engineer has an important part to play. There is clear evidence that the present numbers of the right type of man are insufficient, and that the number of qualified technologists available each year from universities and colleges must be increased.

The early provision of more technologists will not alone meet the need; the number of competent technicians must also be correspondingly increased, bearing in mind that the desirable proportions may well be in the ratio of some five technicians to each fully-qualified technologist. The Council of the Institution fully grasp the importance of this factor and are actively studying the special needs of technicians in relation to their education and training. This question is separate from the question of the provision of courses in technology, and it is important that provision should always be made for the transfer of senior technicians to full status as technologists; but it is equally important to encourage men who are better constituted to become technicians of good calibre to qualify themselves in that respect, rather than to attempt to qualify from the outset as technologists.

In the provision of qualified technologists, it is the hope of the Council that the universities will continue to play their full part; indeed, there has recently been evidence of expansion which is encouraging. But, despite these developments, the proportion of men who graduate in applied science to those graduating in pure science falls far below the national need. It is to be hoped, therefore, that the recent steps which have been taken in some universities will be followed by others; because the development of technological and advanced technological education in the many-sided environment of a university will produce men of broad outlook, which both the industry and the public utilities in this country will need in greater numbers in future. The valuable leaven which develops through the contacts and discussions between students in different faculties is often seen working to the full in residential universities, in consequence of their corporate life; but not all young men who seek to qualify as technologists respond best to the university approach. Others, potentially of no less value to industry; make more rapid progress if they have constant contact, throughout their studies, with current industrial practice; for these men, part-time National Certificate courses will continue to represent a most valuable method of training, but, in the view of the Council, these courses should be supplemented by an additional system, which I should like to describe to you.

The Council are not enamoured of the idea of a technological "university" on the pattern of either the Elektrische Technische Hochschule or the Massachusetts Institute of Technology, and it is their hope that the developments in existing universities, and the "up-grading" of existing technical colleges, will provide the urgently needed facilities for expansion. Apart from considerations of certain grave risks attached to this proposed experiment, the Council hold that the time factor does not permit us to regard this as an immediate solution to a very urgent and pressing problem.

Outside the universities, the additional facilities should be concentrated and confined to a few designated technical colleges. The technical colleges of this country have made and are making a valuable contribution to the educational needs of industry, mainly through the medium of their part-time courses. An additional contribution, both at graduate and post-graduate levels, is required of them. This could be met economically by certain designated colleges which should be developed for this purpose, and one of their most valuable contributions would be their specially close liaison with industry. For electrical engineers, the Council feel it essential that these new courses should be industrially based and of the sandwich type. These designated colleges could also offer opportunities for higher technological education to past students engaged in industry and could work at a level comparable in quality with university post-graduate work, in particular relation to the needs of the industries whose requirements the colleges more particularly serve.

Activities of this kind require staff and equipment of a high order to provide the conditions necessary for significant contributions to advanced technological research. It is felt, too, that it is preferable that a whole college as a unit, and not individual departments within a college, should be designated and developed. It will also be vitally necessary for the designated colleges to work in close association with specialised colleges within their regions, so that the fullest advantage may be taken of the facilities and industrial connections which they possess. In these designated colleges, the courses must be broadly conceived on a wide basis of fundamental science. Their technological departments cannot flourish alone, but must be sustained by close association with equally extensive and progressive departments of mathematics and physical sciences, and other branches of the applied sciences, all of which must be further sustained by research activity. Attention will also need to be given to the maintenance of an adequate standard of entry in the students accepted.

Another important question is that of control. It seems essential to the Council that the designated colleges should be under a wider control than that of the local education authorities. It is desirable that they should each have an independent governing body, broadly representative, including a substantial representation of industry, so that industry's support in financial and other matters may be encouraged and strengthened. Under an independent governing body, the staff will work in an atmosphere of academic freedom, with corresponding advantage to recruitment. It is also important that those with the duty of selecting colleges for designation, and for assessing the adequacy of their academic and technological standards, must themselves be of high academic and professional status. It follows, as a corollary, that the designated colleges should be substantially financed from national sources and there is much need for careful planning of the method of allocating these central funds. We meet at a time when decisions in these vitally important matters are, I hope, imminent. It is the earnest hope of the Council that the contribution they can make from their experience will be heeded and given its full weight.

