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A Seven-Day Journal

Road Engineers' Conference.

DURING his Presidential Address at the final meeting at Oban on Saturday, September 19th, of the Highway Engineers Association of Scotland, prior to its being merged with the Institution of Municipal and County Engineers, Mr. W. Macdonald, road surveyor for the Lorn district of Argyll, referred to the proposal of the Government to take over certain specified Class I roads. From newspaper reports it appeared that the basic principle in the change-over was actuated chiefly by a desire to secure greater uniformity in methods of road construction. But if that meant the dreadful monotony in design which had appeared throughout the country in the shape of housing, then he pleaded that no such repetition should come to exist on the road system. Referring to road resurfacing, Mr. Macdonald said there was still a wide field for the invention of machinery suitable for work of that kind. While it was recognised that in conjunction with the Ministry of Transport the National Physical Laboratory had accomplished valuable work in connection with the testing of materials and road surfaces, it appeared that the scope might usefully be widened to embrace research on road plant.

General Refractories Limited.

ON Thursday last, September 17th, the new administrative offices of General Refractories, Ltd., at Genefax House, Tapton Park-road, Ranmoor, Sheffield, were opened by Lord Riverdale. In welcoming the distinguished guests, Mr. Frank S. Russell, chairman and managing director of the company, said that the firm had grown with the demand for refractories and its expansion had occurred without destroying competitors. In his reply, Lord Riverdale pointed out the vital part which industry at Sheffield had played in the recovery of the national industries, and that not the least of the recovery was a progressive refractory production. He stated that any firm which, in spite of all the difficulties of exchange and licences, went in for export business was doing one of the greatest services to the country. Unless England exported on a large scale the time would come when it would be very difficult to pay for the foodstuffs and raw materials imported. He stated that one of the main reasons why Sheffield remained a great producing area was that it had a tradition of research, carried out both privately and at the University. Mr. R. A. Kirkby, a director of the company, said that it had been suggested that the company had made some recent acquisitions with a view to forming a monopoly in refractories in this country. He wished to deny that ; rather was it the company's intention to build up a great industry and to take full advantage of the country's natural resources.

Strike at Singapore.

A STRIKE which originated in another industry has spread to the labour employed on the naval and air bases at Singapore, and, according to newspaper reports, is holding up the work. It is reported that some 5000 Asiatics are involved in the Colony, and that of that number about 2000 were engaged on the bases, but the latest information is to the effect that the men are gradually returning to work, after receiving assurances that the alleged grievances would be looked into. The strike started in the pineapple canneries, and called for the intervention of the police. It then spread to the air base, and then to the boilermakers at the naval base, whilst a short but disorganising lightning strike upset the transport system. Whilst it is thought that the trouble was instigated by agitators, the methods of hiring labour in Singapore seem to leave something to be desired. The strikers demand an eight hours' day, increases of wages, the formation of a union, and better conditions. We gather from the latest reports that the trouble has practically subsided, and it remains now to see how far and in what manner the demands of the men can be met or satisfied. It is not anticipated that the strike itself will seriously delay work on the bases. The progress of the Singapore naval base was discussed in a leading article in our issue of Aug. 21st.

The Late Mr. Frank Hornby.

NOT only boys and girls, but many engineers and inventors, heard with regret of the death on Monday last of Mr. Frank Hornby, inventor and manufacturer of "Meccano," at the age of seventy-three years. Whilst his name is more directly associated with clockwork trains, the production of which was added to the primary business—the making of the famous standardised, punctured steel strips and fittings—it is by the latter that he will be remembered. Mr. Hornby was a Liverpool man, and the Meccano idea is said to have sprung to his mind when travelling to the house of a relation who had children to be amused. In a wayside goods yard he noticed a small derrick crane of the familiar type, and observing the manner in which the jib was built up, it occurred to him that with the help of suitable steel strips, bolts and nuts, and some oddments of clockwork, boys could readily make models of cranes and similar structures. The idea seemed so promising that he began to punch the strips with his own hands, and his whole staff was a girl who assembled the parts for sale. That was in 1900, and as an example of the industrial importance that mechanical toy-making may acquire, we may mention that the Meccano factory now gives employment to 1500 persons and covers 5 acres of ground, and that there is a French factory as well. The production of the strips and details is a good example of standardisation. So convenient are the parts for mechanical experimentation that they may be found in many engineering drawing-offices, whilst experimental laboratories, the National Physical amongst them, make frequent use of them. In fact, something that was started as a toy for the amusement of children has become of value to the serious inventor and investigator.

A New Admiralty Research Ship.

ON Wednesday last, September 16th, the announcement was made that Philip and Sons, Ltd., engineers and shipbuilders of Dartmouth, had received an order from the Admiralty for the construction of a non-magnetic research vessel. Built for the special purpose of carrying out magnetic research at sea, the vessel will have a displacement of about 650 tons, and will be rigged as a brigantine. An auxiliary engine, to be built by Petters, Ltd., Yeovil, will be fitted, and a bunker capacity for about 2000 miles at 6 knots is specified. Owing to the nature of her duties, the Royal Research Ship "Research," as she will be called, will be built largely of teak, with bronze and gunmetal frames, &c. The engine will also be especially designed to avoid as far as possible the use of magnetic metals. She is estimated to cost about £100,000, and her complement will number thirty-one, including a scientific staff. In placing the contract, the Admiralty is declaring its intention to take over the work of a magnetic survey of the oceanic areas, brought to an end in November, 1929, when the non-magnetic ship "Carnegie," the property of the Carnegie Institution, was destroyed by fire at Apia, Western Samoa, thus terminating the collection of information which had been issued for twenty-five years. The results of this research had always been available to the Admiralty through the courtesy of the Department of Terrestrial Magnetism of the Carnegie Institute at Washington, and the Department has now presented full details of the construction and equipment of the ship "Carnegie," and is giving the services of her commander as consultant in the design of the "Research."

New Factories Bill.

THE last consolidating Factory Act was passed thirty-five years ago, and the Government has admitted that a revision is overdue. Hence it proposes to bring in a Bill in the next session. To ensure that the Bill shall be satisfactory, a Factories Bill Campaign Committee has been set up, and it is hoped that members of all parties will support it. Miss Gertrude Tuckwell is Chairman, and Lord Listowel Hon. Treasurer of the Committee. One of the prime objects of the Bill will be to secure a new statutory limitation of the working hours of women and young persons. The Chief Inspector of Factories has pointed out that there is a tendency to increase the hours of such workers since trade improved, and has observed that they are generally worked by the least physically fit portion of the industrial population. "The best workers tend to go to the best employers, and the weakest to drift to the factories with the longest hours and the least good conditions." The need for a new Bill has been admitted for years. According to the Committee, one was drafted in 1924 by a Labour Government, and another in 1926 by a Conservative Government, and it is understood that the foundations of both were laid before the war. Sir Edward Troup, when Under-Secretary at the Home Office, wrote between 1922 and 1924 that "probably no departmental Bill has ever had more labour or a greater variety of technical knowledge devoted to it." We understand that the new Bill will embody the substance of the drafts referred to above.

Civil Aviation.

THE Report on the Progress of Civil Aviation published by H.M. Stationery Office last week, contains many interesting particulars about aviation in the United Kingdom, the Dominions, and Colonies. The regular air services operated by United Kingdom companies, both at home and across oceans, made 87,200 stage flights last year, carried 200,000 passengers, 714 tons of mails, and nearly 2000 tons of freight. The number of passengers increased by 48 per cent., the weight of mails by 186 per cent., and the weight of freight by 62 per cent. over the preceding twelve months. As showing the spread of amateur flying, it may be noticed that at the end of 1935 there were seventy light aeroplane clubs in the United Kingdom with a membership of over 9000, and with nearly 2500 members holding "A" pilot's licences. There were also at the end of the year thirty-one gliding clubs with a total membership of 1000, of whom probably one-fifth actually glided. It is of particular interest to note that the export trade in aeronautical products improved greatly, reaching during the year a value of £2,721,441. "More than seventy States throughout the world," says the Report, "appear on the industry's order book, indicating the wealth of experience of operating conditions that is inevitably at the service of the British aircraft designer, as well as the world-wide ramifications of the industry's export activities." The Report deals also with the seaplanes and landplanes to be used in the Empire Air Transport Scheme, and with a new type of aircraft for the Transatlantic service, the Mayo composite craft—see THE ENGINEER, January 3rd, 1936—in which a large flying boat ascends with a smaller long-range seaplane which is launched from the parent as soon as the desired operating height has been reached.

Maiden Voyage of the M.V. "Dunvegan Castle."

THE Union Castle Mail Steamship Company, Ltd., recently took delivery of the new motor vessel "Dunvegan Castle" from the builders, Harland and Wolff, Ltd., after very successful trials, and the vessel sailed on Friday last on a special voyage to South and East Africa. The line has placed in service four passenger liners with a total gross tonnage of 80,000 within the space of seven months. The new vessel is a sister ship of the "Dunnottar Castle," delivered in June last. She has an overall length of 560ft., a moulded breadth of 71ft. 6in., and a gross tonnage of 15,007, a rounded stem, a cruiser stern, two masts, and a single funnel of the streamlined type. Her twin main engines are Harland Burmeister and Wain double-acting, two-cycle, airless injection, nine-cylinder units of 450 mm. bore and 1200 mm. stroke. The uniflow scavenging system and tuned exhaust pipes are embodied in the design. The auxiliary plant consists of four 350 kW generators, each driven by a six-cylinder, 280 mm. by 500 mm. engine of the same type at 330 r.p.m. Two waste-heat boilers equipped for oil firing in port are also provided, and electric auxiliaries are fitted. An interesting installation is the Harlandic electric clock control, which automatically keeps correct ship's time without resetting during the voyage.

Hampshire Coast Protection.

A PUBLIC inquiry was held by Mr. R. Gadsby, an Inspector of the Ministry of Health, at Bournemouth Town Hall, on Tuesday last, September 22nd, at which it was stated that the proposal to construct a concrete groyne, estimated to cost about £19,000, was made necessary by the mining of ironstone at Hengistbury Head about 100 years ago. Mr. F. P. Dolamore, a former Borough Engineer of Bournemouth, explained that between 1840 and 1870 mining operations had exposed the sandy material of the headland to the action of the wind and sea. The consequent erosion, if unchecked, might lay open Christchurch Harbour to the south-westerly gales and turn Hengistbury Head into an island. It was proposed to fill in a "deep" between the sea end of the headland and a ledge of rock 700ft. to seaward by the action of a groyne. Mr. Dolamore expressed himself as confident that the presence of the groyne would cause sand and shingle to accumulate to the west of the headland instead of, as at present, being carried round it. The accumulation would protect the cliffs, which were now eroding at a rate varying between 4ft. and 1½ft. per annum. The Christchurch Borough Council was stated to have withdrawn its initial opposition to the scheme and the approval of the Ministry of Agriculture, the Board of Trade, and other authorities had been obtained. There being no opposition, the inquiry was closed.

Non-skid Road Surfaces.

SPEAKING at the National Road Transport Conference at Brighton on Tuesday, September 22nd, Major F. G. Turner, Engineer-in-Charge of experimental Work at the Ministry of Transport, pointed out that in designing concrete roads weather protection was as necessary as protection from wear. He expressed favourable views on the subject of tar and bituminous surfaces, and mentioned that in a certain case an asphalt surface had been applied to a stretch of concrete road surface which had already been in use for a number of years. Not only did the road surface remain undeformed, but an excellent riding surface resulted. The application of thin carpets of balanced mixtures of stone and binder as a means of renewing the top dressing of a road had produced excellent results as a non-skid surface. Professor R. G. H. Clements, of London University, pointed out that road work to-day was entirely experimental and that the experiment did not cease with the engineer's work. Scientific work was required from the chemist and from others concerned in the production of materials. Excellent results had already been obtained in Germany, but, as in most foreign countries, the problems of traffic density encountered in England were unknown. Lord Howe, chairman of the British Road Federation, pointed out the danger of roads the colour of which was highly light-absorbent. The colour of the road surface made a great difference to the danger of driving at night. The dangers of the existing design of roads, particularly the danger of the 30ft. wide road as opposed to the 40ft. road, were also mentioned.

The Art of Gear Design.

By H. E. MERRITT, D.Sc.

No. XI.

(*Continued from page 279, September 18th.*)

PRINCIPLES OF GEAR-TOOTH GENERATION.

A NECESSARY preliminary to the study of the detail design of tooth forms is an understanding of the principles underlying the methods by which the teeth will ultimately be produced. It might be assumed that if a tooth is designed, for example, to have an involute profile of certain basic dimensions, the manner in which the tooth form is actually produced is no concern of the designer. Such an assumption, commonly enough encountered, gives a good deal of trouble to those responsible for the production and performance of gears.