I would like next to speak from the viewpoint of the electricity supply industry. The success of the supply industry is dependent in large measure on the provision by the electrical plant manufacturers of up-to-date equipment at an economical price, and to produce such equipment the manufacturers, in turn, depend on the universities and technical colleges for adequate numbers of well-trained technical staff. We, too, depend directly on the training establishments for staff to plan and operate our equipment. These establishments also render us a further service in the field of research; recognising the value of the best possible scientific advice, the British Electricity Authority have appointed a Research Council, the members of which are drawn mostly from the universities. The Authority have also established a fund from which grants are made to universities and higher technical colleges to assist them in conducting long-term researches of a fundamental character, affecting the supply of electricity. Our relations with the training establishments are thus of the closest.

The most important electrical development on which we are now engaged is the 275-kV grid. With a transmission line now operating in Sweden at 380 kV, and lines approaching or exceeding this voltage being planned or under construction in other countries, it is sometimes suggested that we ought to have adopted a voltage higher than 275 kV. Our difficult atmospheric conditions, however, impose on us a special insulation problem and, had we waited for its solution, construction of our higher-voltage system would have had to be postponed for at least five years, and urgent major transmission reinforcements, which could not be postponed, would have had to be carried out at 132 kV. In any case, with our relatively short transmission distance, 275 kV is the most economic voltage for the amounts of power we are likely to have to transmit during the next ten or 15 years. We are, however, making provision on the more important lines for an increase of voltage to 380 kV, should this prove necessary in the future. In the meantime, I am confident that the 275-kV system which is now being built will both call forth and do full justice to the talents of the research engineers and plant designers of the electrical manufacturing industry.

An interesting project is the possible cross-Channel cable. A joint committee of the British Electricity Authority and Eléctricité de France have been giving close study to this and have provisionally recommended a 132-kV connection with a capacity of 100 MW, comprising four single-core cables, one cable being spare. Owing to diversity between the system demands and the method of generation in the two countries, this provision to pass power in either direction is considered to be an economic proposition. Again, it may be asked why a higher voltage and higher capacity are not proposed. One reason is that the existing transmission system in the northern part of France is not strong enough to deal with a heavy cross-Channel power transfer, which would entail an expensive 220-kV reinforcement from a point near Paris. Viewed from the standpoint of both countries, a 132-kV connection is the most economic, but we have in mind that the capacity of the connection could be quadrupled by changing over to direct-current transmission in, say, ten years' time. The decision whether to instal this cable will not be made, however, until

* Address delivered on July 14, 1952, at the British Thomson-Houston Company's Summer School in Electrical Engineering. Abridged.

certain research and development work has been carried out; it is estimated that this will take about 18 months.

What of the future? I would like, first, to say a word on the question of the expansion of the electricity supply industry. Few of us in the electrical profession, I think, have any doubts as to the continued growth of the use of electricity for all purposes for a long time to come. The prospective development of nuclear power, which, thinking in terms of the next 100 to 150 years, seems likely to become a predominant source of power and which, it seems, will have to be used in the form of electricity, lends added assurance to this view. It is unfortunate, therefore, that we hear to-day so many voices advocating artificial restrictions in the use of electricity for other than industrial purposes. For the first time since the war, the growth in demand for electricity in this country has been checked, and output is now approximately equal to, or, if anything, a little below, the level of a year ago. While we can be glad, perhaps, of a temporary respite to enable us to catch up with arrears of plant construction, it is to be hoped that no steps will be taken to curb the natural trend of electrification, which we believe to be so essential to our continuing prosperity. These are no idle fears, however, as the rate of new plant construction which the Government are proposing to permit in 1956 and 1957 is well below what is required to meet the average rate of increase of demand and is also below the capacity of the plant manufacturers.

THE AMERICAN BUREAU OF SHIPPING.

MR. WALTER L. GREEN, President of the American Bureau of Shipping, presented some interesting figures regarding the progress of American-owned and world shipping in his address to the Board of Managers, of which he is chairman, delivered in New York on July 29. Vessels classed with the Bureau at that date, he stated, numbered 8,494, aggregating 37,153,772 tons gross; to which were to be added a further 759 vessels, totalling 3,511,350 tons, then under construction in United States or foreign yards, making, in all, 9,253 ships of 40,665,122 tons. In England and Scotland, 29 large vessels were under construction, 22 being tankers, and two being bulk ore-carriers. The remaining five are cargo vessels. Tanker construction figured largely in the tonnage on order from other countries, to the Bureau's classification, 22 tankers being in hand in Germany, 12 in Japan, 12 in Holland, seven in Italy, five in France, and three in Belgium.

The trend towards increased size of tankers, Mr. Green observed, still continued, and the Bureau had reviewed designs for ships up to nearly 60,000 deadweight tons. It was expected that orders for tankers in that range, and for ore-carriers up to 40,000 tons, would be placed in the near future. Some of the vessels would be over 700 ft. long and 95 ft. to over 100 ft. in breadth. Such dimensions introduced structural design problems, because restrictions on draught at ports necessitate unusually large ratios of length and beam to draught, with the least depth of hull that will ensure the requisite strength. This has resulted in the use of shell plates and deck plates of thicknesses never previously contemplated.

Associated with this problem is that of the strength of welded hulls. Following the breaking in two of two tankers in January of this year, an exhaustive review was made of the design, construction and service records of all vessels of that type (the T-2 type) classed with the Bureau. As a result, all owners of such ships were required to have the bilge keels riveted to the shell, and to provide additional crack-arresting features, in association with additional effective longitudinal material to increase the longitudinal strength. This directive was issued on April 4 and the work is now proceeding, though somewhat retarded in execution by the recent prolonged strike in the United States steel industry. A manual is also in preparation, dealing with the loading of T-2 tankers, to guide the operating personnel in avoiding conditions of loading or ballasting that might induce unusually severe longitudinal stresses.

PHOTOELECTRIC ABSORPTIOMETER.

THE illustrations below are of a new photoelectric absorptiometer, or colorimeter, which has been introduced by Messrs. Hilger and Watts, Limited, 98, St. Pancras-way, Camden-road, London, N.W.1, under the name of the "new Biochem absorptiometer." It is a compact instrument designed for use in chemical laboratories. An unusually high degree of accuracy, for a single-cell type of instrument, has been achieved by embodying in it a sensitive, but robust, reflecting galvanometer, and

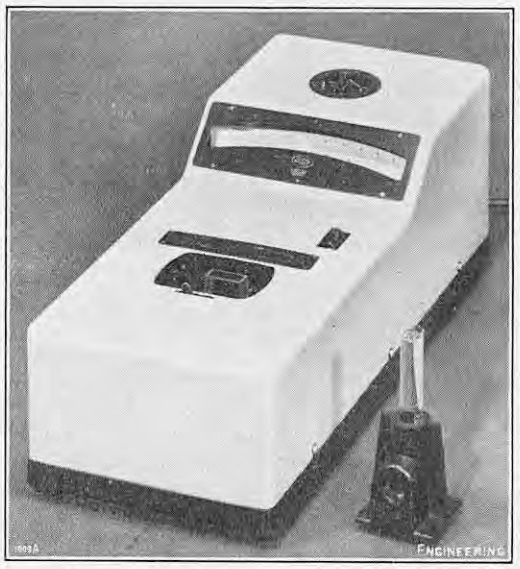


FIG. 1. COMPLETE INSTRUMENT.

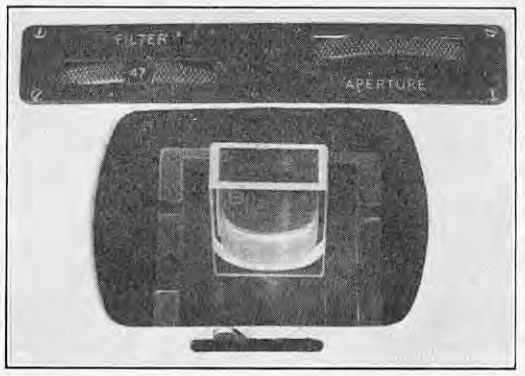


FIG. 2. CONTROLS.

by careful attention to the optical design. As a result of the high degree of sensitivity, it has been possible to use filters with a much narrower bandwidth than is usual in such instruments.