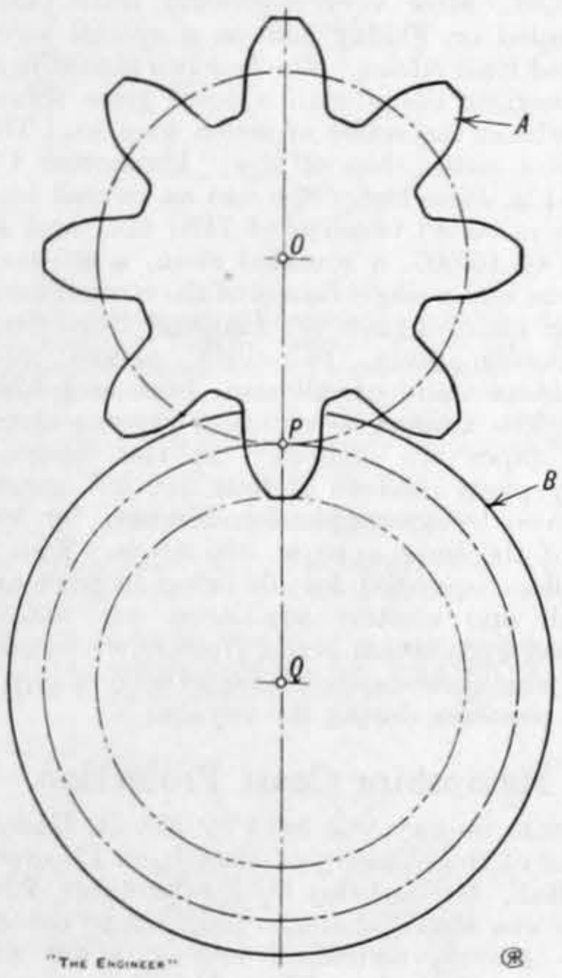


FIG. 65—ELEMENTS OF A GENERATING PROCESS

Because an involute tooth is superficially simple, it does not follow that any involute profile can easily be produced, even if at all; internal gears in particular are full of pitfalls. Furthermore, it must be borne in mind that a tooth profile is not limited to the portion which actually comes into engagement, but extends, as the clearance curve, down to the bottom of the tooth space. The form of the clearance curve is determined by the shape of the cutter in conjunction with the method of production employed, and not only influences the strength of the tooth, but may also limit, or interfere with, the working portion of the profile.

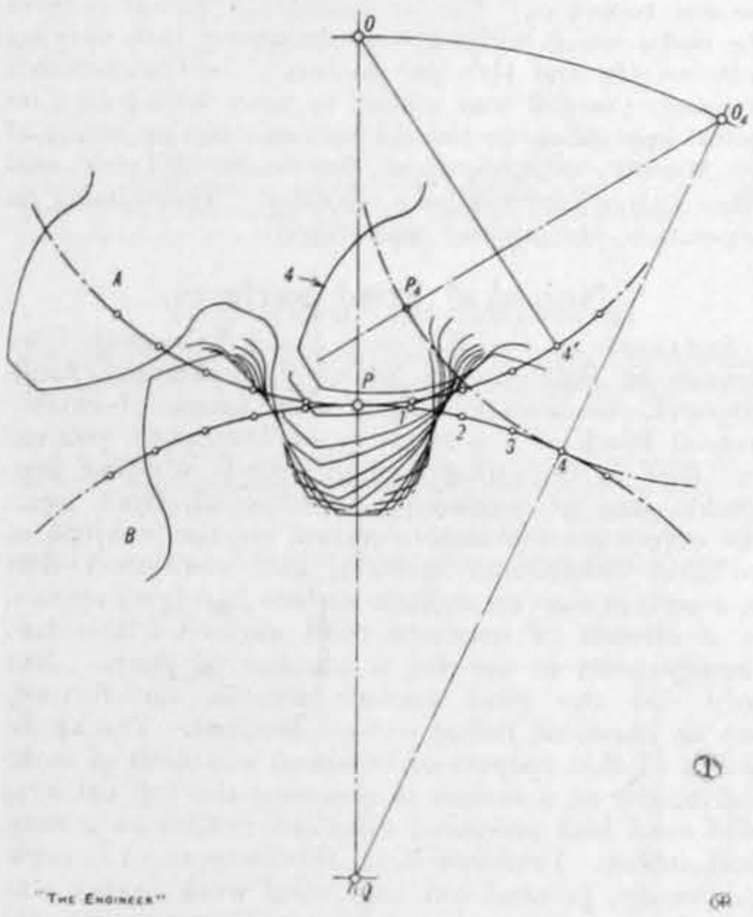


FIG. 66—ROLLING MOTION BETWEEN GENERATING CUTTER AND WORK

The variety of gear-cutting processes is so great that a comprehensive description of them, and of all their intricacies, cannot here be attempted; but for the purposes of design to meet normal requirements only the principles underlying what are known as "generating" processes need be dealt with.

The Meaning of "Generation."—All gear design is based on the fact that if two bodies (a pair of engaging gear teeth in particular) have a predetermined relative motion and touch each other at every instant, their respective profiles or surfaces bear a definite relationship to each other. The principles governing the relationship between the surfaces and the position and motion of the points or lines of contact between them have already been discussed.* If the relative motion of the surfaces and the form of one of them are given, the determination of the form of the other may be regarded as a problem capable of solution by either graphical or analytical means.

The actual production of gear teeth represents a solution of the same problem by mechanical means, and the method employed is termed "generation." Any such method may be regarded as the mechanical embodiment of a combination of two principles which may be described as follows:—

(*a*) A cutting point or cutting edge is given a motion whereby it is caused to sweep out the surface of the teeth of the known member of a pair of conjugate gears (the mating member being required).

(*b*) A "blank," in which a tooth form conjugate to that represented by the cutter is to be generated, is mounted in the appropriate relationship to the cutter and the motion which the finished gear would have relative to that to which the cutter corresponds is superposed on the cutter and/or the work.

By the addition of relative motion other than that required to give the cutting action, the profile given to the work is different from that of the cutter, and it is this which distinguishes generation from forming, in which the shape of the cutter is merely reproduced.

The difference between generation and forming is illustrated by the production of a screw thread by the alternative processes of milling and chasing. When chasing, the work is given a helical motion relative to the tool, and the thread form produced is a copy of that of the tool, taken in the plane containing the cutting edges. In the milling process, however, the edges of the rotating cutter sweep out a surface of revolution, and by superposing the helical motion of the work a thread form is produced which is different from that of the cutting edges and, in fact, from any section of the surface of revolution which they sweep out.

Determination of Tooth Profile by Graphical-Generation Method.—In the actual cutting of gears only the generation of surfaces comes up for consideration. By way of example, however, the generation of one plane curve or profile from another may with advantage be described, particularly since the process frequently has to be carried out graphically (possibly with mechanical aids) in gear design problems.

Referring to Fig. 65, suppose that two gears are required to operate on centres O and Q respectively, that the profile of the teeth of A is known, and that the form of the teeth of B (which is shown only as a "blank") is required. After finding the position of the pitch point P corresponding to the centre distance and angular velocity ratio, the analytical or equivalent graphical solution would consist in determining the path of contact which the teeth of A would have, and thence finding the profile of B which would give the same path of contact.

The graphical or mechanical solution by generation consists in giving the profile of A the property of cutting or marking the surface of the blank B; by tracing on, or cutting away, the surface of B along the profile of a tooth of A in a number of successive relative positions of the pitch circles during their relative rolling motion, a tooth profile conjugate to the teeth of A results.

It may be noted that the given relative motion of the generating and generated members may be produced in a variety of ways. The actual motions consist of rotations about the respective centres O and Q; this corresponds to rolling of the pitch circles at the point P, but the same relative motion takes place if the pitch circle of B is fixed and that of A is rolled round it. This is illustrated in Fig. 66, in which the pitch circle of B has been divided into equal arcs by points P, 1, 2, 3, 4, etc., the pitch circle of A being similarly divided into arcs of the same length. When A rolls over B to bring the points 4 and 4′ together, the centre of A will be at O_4 and the tooth profile of A will be in the position 4. Repeating this process a sufficient number of times gives a corresponding number of positions of the generating tooth profile. The tooth profile of B is the envelope of all the successive positions of the profile of the generating tooth.

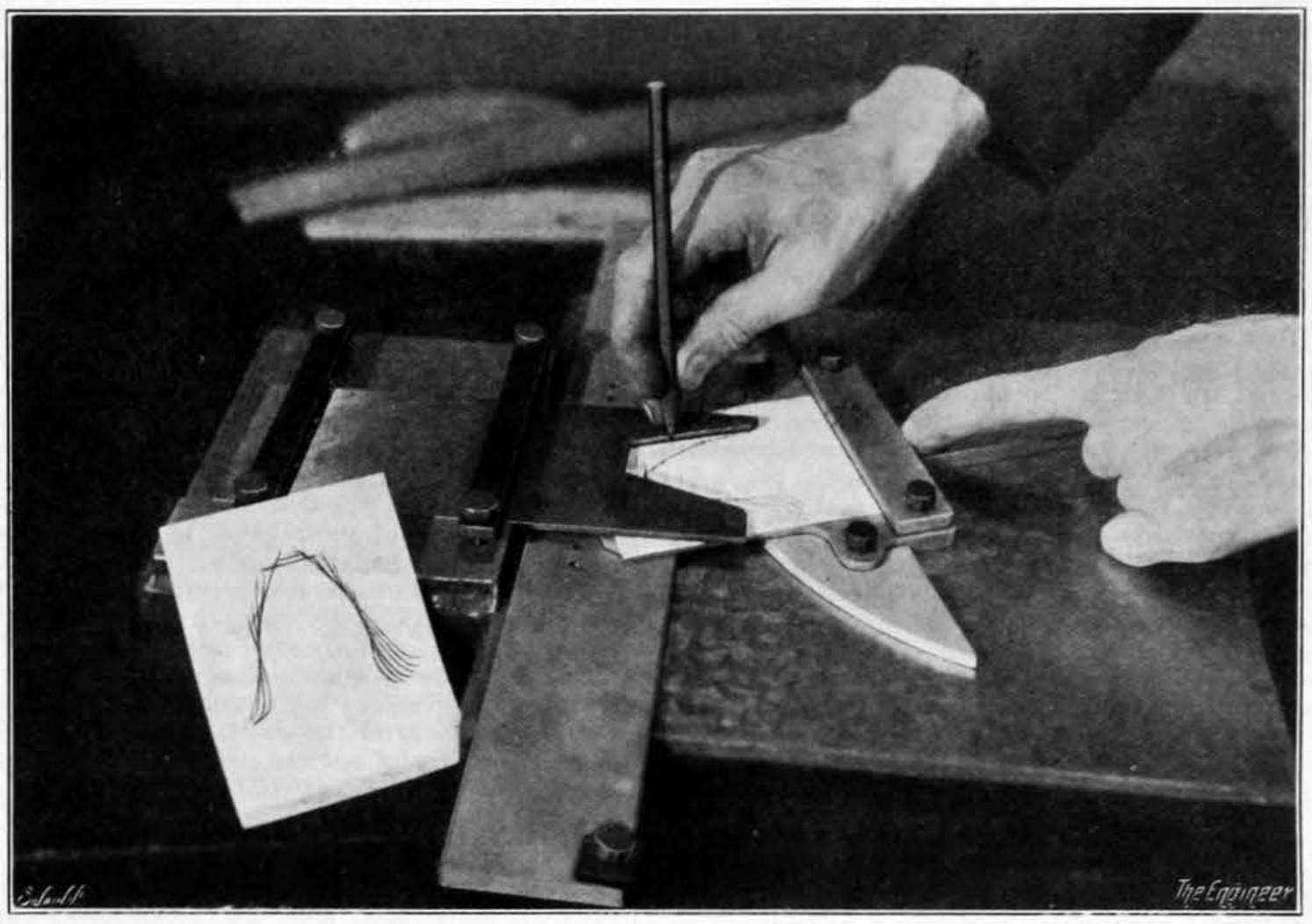


FIG. 67—INSTRUMENT FOR ROLLING TOOTH PROFILES GRAPHICALLY

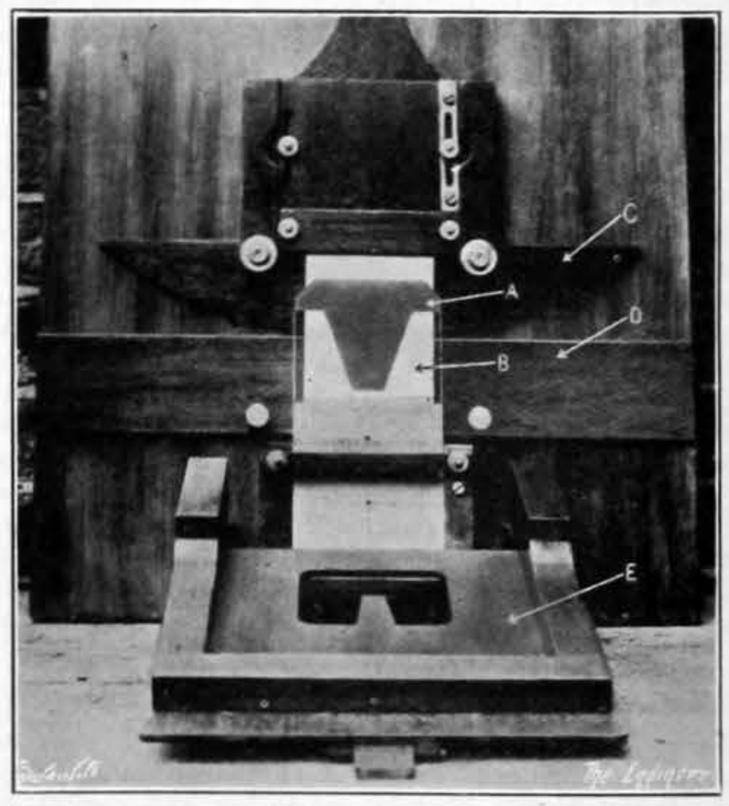


FIG. 68—INSTRUMENT FOR ROLLING TOOTH PROFILES PHOTO-MECHANICALLY

If this procedure is followed in the graphical determination of tooth forms the most convenient method is to keep the pitch circle and tooth profile of the generating tooth A fixed in position, draw the pitch circle of the generated tooth B on tracing paper, and subdivide both pitch circles into arcs of equal length. The pitch circle of B may then be rolled over that of A by bringing successive marked points into coincidence (keeping the pitch circles in tangential

* THE ENGINEER, August 21st and 28th.

contact), in each position the outline of the generating tooth being traced. The result on the tracing will be identical with that shown in Fig. 66.