Eight narrow-band filters are mounted in a rotatable disc so that the correct one for the job can be instantly selected. A minor, though useful, feature is that the disc is provided with flats on its circumference; engraved numbers on these flats, as shown in Fig. 2, indicate the approximate transmission peak of the filter in use. Thus, the selection of the right filter is instantaneous and independent of code numbers. A single light source is used for the measuring system and the galvanometer spot-light: a low-voltage lamp is connected, in one model to a built-in constant-voltage transformer or, in another model, to separate batteries. By reversing the usual arrangement of spot galvanometers, i.e., by using a white matt opaque screen instead of a semi-transparent screen, the operator always sees the spot clearly without having to move his head to secure the best illumination. The spot illumination is clear and can be observed without difficulty in a well-lighted room.

Two interchangeable cell mounts are available; that fitted to the instrument takes flat-sided (Spekker) cells with $\frac{1}{4}$-cm. to 4-cm. path length, and is provided with a combined cover and filling funnel, which is invaluable when the fugitive nature of a colour reaction makes it necessary to take readings immediately after the solutions have been mixed. An additional cell mount takes cylindrical cells and has an optical system which largely overcomes the chief drawback of the use of cylindrical cells with photoelectric colorimeters, namely, the fact that such tubes are, in effect, lenses with a focal length that varies considerably with the refractive index of the contained solution and is not consistent for different parts of the spectrum. Consequently, with the usual uncompensated system, there is a variation in the illuminated area of the photocell and therefore a source of error that may be more serious than is suspected. Both the cell mounts are made of a polythene plastic which is highly resistant to most solutions and solvents. They are easily and quickly interchanged. The controls are grouped together, as shown in Fig. 2, and consist of a simple shutter for the measuring light, an on-off switch, the filter selector drum, and a light control for setting the full-scale reading.

NOTES ON NEW BOOKS.

Mathematics for Engineers.

By R. W. DULL; revised and edited by R. DULL. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7.50 dols.] and McGraw-Hill Publishing Company, Limited, 95, Farringdon-Street, London, E.C.4. [Price 64*s*.].

THIS third edition of a deservedly popular book is a major revision, after ten years, of a text first published as long ago as 1926. The general arrangement and all the main features of the original work have been retained, so that algebra, trigonometry, analytical geometry and the calculus are covered in compact style, but quite extensively enough to meet the day-to-day demands of all but highly-specialised engineers. Among its attractive features, the treatment of complex slide-rule techniques and the compilation of formulæ in mensuration, mechanics and the theory of structures deserve special mention. The new material added in the latest edition includes an expansion of the earlier notes on infinite series and determinants, as well as entirely new chapters on differential equations and dimensional analysis. The resulting text, comprising over 800 pages, illustrated by graphs and line diagrams, and clarified by numerical examples bearing on practical design problems, is admirably suited both to engineering students and to senior engineers whose dimly-recalled mathematics needs a convenient and comprehensive source of reference.

Fuel Saving Charts.

By WALTER GOLDSTEIN. John D. Troup, Limited, 90, High Holborn, London, W.C.1. [Price 7*s*. 6*d*., including postage.]

THE 24 charts which form the subject of this brochure are reprints of a series which have appeared in *The Steam Engineer*. The title of the collection should not be taken too literally, for the only saving that such charts can make is possibly that of time, by providing approximate answers to questions that would usually be settled more precisely by simple arithmetic or, in some cases, by recourse to steam tables. The object of the first chart is to determine the heat loss in the flue gases from a furnace burning coal or coke. The user of the chart has to know, besides other things, both the net calorific value of the fuel, and either the maximum CO_2 theoretically obtainable from it, or the percentage of its volatile constituents. Starting from the latter, he will have to make five rectangular steps among the various lines on the chart to arrive at a scale providing the answer. In the case given as an example, the process described indicates a loss which differs by less than three parts in a hundred from the loss computed by the ordinary formula, which could be worked out in less than a minute by any intelligent fireman from the data provided by his CO_2 meter and thermometers alone. Not all of the charts are so complicated as the one referred to, but most are of the same general type. The simplest of all assumes the external heat losses of Lancashire boilers to be dependent only on their diameters, without regard to the effectiveness of their lagging or whether they are single or in a battery. Others relate to heat losses from