The instrument (in use in the technical department of David Brown and Sons, Ltd.), shown in Fig. 67, represents a step towards generation by purely mechanical means. A segment representing a

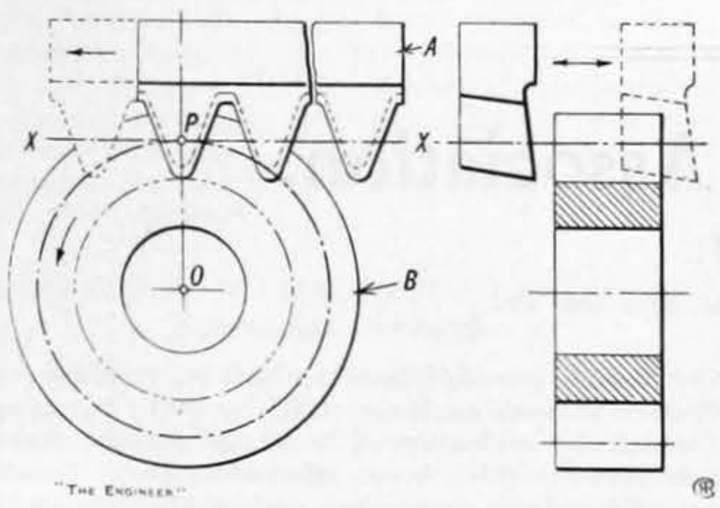


FIG. 69—GENERATION OF SPUR GEAR BY RACK-FORM CUTTER

portion of one of the pitch circles is attached to a base plate and a templet representing the generating tooth is mounted above it in the correct relative position. (The segment and templet shown in the illustration correspond to the pitch line and tooth of a rack.) The pitch circle of the gear to be generated is represented by a second segment, and this is secured to a movable platform to which may be clamped a piece of card on which the generated tooth is to be drawn. The two segments are then rolled together, slip being prevented by a steel tape clamped to opposite ends of the respective segments, and in each of a large number of positions the profile of the templet is transferred to the card by drawing. A typical result is inset.

A still further stage is represented by the photo-

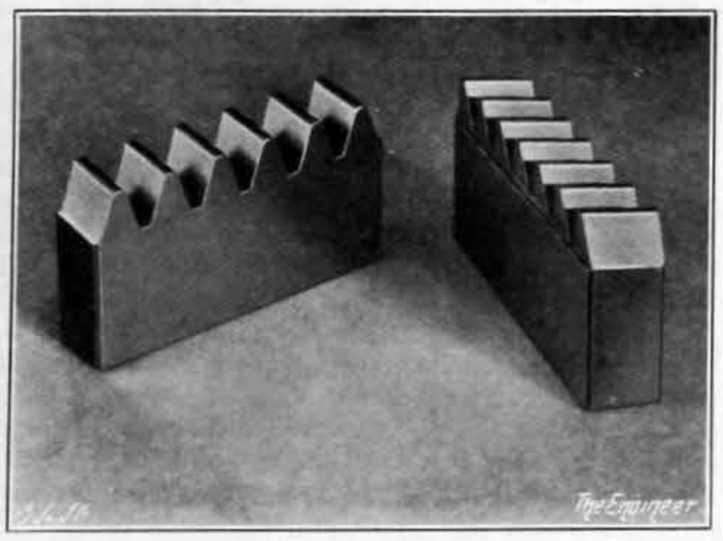


FIG. 71—TYPICAL RACK-FORM CUTTERS FOR SPUR AND HELICAL GEARS

mechanical apparatus, similar in principle, shown in Fig. 68. Here the counterpart A of the templet is used, the card B on which the generated tooth profile is required is photographically sensitised, and a beam of light is directed perpendicularly on to the templet and, where it is cut away, on to the surface of the card. In any one position the form of the generating tooth is impressed photographically on to the surface of the card, and if the segment C carrying the card is given a complete rolling movement over the straight-edge D (which represents the pitch line of the rack tooth A) the result, on developing the image, is the sum or envelope of all the positions of the generating tooth profile in white on a black background. A shield E can be swung into position to protect the card from extraneous light.

The final step towards complete mechanical generation consists in converting the templet into an actual cutter. If, for example, a cutter were made with suitably relieved cutting edges identical in profile with the teeth of the gear A in Fig. 65, and were reciprocated in the direction of its axis, the cutting edges would sweep out a surface corresponding to the actual tooth surfaces of the gear represented by A. By then mounting a blank in the position of B and providing a mechanical drive whereby the cutter and blank are given rotary motions about their respective axes with the appropriate angular velocity ratio, the cutter would generate conjugate teeth in the blank.

Generation by Means of a Rack-shaped Cutter.—In the foregoing example it has been assumed that the cutter corresponds in form (with the exception of additions to the height and thickness of the tooth form in order to give the necessary clearance and backlash) to the mating gear. Generation by means of such a tool may be termed "copy-generation." From the properties of intermating series already discussed,* however, it follows that if the cutter be made in the form of one member of such a series all the gears which it generates will mesh correctly with each other.

In particular, the cutter may be in the form of a rack. By adopting the involute system of tooth profiles the cutter corresponding to the rack will have straight sides (ignoring certain arbitrary modifications discussed in a later section) and its manufacture, although rendered slightly more difficult than at first sight appears, by reason of the degree of accuracy required, is at least easier than if the profile were given any other curved form.

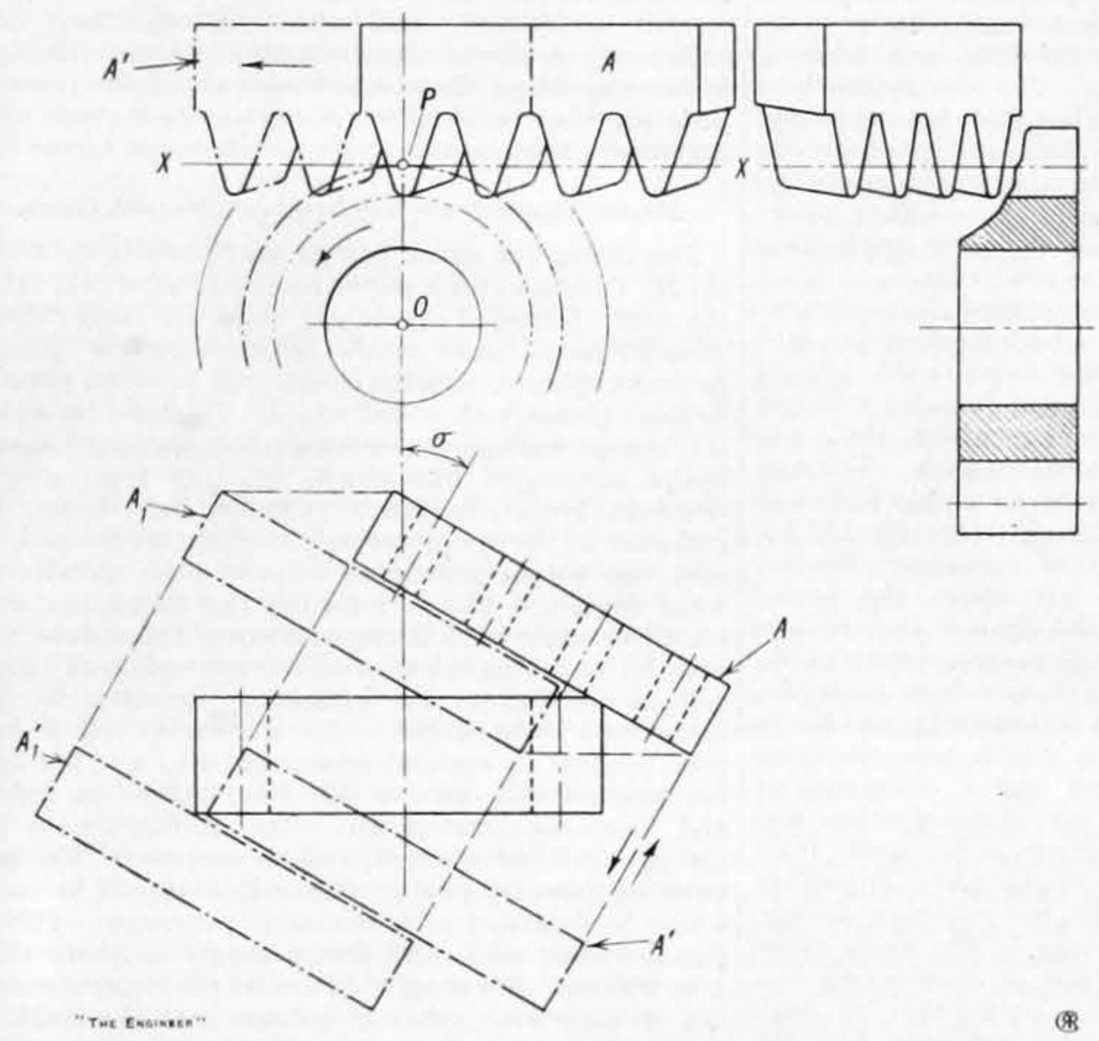


FIG. 70—GENERATION OF HELICAL GEAR BY RACK-FORM CUTTER

The arrangement of such a cutter relative to the blank is illustrated in Fig. 69. The cutter A, which may be adjusted radially with respect to the axis of the work, is reciprocated in order that its edges may sweep out the surface of the teeth of the imaginary rack forming the basis of the design of the tooth profile required to be given to the blank B. In addition to this reciprocation, the cutter is advanced in the direction of the pitch line X P X and, at the same time, the work is rotated about its axis O at a speed such that its pitch circle through P has the same linear velocity as that of the rack, *i.e.*, the pitch circle of the blank and the pitch line of the rack roll together. In consequence the straight cutting edge generates an involute profile in the blank in accordance with the principles of conjugate tooth contact. For such a process to be continuous the length of the rack cutter would require to be somewhat longer than the pitch circumference of the work; since this is usually impracticable, the cutter is withdrawn from the work after it has advanced a distance equal to one pitch (or an integral number of pitches) and returned to its starting point, the blank meantime remaining stationary. This cycle is repeated until all the teeth are cut.

Provided that the method of relieving the cutter is suitably chosen, the cutter can be re-sharpened without changing its profile. The process is suitable for cutting external gears only.

Rack Generation of Helical Gears.—A helical involute gear is conjugate to a straight-sided rack having inclined teeth. The method described above for generating spur gears can therefore be easily adapted to the cutting of helical gears by changing the direction of reciprocation of the rack cutter. The arrangement is then as illustrated in Fig. 70. The cutter A is reciprocated in a direction inclined to the axis of the work at an angle equal to the spiral angle required, and is simultaneously rolled over the blank in the direction X X. The normal profile of the basic

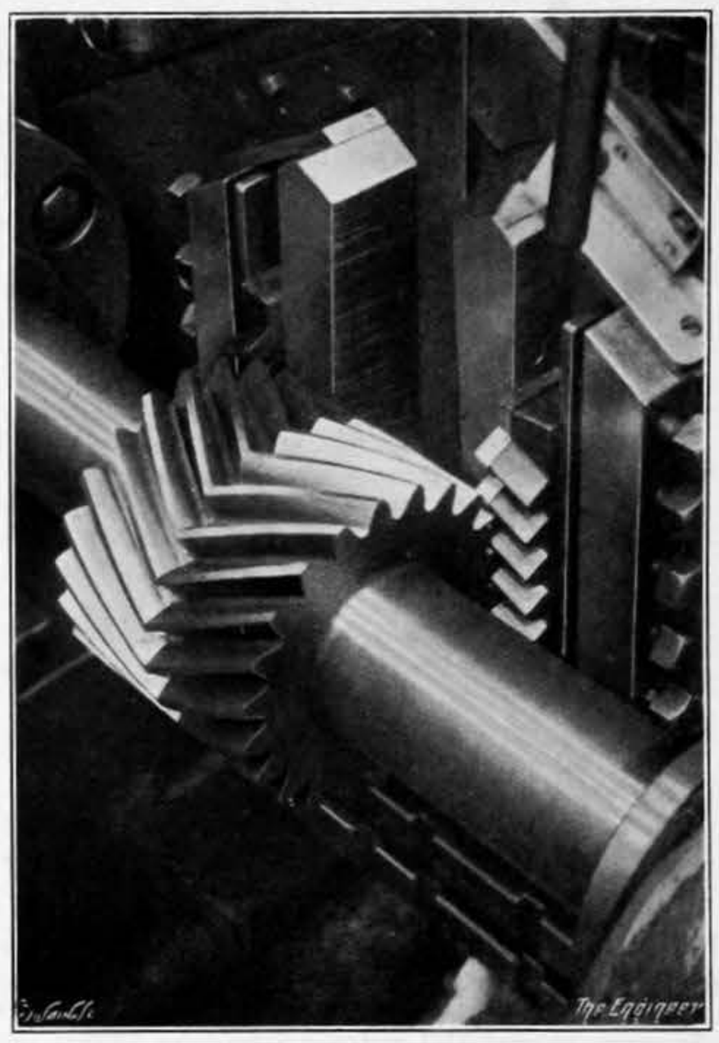


FIG. 72—DOUBLE-HELICAL PINION IN COURSE OF GENERATION

rack of a helical or spiral gear may be, and usually is, identical with that of a spur gear of the same normal pitch, and consequently the same cutter will produce all spur, helical, and spiral gears of the same normal pitch, regardless of number of teeth and spiral angle, and all such gears will be conjugate to each other if mounted in the appropriate relative position. Typical cutters are shown in Fig. 71.

The same principles may be applied to the profile grinding of the teeth of spur and helical gears by substituting for the cutters an abrasive wheel which either represents directly, or sweeps out in the course of its motion relative to the work, the plane faces of the teeth of the imaginary rack.