pipe lines, bare and insulated; pressure losses in pipes and fittings; theoretical chimney draught; the pressures and temperatures of saturated steam; the total heat of steam; the density (called the specific gravity) of steam and water, and many other matters that may be of interest to owners or operators of steam plant. Wherever coal is concerned, the calculations appear to be based on the lower calorific value, which is contrary to accepted practice.

Deep Diving and Submarine Operations.

By Sir Robert H. Davis, D.Sc., F.R.S.A. Fifth edition. St. Catherine Press, Limited, 39, Parker-street, London, W.C.2. [Price 35*s.* net.]

It is given to few authors to produce such an acknowledged classic as this work, described in the subtitle as "A Manual for Deep Sea Divers and Compressed Air Workers"; but few authors bring to bear on their subjects a comparable knowledge. The fourth edition appeared in 1935, so that a considerable amount of specialised experience, accumulated during the recent war, has had to be incorporated; in particular, there has been a great increase in the use of self-contained diving apparatus, operating on the regenerative system. In this edition, a notable chapter has been contributed by Captain W. O. Shelford, R.N., on the work of the naval "frogmen," and the use of midget submarines. A folding frontispiece provides a key to the various diving suits, deep-sea apparatus, escape equipments, etc. The latest types of metal diving armour, underwater observation chambers, etc., are also described. The general reader as well as the specialist will find much of absorbing interest in this book—not least, the chapter on "Diving for Treasure."

Sailing Ships: Their History and Development as Illustrated by the Collection of Ship Models in the Science Museum. Part II.—Catalogue of Exhibits, with Descriptive Notes.

By the late G. S. Laird Clowes, M.A., A.Inst.N.A. Fourth edition, revised and expanded by E. W. White, A.M.Inst.N.A. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 6s. net.]

It is a commentary on the trends of the times that this catalogue, which was sold for 2*s.* 6*d.* before the war, now costs 6*s.* The Science Museum is under the control of the Ministry of Education, and there was a time when education, by means of Science Museum publications, was deemed an end in itself, worth subsidising from public funds. Now, however, Government publications are expected to pay their individual way. Even so, the catalogue is good value for its enhanced price. The most obvious changes since the previous (pre-war) edition are in the Plates, several of which are new; and in the warning note that, because of lack of space, "a considerable number" of the items described are not on exhibition in the galleries of the Museum. To the late Mr. Laird Clowes—a prominent supporter of the Society for Nautical Research—the revision of this liberally-annotated guide to the sailing-ship model collection was a labour of love. Mr. White has amplified it here and there, with advantage; but, for the most part, the work of the original compilers—for Laird Clowes was not the first—still stands.

The Gas Welding of Aluminium.

Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 2*s.*]

This brochure, Information Bulletin No. 5, is a revision of an earlier publication bearing the same number, which was issud in 1943 under the title of *Fusion Welding of Wrought Aluminium Alloys*. In the revision, the former section on metallic arc welding has been deleted, as it is to be included in a separate publication, to be issued shortly. The present brochure deals with fusion-welding methods and the modifications to them which are necessitated by the characteristics of aluminium. An appendix gives the specified composition of aluminium welding wire and another sets out in tabular form the relation of the relevant B.S. Specifications to the corresponding aircraft specification numbers. There is a short but useful bibliography.

CONTRACTS.

Contracts have been placed by British Railways for new equipment for the renewal of the power-supply system of the electrified lines of the Southern Region at a cost of 12,000,000*l.* The new system will operate at the national standard frequency of 50 cycles, taking current from Deptford power station, now being rebuilt, and also directly from the national grid. The General Electric Co. Ltd. and the British Thomson-Houston Co. Ltd., will supply the high-voltage switchgear. The Hackbridge and Hewittic Electric Co. Ltd., the General Electric Co., Ltd., and the English Electric Co., Ltd., will supply the rectifier equipment. The British Thomson-Houston Co. Ltd., and Bertram Thomas, Engineers, Ltd., will be responsible for the direct-current switchgear, and Pirelli-General Cable Works Ltd. will furnish the high-voltage and pilot cables.