Generation of Double-helical Gears by Rack Cutters.—An interesting extension of the principle described above is provided by the "Sunderland" process for generating double-helical gears having teeth which are continuous at the apex. The method, illustrated in Fig. 72, consists in the employment of two cutters of rack form arranged to reciprocate alternately in directions parallel to the tooth spirals of the right and left-hand helices of the gear. The stroke of each cutter terminates in the central plane, and each cutter therefore clears away the chip left by the other on the preceding stroke. The cutting edges sweep

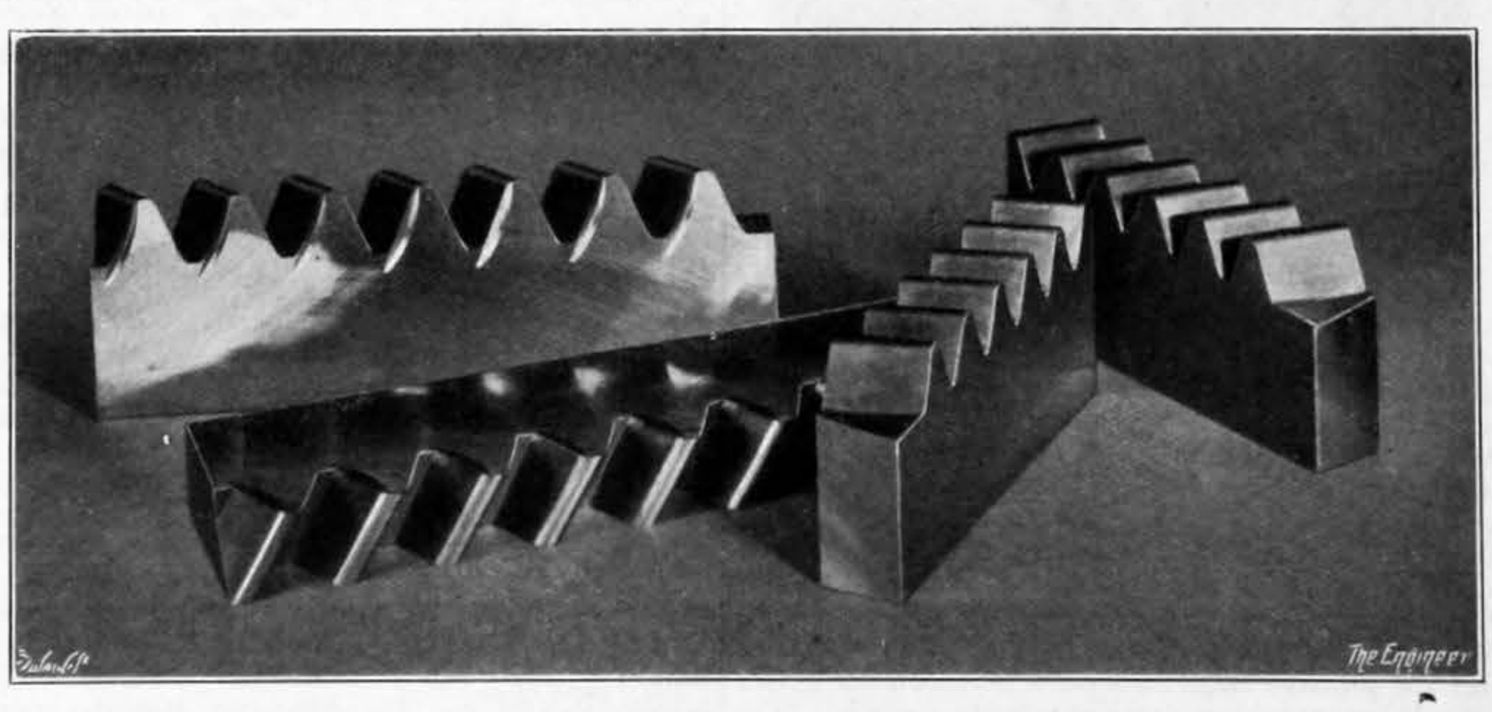


FIG. 73—RACK-FORM CUTTERS FOR PLANING DOUBLE-HELICAL GEARS

* THE ENGINEER, August 21st and 28th; Principles of Tooth Contact, Part VI and VII.

out the surfaces of an imaginary double-helical rack with which the gear to be generated will be conjugate; the generating action is derived from rotation of the work and superposed linear motion in the direction of the pitch line of the head carrying the cutters, in the manner described in the previous example. Typical double-helical cutters are illustrated in Fig. 73.

Generation by Gear-shaper Cutters.—A rack-shaped cutter may be replaced by one corresponding in form to any gear which can be derived from the same basic rack. This is the basis of the "gear-shaper" process, the cutter being in the form of a pinion having involute profiles and suitably relieved flanks. The relative position and motion of the cutter and the work correspond to two gears rotating in mesh, and Fig. 74, in illustrating this, also shows the possi-

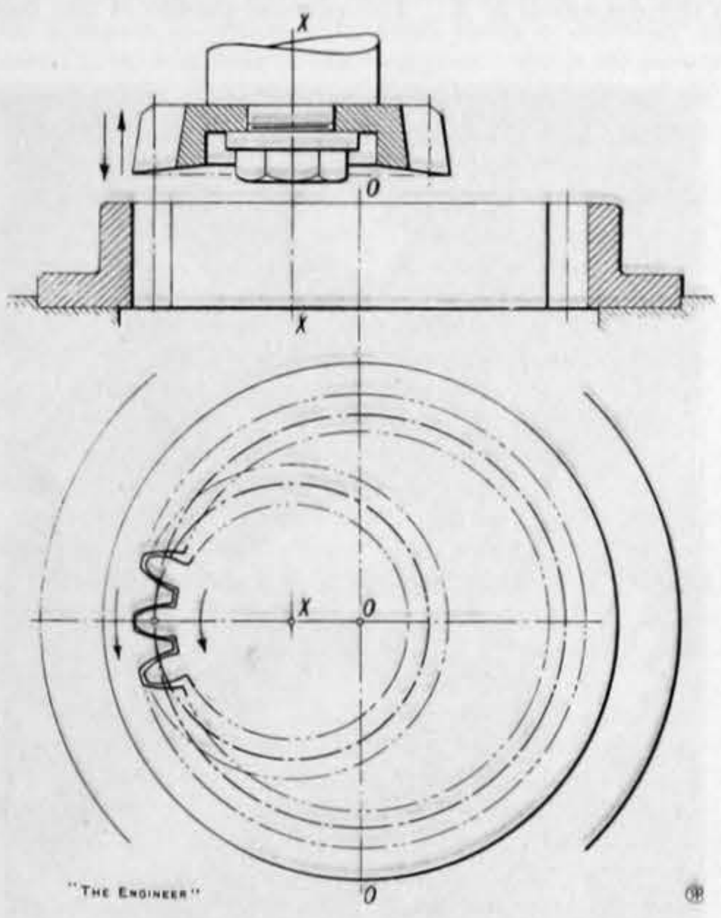


FIG. 74—GENERATION OF INTERNAL GEAR BY GEAR-SHAPER PROCESS

bility offered by the process of generating the teeth of internal gears.

As before, reciprocation of the cutter in the axial direction causes the cutting edges to sweep out a surface corresponding to the teeth of the conjugate gear which the cutter represents. In addition, the cutter and work are mechanically connected and caused to rotate at speeds appropriate to the respective numbers of teeth; in this sense the process is continuous and does not involve the intermittent cycle for indexing necessary in the rack-planing process as usually carried out.

The effect of sharpening a cutter of this type, which must necessarily be provided with adequate clearance on the flanks of the teeth, is to reduce the diameter of the cutter, and the question of what variation results in the form of the gears produced

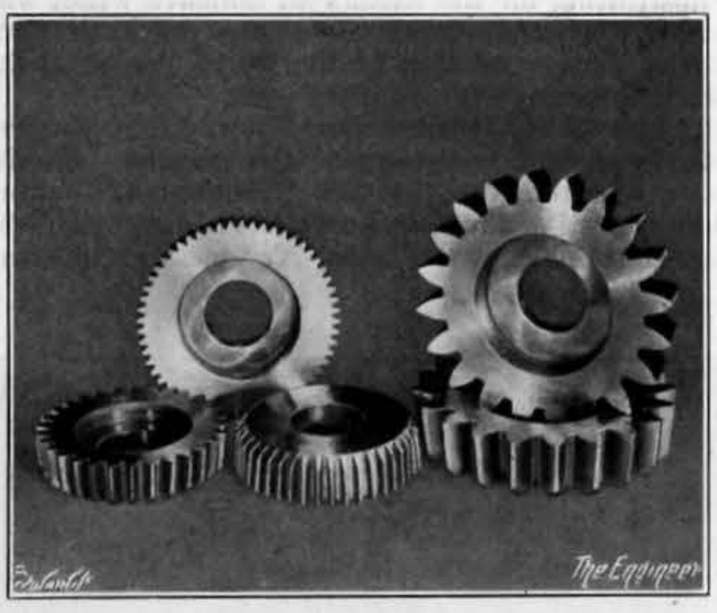


FIG. 75—TYPICAL GEAR-SHAPER CUTTERS

naturally arises. Fortunately, the property of involute gears of working correctly at varying centre distances overcomes the difficulty which any other tooth form would present. Without going into detail at this stage, it may briefly be stated that the profiles of the teeth of the cutter on every transverse section are involutes to the same base circle. As the diameter of the cutter is reduced by sharpening, the centre distance (when cutting an external gear) decreases and the pressure angle and pitch at which the cutter actually operates are correspondingly reduced. The base diameter being constant, however, the base pitch remains the same and the base diameter of the gear produced is therefore unaltered. There are a number of points of detail which arise in making a closer study of tooth forms as generated by this process, in connection with the form of the clearance curve, the paths of face and flank contact, tooth thickness, and, in the case of internal gears, interference in various forms, but consideration of these is reserved until later.

By making the teeth of a gear-shaper cutter of helical form and giving the cutter a helical reciprocating motion with the corresponding lead, helical gears may be generated. Such a cutter may be regarded as conjugate to the basic rack from which the helical gears are derived. For mechanical reasons, the spiral angle which can be given to the teeth by this process is limited. Typical gear-shaper cutters for spur and helical gears are illustrated in Fig. 75; it may be noted that in the course of manufacture these cutters are themselves generated from an abrasive wheel, the active surface of which represents a tooth of a straight-sided rack.

(To be continued.)

The British Association.

No. II.

(Continued from page 288, September 18th.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCES.

The Production and Technical Application of High Voltages.

ON Monday morning, September 14th, Section A discussed the production and technical application of high voltages. The subject was selected by the Council of the B.A. for discussion as having a direct bearing on the life of the community.

Dr. T. E. Allibone (Metropolitan-Vickers Electrical Company, Ltd.), who opened the discussion, said the fact that the subject had such a bearing upon the life of the community would be appreciated by considering how dependent we were upon the continuity of service of the 132 kV grid transmission system. It was the business of high voltage engineers to study the technical features involved in producing and maintaining that system. He also referred to the use of high voltages in the hospitals for the taking of X-ray photographs (a million such photographs are taken in the hospitals of the world annually) and the treatment of disease, and said that many new developments were likely to find application as curative agencies in the next few years.

The four types of high voltages used, he said, were A.C., impulse, D.C., and high-frequency A.C. Measurement of only the first type could yet be said to be satisfactory. A.C. and impulse voltages were used mainly in engineering, whilst D.C. was used mainly in physics and medical work. Voltages of about 1 million were necessary to supply sufficient information for the designs of apparatus for 132 kV systems, and in the tests that had been devised ample tolerances had been left above the actual operating voltages to safeguard against the changes in operating conditions—humidity, atmospheric pollution, lightning disturbances, temperature rises, &c. D.C. voltages were applied extensively to X-ray tubes, a field of application which was widening rapidly; higher voltages and higher intensities of rays were being used. Atomic disintegration and the production of radio-active substances from high-voltage vacuum tubes might have important applications to medical research in the coming decade.

In the course of a brief review of the many types of generators at present in use in engineering and physical laboratories for the production of high alternating, direct, and impulse voltages, and the purposes for which they were used, Dr. Allibone said that there were so-called 1,000,000-volt transformers, but it had become practicable to use smaller units, of 500,000 or 300,000 volts each, in series, and to energise one from the other by putting a tertiary winding into the first transformer to supply power through the primary of the second, or to supply each transformer through alternators driven through a bakelite shaft. As many as six had been connected in a cascade in one transformer built by the General Electric Company.

Dr. Allibone mentioned the recent installation of electrostatic precipitators at a power station, the equipment precipitating 1000 tons of dust per week, which dust would otherwise pass up the smoke stack.

The Ionisation Measurement of Short-wave Radiation.

Dr. G. W. C. Kaye and Mr. W. Binks (of the Physics Department of the National Physical Laboratory) presented a paper on the accurate measurement of the quantity or "dose" of radiation administered to patients, pointing out that the success and safety of cancer treatment by X-rays and radium, whether singly or combined, depended largely upon accurate measurement. The most satisfactory method available, said the authors, was a physical one involving the determination of the ionisation produced in air by the electrons liberated by the radiation. For X-radiation the air-ionisation unit of quantity called the röntgen had been accepted internationally, but the difficulties hitherto encountered in measuring very short-wave radiation, such as the γ-rays from radium, had given rise to doubts concerning the feasibility of expressing X-ray and radium measurements in a common unit, a procedure admittedly desirable. The difficulties of realising the röntgen in the case of γ-rays were due to the long ranges of the electrons liberated in air (up to 10ft. or 12ft.).

Dr. Kaye and Mr. Binks, however, showed that those difficulties could be overcome by the use of a very large parallel-plate ionisation chamber, of effective dimensions about 12ft. by 10ft., by means of which the unification of X-ray and radium dosage measurements had been effected. They pointed out, at the same time, that such a chamber, while serving its purpose as an ultimate standard of reference, was quite impracticable for medical purposes. But the results established that for everyday practice small ionisation chambers having appropriately thick walls of "air-equivalent material"—a type already in use for X-ray measurements—could be employed successfully for γ-rays.

In the "air-walled" chambers the volume of air ionised is defined by a completely enclosing chamber, the walls of which have an effective atomic number the same as that of air. By attention to the experimental conditions, said the authors, they had sufficiently removed the anomalies, so that medical workers could go ahead and make use of the röntgen just as they could the X-rays, which was very important, because often they were both used together.

Measurement of Voltage by Spark Gaps.

Discussing the spark gap as a voltmeter, Professor W. M. Thornton (in a paper he contributed) said that the three forms of spark gap used for high-voltage measurements were those between needle points, between spheres, usually equal, and between parallel circular plates with rolled edges. To these he added the corona voltmeter, in which the discharge was a radial stream of fine sparks starting from a wire enclosed by a concentric cylinder, but ending by diffusion in the space around it. The needle gap, he said, was not an instrument of precision; the electric wind from the points retarded the formation of a complete ionic path between them. The sphere gap was the most convenient of all the methods, and within certain restrictions was sufficiently accurate for use in industry as an indicator that a specified voltage had been applied to apparatus connected to it. The gap between parallel surfaces was the simplest in theory and most accurate in use. The voltages used for testing were either alternating or rectified. The gap between parallel plates with rolled edges, he said, could be regarded as a standard voltmeter. It was fundamental, consistent and accurate to more than 1 in 1000 at all voltages. Parallel plate gaps should not be used with spacings greater than one-tenth of the radius of curvature of the approach to the parallel part. When that was exceeded the curve of calibration changed suddenly in direction at an applied voltage depending on the diameter of the plates. It was necessary, as in the case of sphere gaps, to have pairs of plates, each of which covered a certain range of voltage. When the critical gap was not exceeded, the parallel gap had several advantages. It was set to a desired spacing as readily as a sphere gap; it had no spread of field within the central part of the area, in which the spark-over invariably occurred; the random ionisation that was required to start any spark discharge in air existed over a much larger volume and the choice of spark path was much wider; irregularities due to draughts or neighbouring bodies were less, and since it was not affected by stray fields it could be used without shielding or in more confined places.

More uniform results in the calibration of spark gaps, he continued, would no doubt have been obtained in the past if there had been a standard absolute method of voltage measurement. The capacitance divider method had the disadvantage that it was difficult to measure low alternating voltages to the desired order of accuracy by instruments that took little or no current. Out of several absolute methods, such as the attracted disc electrometer, the ellipsoid voltmeter, the capacitance divider, and the use of a rectified condenser current, the best were those in which the measurements were made at the high voltage itself and not by a dilution method. Of those, the ellipsoid voltmeter had been found to give the most satisfactory results. It consisted of a small metallic ellipsoid a few centimetres long and a few millimetres in diameter, the dimensions of which were known to a high order of accuracy, suspended between large parallel plates with rolled edges, set at a fixed distance apart by end gauges. One such instrument had been in constant use for six years. The ellipsoid was suspended midway between the plates and, in the large instrument used, had a free period of 173 seconds. It was given a very slight turning movement, and when almost at right angles

to the plates, as observed by a transit telescope, the field was applied and the swings counted. They were recorded on an electric chronograph and the readings reduced by the Gauss method. Individual readings agreed regularly to 1 part in 10,000.

It was easier to measure, accurately and directly, alternating voltages of the order of 100 kV than the low voltages of the condenser divider method, and to obtain results to the same order of precision as those to which the standard ohm were known.

An investigation for the purpose of standardising the parallel plate gap and comparing its behaviour with that of the sphere gap, concluded the author, was in progress for the Electrical Research Association by Mr. F. M. Bruce.

The Breakdown of Dielectrics Under Transient Electrical Stresses.

Mr. R. Davis (of the National Physical Laboratory), in a paper on this subject, pointed out the great assistance which had been given to the experimental study of the breakdown of gaseous, liquid, and solid dielectrics by the development of the impulse generator and the high-speed cathode ray oscillograph. With high voltages, he said, some form of voltage divider for use in conjunction with the oscillograph was required, and precautions must be taken in using the resistor type. Errors in recording were introduced chiefly through the capacitance to earth of the high-voltage arm of the divider.

The paper discussed the breakdown of air with reference to different electrode systems, such as sphere gaps, and the author included the special case of a solid dielectric located between the electrodes in parallel with the air path; as an example he mentioned the insulators used in high-voltage transmission systems. Having discussed experimental laws, he made the generalisation that breakdown occurred most easily when the stress at the positive electrode was greatest.

The paper concluded with a discussion of the polarity effects in measuring gaps, and flash-over of insulator systems; of the impulse strength of liquid and solid dielectrics; and, in the case of the latter, of the part played by the immersing medium.

The Electric Strength of Dielectrics.

Dr. S. Whitehead, of the British Electrical and Allied Industries Research Association, in a paper on this subject, considered the ultimate limitations of voltage or electric stress which could be applied to an insulator on the assumption that supernumerary defects, such as imperfections or irregularities in the solid material, had been removed, and he expressed those limitations as physical constants of the material. Attention was directed mainly to (*a*) liability to thermal instability; (*b*) the increase of conductivity at high electric stresses, interpreted in terms of ionisation as in gases; (*c*) the electrical stability of the solid structure in analogy with the mechanical strength.

Discussing thermal instability, the author said there was room for improvement in the temperature limitation of organic products, in the reduction of their temperature coefficients and of their thermal resistivities. For example, some dry papers had very small energy losses, but their thermal resistivities were of the order of 100 times that of quartz. Recently decreases in the thermal resistivity of organic composites had been effected by using inorganic fillers such as sand. The thermal resistivities of inorganic composite, although lower than those of the organic products, were much higher in general than those of the crystals.

The general order of the thermal voltage was such that the thermal instability limitation was unlikely to enter for voltages less than 100 kV at power frequencies. In high-voltage equipment the amount of solid insulation was usually reduced to the minimum compatible with mechanical rigidity. Thermal instability required consideration where either very high voltages or high frequencies were involved. Where the normal conductivity was the only source of loss, the thermal voltage was independent of frequency.

In a cable the thermal and electrical fields were parallel, and the difficulty of constructing cables with solid dielectric for 1000 kV could be appreciated.

Apart from its physical significance, and possible direct applications, said the author, the thermal voltage was valuable as being a simple function of the physical constants of a material, and expressing its liability to thermal instability. A case could be made for its use as giving a figure of merit to a material in respect of that limitation to its use. It also indicated the direction in which improvement might most advantageously be sought.

The author then considered the conception of ionisation and the possible existence of statistical "ionisation potentials" in analogy with ionisation in gases. If it be assumed, he said, that an ion could generate a given number of new ions proportionately to the field strength and distance traversed, it might be shown that, as in gases, the conductivity should be an exponential function or, to a first approximation, a linear function of the voltage. That conception involved a given voltage drop per pair of ions formed, *i.e.*, there was a constant "ionisation potential." He gave examples of ionisation potentials deduced in that way from the results of a number of investigations; they showed a wide range of variation, but did not vary with such factors as moisture content, temperature, and frequency.

In a simple theory the increase of conductivity with electric stress should be mainly a function of the voltage, so that the thickness entered into the conductivity field strength relations. Although Hartshorn had found evidence of that in mica and synthetic resin, little information was otherwise available, owing to the difficulty of obtaining specimens of different thicknesses which were entirely comparable.

It was very difficult to account physically for potentials of more than at most a few volts. Possibly, owing to the dissipation of energy in ways not producing ionisation, the apparent "ionisation potential" was much greater than the true. Some recent tests by the E.R.A. on the breakdown of very thin varnish films and impregnated paper had not given breakdown voltages less than between 1000 and 2000 volts. The minimum voltage at which an appreciable increase of conductivity with stress had been observed appeared to be at least about 500 volts. It was possible that those minimum voltages were of the order of the ionisation potentials.

So far, only indications of ionisation by ions of one sign had been obtained. That would not produce electrical instability without the interposition of some other factor, such as ionisation by ions of the opposite sign, local thermal instability, &c. Accordingly, before a breakdown stress could be deduced, a more detailed knowledge of breakdown processes was necessary. Such a connection seemed possible where a continuous transition to breakdown was observed, but often breakdown was abrupt and discontinuous.

Coming to the factor of ultimate electric strength, the author said that the high field strengths which were theoretically compatible with thermal stability, and which were also apparently compatible with the electrical stability of the ionisation he had mentioned, were not, in fact, realised because an abrupt instability occurred earlier. In measuring that type of electric strength, great care must be taken to avoid spurious results, but methods had been developed for the majority of instances. His colleague, Mr. Thomas, had made a large number of such determinations. Despite a wide dispersion of results, a number of values fairly concordant between different investigators had been found. The author exhibited a table of intrinsic electric strengths observed for various materials. The values all lay in the range 100,000 volts to 10,000,000 volts per centimetre, and the majority were grouped around 1,000,000 volts per centimetre. Thus, he said, there was less difference as between different materials in intrinsic electric strength than there was in the other limitations so far considered.

Having indicated various ways in which the ultimate electric strength could be explained, he said it was not possible at present to decide between them. In any case, the effect of irregularities, structural defects and mosaic effects had not been taken into account. The experimental technique normally employed was such that only a small area was exposed to the electric field, but, nevertheless, it was possible that the similarity between the intrinsic electric strengths of different materials might be due to defects as compared with ideal structure. Recent work on solid structure had shown that such defects might themselves be characteristic of the general type of structure, so that the electric strength might still be characteristic of the material, although not explicable in terms of an ideal model.

There seemed no reason, he concluded, why materials should not be used having a voltage limitation as regards thermal instability greater than 1000 kV, and a field strength limitation not less than 500 kV or 1000 kV per centimetre. Those limitations were not at present severe, although the voltage limitation might in special cases become important for future development. The present working field strengths were very much less than the intrinsic limit suggested. Accordingly, on both accounts there was a considerable field of opportunity in improving existing materials and types as regards uniformity and grosser defects and utilising them to the best advantage. The necessity for removing or reducing their inherent limitations might still be regarded as a problem for the future.

Some Electrical Discharge Phenomena on High-Voltage Systems.

Mr. C. W. Marshall (of the Central Electricity Board) made a contribution on this subject, in the hope that it might help to illustrate to physicists how discharge phenomena were regarded by electrical engineers. He pointed out that electrical engineers and physicists had occasion to deal with discharge phenomena of the same fundamental nature, and their ways of regarding them were different.

The chief problem in the technical operation of electrical systems, he said, was the insulation of the high-voltage conductors. The insulating materials used were air, porcelain, oil, bituminous or resinous compounds, and paper impregnated with either oil or bakelite resin. Any electrical breakdown of an insulating material was accompanied by an electrical discharge having characteristics depending on the nature of the insulating material and the type of discharge. The various discharge phenomena which were encountered in the operation of a high-voltage system he classified as (*a*) corona, (*b*) surface discharges on porcelain, (*c*) internal discharges in solid insulation, (*d*) arc discharges.

Corona or brush discharge took the form of a steady violet coloured discharge in the air in the vicinity of high-voltage conductors. The discharge current was very small, of the order of micro-amperes for a conductor of small area. Corona usually occurred on outdoor high-voltage plant and transmission lines. It was due to the local breakdown of the air owing to the high voltage gradient near the conductor, and it was intensified under humid conditions. Corona was usually quite innocuous, although, on long high-voltage lines, the loss of power due to corona might be appreciable.

Visible and audible discharges often occurred on the surface of the porcelain. In humid atmospheres the resistance of the porcelain surface fell to a relatively low value, with the result that spark discharges occurred. They were usually self-extinguishing, as the heating effect of the discharge current dried the porcelain surface so that the resistance of the discharge path was increased and the discharge could not be maintained. After some time the porcelain surface returned to its original condition and the discharge was initiated again. The discharge current was of the order of tens of milliamperes per insulator. Such discharges did not normally give rise to any inconvenience or damage. Intense and frequent discharges indicated that the factor of safety of the insulation was low, and that arc discharges were imminent.

Coming to internal discharges in solid insulation, he said the air in voids which were liable to form in non-homogeneous solid dielectrics (such as impregnated paper) was readily ionised owing to its low dielectric constant and to the high stress at which the insulation was worked. Those internal discharges might easily escape notice and might lead to the cumulative deterioration of the dielectric by a process of "tracking." The initial discharge burned a minute portion of the dielectric in its immediate vicinity and the carbonised products so formed extended the zone of the discharge. The process continued until an extensive conducting track of carbon was formed in the dielectric and ultimately a direct short circuit occurred. Even at an early stage internal ionisation gave rise to an increase in the power factor of the insulation. That fact was often utilised to detect such discharges.

Discussing arc discharges which accompanied a complete breakdown of the insulation between conductors of a system, he said they involved currents of the order of 1000 amperes, which persisted until the supply was cut off. The discharge might develop into a power arc, and such arcs were often also initiated by lightning. The high-voltage lightning discharge broke down the insulation and was followed by an arc which was sustained by the power supply. Owing to the large amount of energy involved, a power arc might cause extensive damage to electrical plant. The author concluded with the comment that the apparatus and technique for delimiting the effects of such power arcs on interconnected power systems constituted a relatively new and extremely important branch of electrical engineering.

(*To be continued.*)

The Galloway Water Power Scheme.