The Marconi International Marine Communications Co., Ltd., Chelmsford, Essex, have received an order for the supply of radio and radar equipment for the 16,500 steam-turbine tanker Sonap, building at the Antwerp yard of John Cockerill S.A., for the Sociedad de Navegacion Petrolera, Chile. The radio-communication equipment comprises transmitters and receivers, and the radar equipment will consist of one Radiolocator IV, having a range of 40 miles, a Lodestone direction finder and a Visagraph echometer installation.

Newton, Chambers & Co., Ltd., Thorncliffe Ironworks, near Sheffield, have received a further order for 30 eight-wheel bogie-type ingot-casting cars, each of 120 tons capacity, for the Abbey Works of the Steel Company of Wales Ltd. These are additional to the 86 similar cars previously supplied. The cars are of all-welded construction and are made from heavy plate. They are each 20 ft. long by 7 ft. wide, and weigh 30 tons. The firm are also supplying 20 all-welded four-wheeled ingot-casting cars, each to carry a load of 50 tons, to the new Norwegian steelworks, A/S Norsk Jernverk.

Head, Wrightson & Co., Ltd., Thornaby-on-Tees, have received an order from British Railways for two 135-ton transformer wagons. Each wagon comprises two main longitudinal beams, placed on each side of the wagon to carry the transformer, the beams being supported on an equalising beam at each end, which in turn is supported by two six-wheeled bogies. The distance between the flanges of the beams is adjustable from 6 ft. 11 in. to 9 ft., in 5-in. steps.

LAUNCHES AND TRIAL TRIPS.

S.S. "World Concord."—Single-screw oil tanker, built and engined by Vickers-Armstrongs Ltd., Barrow-in-Furness, to the order of Mr. Stavros S. Niarchos, for the North American Shipping and Trading Co., Ltd., London, W.1. Second vessel of an order for two. Main dimensions: 625 ft. between perpendiculars by 86 ft. by 45 ft. 9 in. to upper deck; deadweight capacity, about 31,000 tons. Parsons double-reduction geared turbines of Pametrada design, developing 12,500 s.h.p. at 100 r.p.m. in service, and two Foster Wheeler oil-fired water-tube boilers. Service speed, 15 knots. Trial trip, June 27.

M.S. "City of Exeter."—Twin-screw vessel carrying 106 passengers and cargo, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for Ellerman Lines Ltd., London, E.C.3. Second vessel of an order for four. Main dimensions: 500 ft. between perpendiculars by 71 ft. by 41 ft. to upper deck; deadweight capacity, about 10,700 tons on a draught of 28 ft. 6 in.; gross tonnage, 12,500; displacement, 19,645 tons. Two Hawthorn-Doxford six-cylinder opposed-piston heavy-oil engines, developing a total of 12,650 b.h.p. at 115 r.p.m., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Service speed, 16½ knots, fully loaded. Launch, July 7.

Coastal Minesweeper No. 1.—First vessel of a new series, built by John I. Thornycroft & Co., Ltd., Southampton, for the Royal Navy. Length 152 ft. by 28 ft. 9 in. beam. To carry three small guns. Main oil engines constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, July 9.

M.S. "Cherbourgeois No. 5."—Twin-screw Diesel-electric tug, built by Chantiers et Ateliers Augustin Normand, Le Havre, for the Société Cherbourgeoise de Remorquage et de Sauvetage, Cherbourg, France. Main dimensions: 131 ft. 10 in. overall by 29 ft. 6 in. by 14 ft. 6 in.; displacement, 672 tons. Two M.A.N.-type Diesel engines, developing 1,500 h.p. at 150 r.p.m. Speed, 12 knots. Launch, July 10.

M.S. "Glitra."—Single-screw cargo vessel, built by Clelands (Successors), Ltd., Wallsend-on-Tyne, for the Norwegian trade of Chr. Salvesen & Co., Leith. Main dimensions: 205 ft. by 32 ft. 5 in. by 14 ft.; deadweight capacity, 1,150 tons. British Polar oil engine, developing 850 b.h.p., constructed by British Polar Engines, Ltd., Glasgow. Launch, July 22.