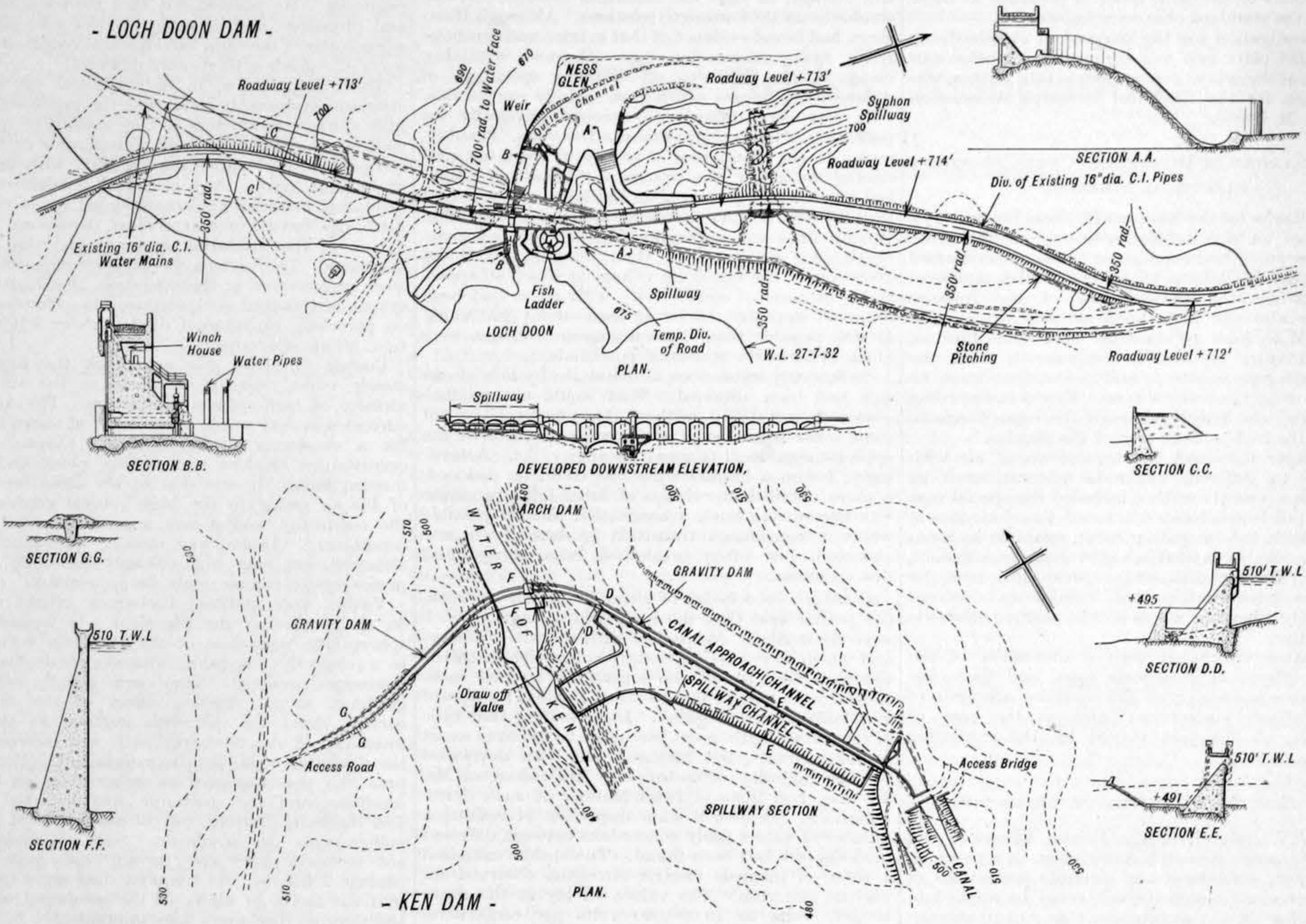
No. III.

(*Continued from page 285, September 18th.*)

THE Galloway power scheme is notable for the fact that with the exception of minor structures, such as the Muck Burn dam and the Bow Burn dam, arch structures have been constructed wherever the contours of the country and the nature of the rock on the river banks made it possible to choose a suitable site. Of the eight large dams in the scheme only two, Clatteringshaws and Doon, are gravity structures. The first named of these two was built during the first stage operations. It is situated in a wide moorland valley quite unsuitable for a single-arch structure. While a multiple arch design might perhaps have been adopted, there is little question that the gravity dam, built as it is with a slight curvature in plan, is more satisfactory architecturally than the alternative design could have been. The Doon dam is situated at the head of the gorge down which the river flows out of

THE GALLOWAY WATER POWER SCHEME—DESIGNS OF DAMS

SIR ALEXANDER GIBB AND PARTNERS, WESTMINSTER, CONSULTING ENGINEERS



"THE ENGINEER"

THE GALLOWAY WATER POWER SCHEME—CONSTRUCTION OF DAMS AND SPILLWAYS

SIR ALEXANDER GIBB AND PARTNERS, WESTMINSTER, AND MESSRS. MACLELLAN, WESTMINSTER, JOINT CONSULTING ENGINEERS



Doon Dam—Downstream Side
Carsfad Dam—Curved Gravity Spillway Section



Blackwater Dam and Kendoon Canal
Earlstoun Dam—Gravity Section Spillway



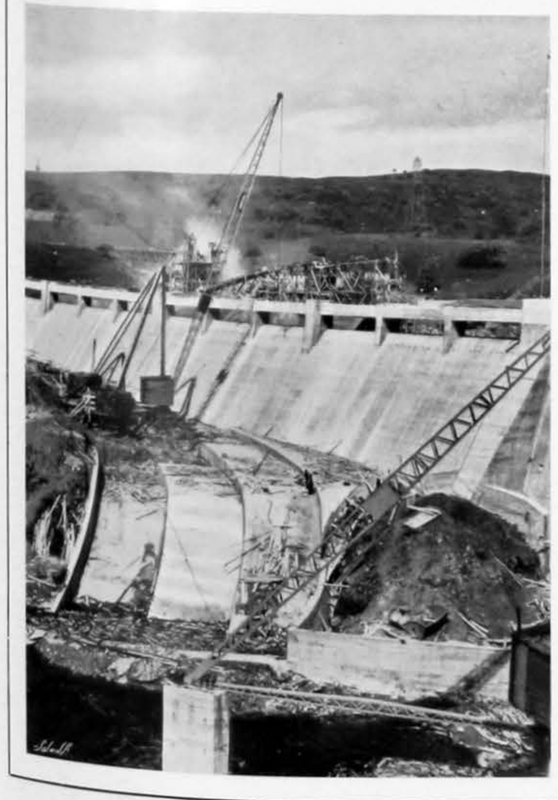




Ken Dam—Spillway and Spillway Channel
Carsfad Dam—Gravity Section Spillway and Apron



Ken Dam—Spillway Apron and Bucket
Carsfad Dam—Arch Section Spillway Channel





the loch. But on account of the very steep gradient of the river bed immediately downstream of the loch an arch dam of much greater height to be built in the gorge proved economically unsound as compared with a gravity structure spanning the crest of the saddle at the head of the gorge. The dam, though long, is low. The remaining six dams, the Deugh, Ken, Blackwater, Carsfad, Earlstoun, and Tongland structures, are all situated where the rivers concerned pass through deep valleys which at places assume proportions almost gorge-like. As, however, it was, in general, desired to "back up" the water level to the greatest possible extent, and as the contours of the valleys open out considerably at the higher levels it was necessary to continue the arch dams on one or both sides by tangential gravity dams, and, in some instances, to carry on the walls still further in the form of embankments with concrete facing walls or core walls. Where, as at Carsfad in particular, the height of the dam approaches closely the complete depth of the valley, and, in addition, the dam forms for part of its length one of the walls of the approach canal to the intake works, the complete structure takes the form in plan of a horseshoe. The following table gives the heights of the various dams, the radii of curvature of the arch sections, which were, of course, determined to a principal extent by the widths of the valleys concerned, the batter of the downstream faces, and the total length of spillway. All the dams have vertical upstream faces, and the line of the batter intersects the vertical at a considerable height above the spillway :—

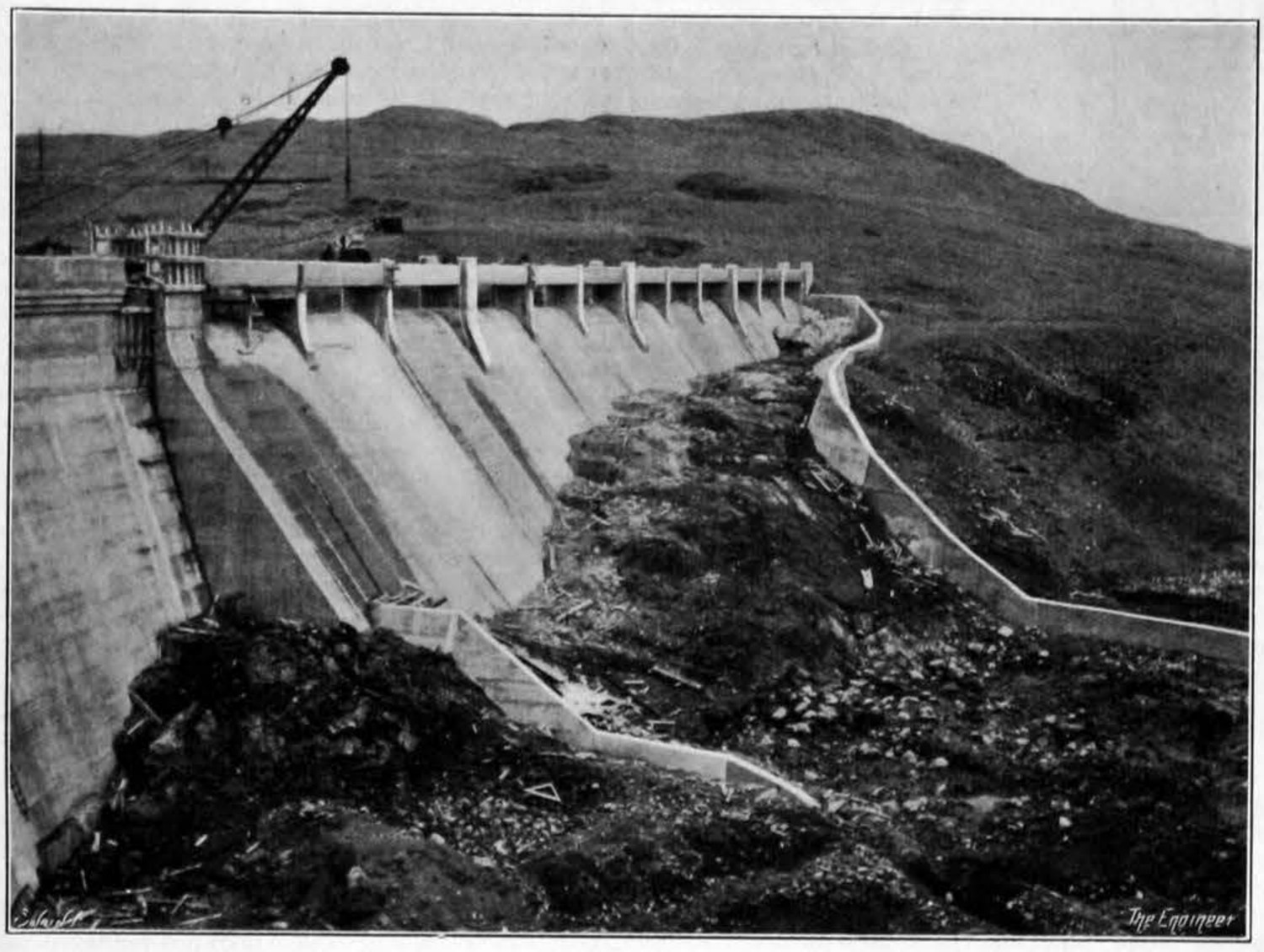
Dam.	Height of spillway from original ground level, feet.	Radius of curvature, feet.	Downstream batter.		Length of spillway, feet.
			Arch.	Gravity.	
Doon*	44	—	—	0·75	130
Deugh	70	230	0·33	0·75	370
Ken..	70	165	0·25	0·75	455
Blackwater ..	40	125	0·25	0·75	None
Carsfad	65	190	0·3	0·75	880
Earlstoun† ..	70	145	0·22	0·75	330
Clatteringshaws	75	—	—	0·75	400
Tongland† ..	70	145	0·25	0·75	325

* Doon dam has three siphon spillways in addition to the ordinary spillway over the dam and also a sluice channel under the dam.

† Earlstoun and Tongland dams are equipped with flood-gates.

It is obvious that for a given height, if the radius of an arch dam is increased, the batter must also increase. But it will be observed from the table that a minimum batter of 0·25 to 1 has been adopted, and applied even to the Blackwater dam with its comparatively small radius of 125ft. The Deugh dam has the largest radius of them all, and here the batter has been increased to 0·33 to 1. Earlstoun is exceptional in having a batter of only 0·22 on a radius of 195ft. It will be observed that for a corresponding radius and height Tongland dam has a batter of 0·25. It is interesting to infer from these instructive figures that for any given height there is a limiting maximum radius beyond which the batter of an arch dam becomes so large as to make the structure with its necessarily greater length uneconomic in comparison with a gravity structure of the same height. Of course, numerous other factors have also to be taken into account, particularly the very important one of providing sufficient spillway length, and in doubtful cases they may well tip the balance in favour of one type or the other.

As will be seen from the table, the gravity sections of the arch dam and also the two gravity dams, Clatteringshaws and Doon, have downstream batters of 0·75 to 1. In fact, the gravity sections throughout the scheme only differ from one another according as to whether there is or is not a spillway over them, and according to the width, whether to carry a pathway, as at Deugh and Ken, or roadway, as at Doon, of the superstructure. Towards the ends of the dams, where the head has grown small, they are continued sometimes in the form of a concrete facing wall carried down to good rock foundation and supported by earth filling behind, sometimes as a normal embankment with a concrete core wall carried down to rock, and in one instance at Carsfad, where the work will only come under pressure when the reservoir is nearly full, as a plain embankment with no concrete wall, but having a masonry facing on the upstream side to protect it against wave action. Plans of the Doon, Ken, Carsfad, and Earlstoun dams are reproduced on page 310. The Deugh and Blackwater dams are very similar to the Ken dam. Clatteringshaws and Tongland dams were described and illustrated in our articles of October, 1934, and were illustrated by photographs reproduced in last week's issue. Typical sections accompany the plans.



GRAVITY SPILLWAY SECTION OF DEUGH DAM

ERECTION OF DAMS.

Little need be said about the methods by which the dams were built. The normal practice for such work was followed by the contractors, with a multiplicity of Scotch derrick cranes, and although naturally the manner in which the various cranes and other plant was arranged differed according to the circumstances at each site, the actual methods of laying the concrete, the proportions of the mix, &c., were the same. According to the usual modern practice, each dam was built in "blocks," closing spaces, 2ft. to 6ft. wide, being left between the blocks to be filled in when the concrete placed earlier had set, cooled, and contracted. In a manner similar to that usually adopted the waters of the rivers were diverted during the construction of the dams through temporary openings in their bases. The Deugh, Ken, and Blackwater dams, which all block exits from the same reservoir, were closed at approximately the same date, and the contractors were favoured by some exceptionally dry weather. Usually the operation consists of dropping gates across the upstream sides of the openings and conducting away any leakage through a drainage channel at the base while concrete is filled into the opening. The channel is subsequently sealed and the gates can then be lifted. So dry was the weather that at the Blackwater site it was not even necessary to drop the gates, as the whole flow of the river was easily dealt with by the drainage channel! Earlstoun dam was closed a few weeks later and Carsfad last of all.

At Doon two unusual factors were present and influenced the course of the work. Loch Doon has been a controlled reservoir to some extent for very many years—quite how many is unknown—with a storage depth of 16ft. Towards the end of the nineteenth century a tunnel was driven through from the gorge, down which the river flows, into the loch, and a sluice gate installed to control the flow. This tunnel exists beneath the site of the present dam, and has now been plugged with concrete. A matter that presented the engineers and contractors with more serious problems and which had considerable influence on the sequence of operations in building the dam was that of a pair of pipe lines conveying water from a nearby high-level loch to the Burgh of Ayr. These pipes originally ran along and beside a roadway, which is now to be drowned beneath the risen waters. They had to be diverted from their original position and provision required to be made to carry them across behind the protection of the dam, and yet above the course of the spillway. The original situations and the new positions are shown on the plan of the dam. The pipe lines were dealt with in sections, one at a time, so as to maintain supply. The raising of the level of Loch Doon necessitated that quite a large aggregate mileage of roads should be diverted. One of them is actually carried over the top of the dam. It also will have the effect of submerging an island on which there stood the ancient Doon Castle, which had certain points of interest for antiquaries. In order to preserve this mediæval relic, large parts of it have been taken down and re-erected on the mainland opposite the island. The neighbourhood of Loch Doon is not the only one to be affected by the raising of the water levels and construction of reservoirs. At numerous other places roads have needed to be diverted and provision has had to be made in several instances for the construction of bridges.

NEEDLE VALVES.

Six of the eight large dams are equipped with a needle draw-off valve having a maximum capacity of about 1000 cusecs to supply the necessary compensation water to the river below the dam, and empty the reservoir when necessary. In general design all the dams are similar in this respect, except the Blackwater dam, where, owing to the lesser head, a modified and cheaper arrangement was possible and the Doon dam as indicated later. The arrangement at the Deugh dam shown in a sectional drawing, Fig. 10, is typical. Here a 6ft. diameter steel pipe is embedded in the dam to lead the water to a 6/5ft. Glenfield and Kennedy needle valve with disperser vanes arranged upon a concrete emplacement on the downstream face. The valve is operated by hand from a headstock erected upon a platform immediately above. A mild steel screen with horizontal and vertical bars encircles the entrance to the pipe, which can be closed by an emergency free rolling gate, also manufactured by Glenfield and Kennedy, which normally hangs in a gate-house at the top of the dam. At the Blackwater dam—Fig. 10—where the mean head is only about 28ft., a hand-operated sluice valve fitted with a disperser takes the place of the needle valve, and there is a hand-operated sluice gate instead of a roller gate on the upstream face. Doon is again different from the other dams, in that besides having a 3/2½ft. needle valve, it has also a separate channel through the base of the dam 10ft. lower down, as shown on page 310. The flow of compensation water to the amount of 45 million gallons per day through this channel is controlled by a regulator gate, and only in emergency is it intended to pass this water to the river by the needle valve. Water emerging at high velocity from the channel flows down a concrete slope and over a "bucket" into the river bed. On the upstream face of the dam an emergency bulkhead gate operated by a winch can be lowered either to cover the entry to the channel just described or the entry to the needle valve pipe. The arrangement is such that in the event of any repair of the channel or regulator gate becoming necessary, the water discharged by the needle valve will be thrown clear to the river and will not interfere with the execution of the work, which can be carried on behind protecting stop logs.

The reason for the unusual arrangement at Doon lies in the requirements of the river and fishing interests. Salmon ascend the Doon as far as the loch, and it will be realised that from the point of view of ascending fish the discharge of compensation water smoothly over a "bucket" is preferable to dropping it from a height into the river from the needle valve. At low stages of the reservoir salmon will be able to pass through the regulator valve. For higher stages a fish ladder is provided, to which further reference will be made later in this article. At Deugh, Ken, and Blackwater no provision has needed to be made for ascending salmon, while at Carsfad and Earlstoun sufficient water for compensation purposes can be sent down the fish ladders.

SPILLWAYS.

The problem of providing sufficient spillway capacity is, of course, one that can have a very important influence upon the design of dam eventually selected, particularly when the width of the valley in which the structure is to stand is limited. It was particularly urgent in the case of several of the Galloway dams on account of the large capacity of the rivers and the small surface areas of the reservoirs above them. The Doon and Clatteringshaws dams create reservoirs with surface areas of 2250 acres and 1000 acres respectively, and there is in con-

sequence a large storage capacity available between the spillway level and the maximum flood level. Since heavy flood conditions are comparatively transitory this storage reduces to a considerable extent the amount of water it is necessary to spill while spate conditions still exist. In fact, the storage allows the dam a greater length of time in which to get rid of the excess water. At Tongland, too, despite the fact that its reservoir has a surface area of only 50 acres, Loch Ken, some miles upstream,

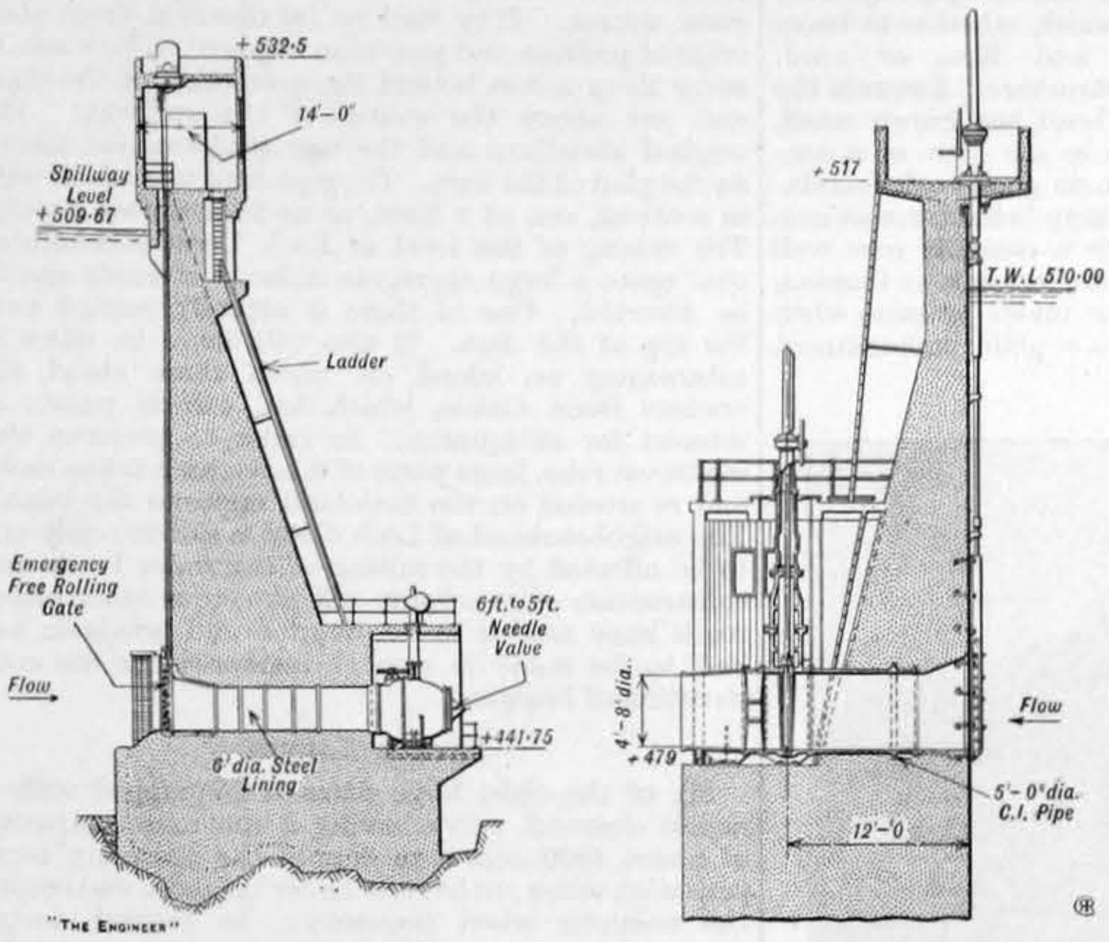


FIG. 10—SECTIONS THROUGH DEUGH AND BLACKWATER ARCH DAMS

having a surface area of 2300 acres, provides a large degree of temporary storage. But at Kendoon, Carsfad, and Earlstoun the conditions are totally different. The surface areas of these reservoirs are respectively 150 acres, 100 acres, and 140 acres. A rate of inflow which would raise the level of Loch Doon by 1ft. in two hours would cause a corresponding rise at Earlstoun in less than ten minutes. Earlstoun, moreover, has a catchment area considerably greater than that of Loch Doon. It will be seen, therefore, that at Kendoon, Carsfad, and Earlstoun the dams, under flood conditions, will be called upon to spill almost the whole of the excess water immediately, and that in consequence very ample spillway capacity has had to be provided.

At only one of the dams was the problem of providing sufficient spill capacity easily solved. At Clatteringshaws there is a great length of dam available and on the downstream side the ground is more or less flat solid granite, so that the overflowing water can easily be guided back to the bed of the stream. At Doon the dam is so situated that it was impossible, even despite the limited spillway capacity required, to find room for it on the dam itself without necessitating an excessive rise in level of the loch. Consequently three siphon spillways have been installed to deal with the excess beyond the capacity of the dam. These siphons, of the self-priming type, are arranged to come into action consecutively as the water level rises. It is, however, interesting to note that the Loch Doon reservoir, with a catchment area of 50 square miles, has existed for at least fifty years with a spillway only 60ft. long.

The Kendoon reservoir is produced by three dams blocking three separate outlets. Thus the spillway capacity can be divided among them, and, in fact, one of the dams, Blackwater, is not provided with a spillway at all. The gravity sections of the Deugh and Ken dams provide, combined, a length of spillway equal to 825ft., sufficient, it is estimated, to discharge the heaviest of floods with a water level not more than 3ft. 4in. above the crest. But further downstream, at Carsfad, the flood waters, of greater quantity of course, owing to the growing catchment area, must be discharged over a single dam. The design of the dam is, however, such that it has a very considerable length, despite the limited width of the valley. By making use of the arch dam as a spill besides the greater part of the gravity section a length of 880ft. is available and sufficient to clear the maximum flood with a rise in water level of 3ft. above the crest. At Earlstoun the maximum flood to be discharged is greater still, and, adequate spillway capacity could not be provided without so modifying the design as to make the dam uneconomically costly, and in consequence two flood gates have been installed and will be arranged to operate automatically as the upstream water level rises. The remaining dam, Tongland, much further downstream and near the mouth of the river Dee, receives the flood waters from almost the whole of the Dee and Water of Ken catchment areas. Despite the existence of storage capacity in Loch Ken, it needs to be capable of discharging a very large quantity of flood water. Owing to peculiarities of the site it was necessary to build a special spillway, 325ft. long, extending in a straight line almost directly upstream before finally curving in to the bank; and in addition to construct two large automatically operating flood gates.

SPILLWAY CHANNELS.

The design of the spillway channels behind the dams was made interesting and complicated by the steep sided nature of the valleys. Although the general situation of each channel was decided upon in the drawing-office at the time when the dams were designed, the actual details were not determined until work at the site had shown how much rock excavation and what condition of rock was likely to be encountered. Thereafter small-scale models of each dam and channel were made in wood and experiments carried out to discover in what manner the water would flow and in what way it could best be guided and controlled. With the sole exception of Clatteringshaws the water has at every dam eventually to be delivered down a steeply sloping concrete apron and over a "bucket" into the river bed at a point sufficiently far downstream to be clear of the toe of the dam. The "buckets" have been designed with a rather greater upturn than has been usual before. Their effect, apparent, if not actually true to fact, is to produce a continuously rotating "roll" of water at the toe of the bucket under and beyond which the remaining water is thrown up with dissipation of energy and subsides into the river.