BOOKS RECEIVED.

Buckling Strength of Metal Structures. By Friedrich Bleich. McGraw Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 10 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 85*s.*]

Basic Engineering Thermodynamics. By Professor Vincent W. Young. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6·50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 55*s.* 6*d.*]

Ministry of Fuel and Power. Report of H.M. Principal Electrical Inspector of Mines for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

United States National Bureau of Standards. Applied Mathematics Series No. 19. *Hypergeometric and Legendre Functions with Applications to Integral Equations of Potential Theory.* By Chester Snow. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 3·25 dols.]

United States National Bureau of Standards. Circular No. 518. *Molecular Microwave Spectra Tables.* By Paul Kisliuk and Charles H. Townes. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 65 cents.]

The Sterling Area: An American Analysis. Prepared under the direction of John M. Cassels. Mutual Security Agency Mission to the United Kingdom, 1, Grosvenor-square, London, W.1; and H.M. Stationery Office, Kingsway, London, W.C.2. [Price 21s. net.]

Conference on Heating, Lighting and Ventilation for Ironfoundries. Ashorne Hill 26th-28th September, 1951. *Proceedings.* The British Cast Iron Research Association, Alvechurch, Birmingham.

Science Museum. Handbook of the Collections Illustrating British Fishing-Boats and Coastal Craft. By E. W. White. Part II. *Descriptive Catalogue and List of Plans.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

Road Research. Note No. 14. *Prevention of Wet-Weather Damage to Surface Dressings.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

Nomographic Charts. By C. Albert Kulmann. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 55*s.* 6*d.*]

The British Electrical and Allied Industries Research Association. Technical Report No. G/XT 132. *Gas-Blast Circuit-Breakers: the Technique of Recording Current in A.C. Power Arcs around the Period of Current Zero, with some Applications.* By F. O. Mason. [Price 15*s.*] No. G/T 249. *Oil Circuit-Breakers—Pressure Set up by Sudden Increase of Fault Current in an Arc Control Pot.* By W. B. Whitney, H. W. Baldrey and A. E. Helden. [Price 18*s.*] No. L/T 266. *On the Vibrations of Long-Chain Molecules—I.* By B. Szigeti. [Price 9*s.*] No. L/T 267. *The Torsional Vibrations of Long-Chain Molecules—II.* By B. Szigeti. [Price 9*s.*] No. Q/T 119. *The Equivalent Circuit of the Capacitor Transformer.* By M. Waters. [Price 4*s.* 6*d.*] No. Q/T 121. *The Calculation of Currents due to Faults between Turns in Transformer Windings.* By B. L. Coleman. [Price 6*s.*] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Fourth Conference on Chemical Works Safety. Palace Hotel, Buxton, 2nd-4th May, 1952. *Proceedings.* Association of British Chemical Manufacturers, 166, Piccadilly, London, W.1. [Price 7*s.* 6*d.*, post free.]

Development of the Guided Missile. By Kenneth W. Gatland. Iliffe & Sons, Ltd., Dorset House, Stamford-street, London, S.E.1. [Price 10*s.* 6*d.*]

X-Ray Crystallographic Technology. By André Guinier. Translated by T. L. Tippell and edited by Professor Kathleen Lonsdale. Hilger & Watts, Ltd. (Hilger Division), 98, St. Pancras-way, Camden-road, London, N.W.1. [Price 56*s.*]

Red Metal: The Calumet and Hecla Story. By C. Harry Benedict. University of Michigan Press, Ann Arbor, Michigan, U.S.A. [Price 4 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 32*s.* net.]

Economy of Building Materials. Report by the Heads of the Works Directorates of the Service Departments and the Ministry of Works. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

Building Apprenticeship and Training Council. Special Report. *Training for Management.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

Electricity Supply in Great Britain. Its Development and Organization. By Sir Henry Self and Elizabeth M. Watson. George Allen and Unwin, Ltd., Ruskin House, Museum-street, London, W.C.1. [Price 20*s.* net.]