As the water must be collected from a considerable length of dam and delivered into a comparatively narrow channel the general design is similar at each dam as will be observed from the engravings in a Supplement to this issue, and on page 318. Excavation has been carried down to the rock behind the dam for a suitable width and a concrete wall or slope built to form the further side of the channel. As the water rushing off the dam tends naturally to flow across the channel and pile up against the wall, it is given at its top an overhang designed to throw back the water on itself. The channel, of course, follows along the downstream face of the dam, growing wider as it approaches the outfall in order to carry the increased quantity of water. The gradient of the floor is considerable and various means have been adopted to break up and slow down the flow. At the Deugh dam, for instance, where the rock is sound, it has been left rough and unconcreted. Elsewhere cross concrete "steps" have been constructed. Finally each channel turns through an angle approaching 90 deg. to carry the water to the spillway apron. The floor at this curve is super-elevated in order to prevent the water piling up on one side. Usually the super-elevation is smooth, but at Earlstoun and Carsfad it is arranged as a series of three longitudinal steps.

The arrangement at the Doon dam is typical as to general design, but differs from it in detail. A road is carried over the top of the dam on arches and at the spillway sections the arches are of greater width than the base of the dam. After some experiment it was found that the most satisfactory flow conditions were obtained by building on the downstream side between the piers of each arch span a low wall or weir over which the water had to flow to reach the spillway channel. In another respect, too, this channel differs from type. The two" bays" of the spillway nearest the centre of the dam discharge the overflow immediately opposite the final apron. It was found on the model that if the ordinary design was adopted this water tended to flow across and over that from the other three bays and that thereby not only was great turbulence created, but the distribution of the water over the apron and bucket was also adversely affected. This trouble has been overcome by the construction of a guiding wall so placed that the water from these bays is not allowed to mingle with the rest until the top of the apron is reached.

(To be continued.)

The Denny-Brown Ship Stabiliser.

On Saturday, May 8th, 1875, a representative of THE ENGINEER attended the trial trip of the steamship "Bessemer" a double-ended four-paddle cross-Channel vessel designed by Mr. E. J. Reed, built by Earle's Shipbuilding Company of Hull and fitted with Mr. Henry Bessemer's swinging saloon. Incidentally, it may be noted, the ship was equipped with a considerable amount of hydraulic machinery. Apart from the hydraulic rams which, under manual control, were intended to steady the saloon when the ship rolled, she was fitted with hydraulic capstans, hydraulic steering gear and hydraulic reversing equipment for controlling her two independent sets of main engines. All this hydraulic gear was made by Brown Brothers and Co., of Edinburgh.

The trial trip began at Dover. In almost dead calm weather the ship crossed to Calais where an unfortunate mishap attributable to the length of the ship and the strength of the tide resulted in about 50 yards of the jetty being wrecked. The return trip on the following Monday was made in equally calm weather with the result that the guests arrived back in England without the least personal experience of the practical operation of the swinging saloon and its merits as a means of preventing sea-sickness. Throughout her subsequent brief career—the company owning her went bankrupt following a second mishap at Calais—she never encountered sea conditions which really put the swinging cabin to a proper test. The cabin, we believe, still exists as a hall attached to a girls' school near London.

On Thursday of last week September 17th another representative of THE ENGINEER left Southampton in the Southern Railway Company's T.S.S. "Isle of Sark" for a short trip in the Channel with the object of witnessing a demonstration of the Denny-Brown stabilising gear with which that ship has recently been fitted. Once again the sea was unkind. It was almost a dead calm and the most that could be done was to reverse the controls of the stabilising equipment in such a way as to cause it make the ship roll artificially and then, righting the controls, to damp out the motion previously produced. One other point of similarity between last week's trials and those of 1875 was noteworthy. The hydraulic equipment by which the fins producing the stabilising effect—or the artificial rolling—were rocked when extended and withdrawn when not required was designed and made by Brown Brothers and Co. of Edinburgh. Of the other partners in the design of the stabilising gear, Messrs. Denny of Dumbarton, we may recall the fact that the "Isle of Sark" does not represent their first association with anti-rolling equipment. In the earlier years of this century they built a cross-Channel steamer fitted with Monsieur Victor Crémieu's system consisting of a four-wheeled truck which was free to oscillate, immersed in lime-water as a damping fluid, on curved rails laid athwartship. On the trial



"ISLE OF SARK" WITH FINS FITTED

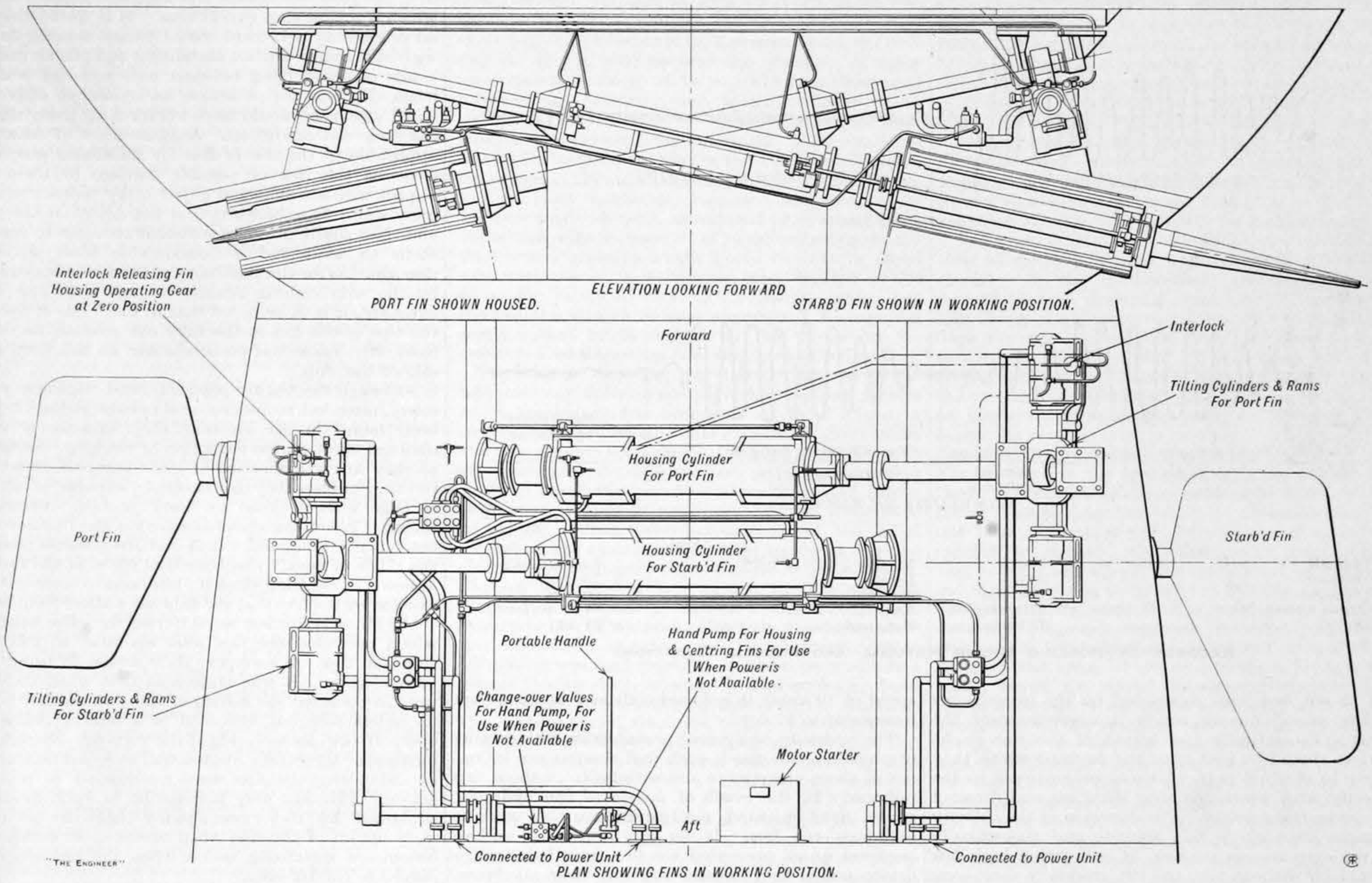
trip of that ship—from Dumbarton to Folkestone—the sea conditions were all that could be desired for demonstration purposes. The equipment, however, did not come up to its inventor's expectations. Monsieur Crémieu was violently ejected from his bunk, the ship's engineer declared that the rolling was if anything less violent with the gear out of action than when it was at work and the captain finally insisted upon the truck being tied up.

Since these early days considerable progress has been made in the art of automatic ship stabilisation. Noteworthy developments have included the Frahm anti-rolling tank system, the Sperry gyroscope system—reaching the height of its development in the equipment, weighing 691 tons installed in the 45,000-ton Italian liner "Conte di Savoia"—the Siemens activated tank system and the Flamm compressed air pipe system.* One other system which has reached the stage of practical trial deserves especial note on this occasion namely the moving fin equipment devised in 1923 by Dr. Motora of the Mitsubishi Nagasaki Shipyard and tested in some Japanese merchant vessels and warships. Dr. Motora it is to be noted was by no means the first to conceive the idea of employing oscillating fins projecting from the side of a ship as a means of controlling or eliminating her rolling motion. An early inventor in this field, if not the earliest, was Wilson, a chemist in Stirling, who in 1889 patented a device of the kind. Sir John Thornycroft at one time also devoted close attention to the idea and we may safely say that many others have been attracted by the conception of moving fins or horizontal rudders as stabilising agencies. To Dr. Motora however undoubtedly belongs the credit of being the first and, until Messrs. Denny and Messrs. Brown took it up, the only one to apply the system in practice on a full scale.

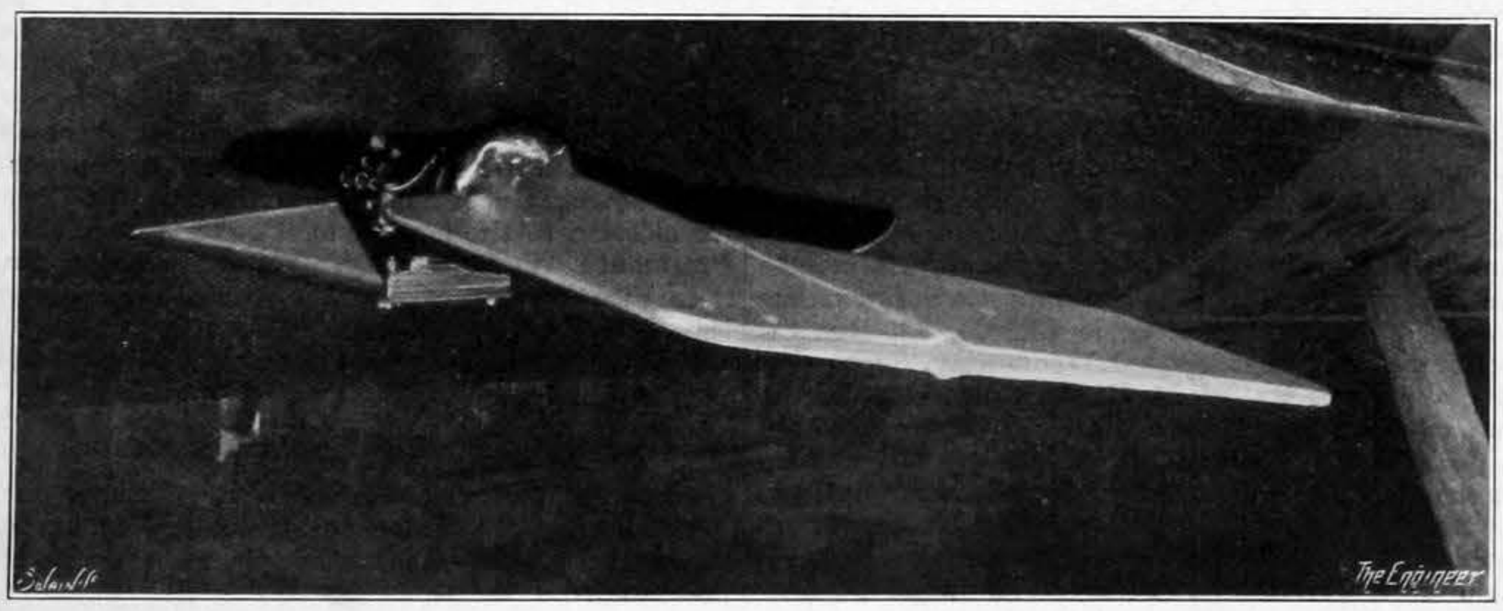
We described and illustrated the Motora system in our issue of June 27th, 1930, in the last of a series of articles dealing generally with automatic stabilising equipment and describing the various systems that had been tried up to that date. In its mode of action and the essentials of its construction the Denny-Brown equipment is identical with the Motora. As illustrated herewith the "Isle of Sark" is provided with two cast steel fins, each weighing about half a ton, mounted on tubular shafts which can be caused to project downwardly and outwardly through the side of the ship about the turn of the bilge. In the inoperative position the fins are withdrawn into water-tight chambers formed inside the hull. In plan the fins are situated approximately beneath the bridge that is to say at about one-third of the ship's length from the bow and therefore some distance in front of the ship's centre of gravity. The fins themselves are designed after the manner of balanced rudders. No attempt has been made to give them a streamline or aerofoil section while from the aerodynamic point of view their "aspect ratio" differs noticeably from that of the ailerons of an aeroplane to which their action bears a close resemblance. For convenience of internal arrangement the two shafts are not set in the same athwartship plane. Each shaft after passing through a stuffing-box at the inner end of the water-tight housing chamber enters a housing cylinder the admission of hydraulic pressure to which withdraws the fin or holds it in the extended position. An internal shaft connected to the tubular shaft by a spline emerges from the upper end of the housing cylinder and is connected by rack and pinion to an adaptation of a hydraulic steering engine by which the fin may be tilted up or down. Interlocking gear is provided to prevent the fins from being oscillated unless they are fully out and to prevent their withdrawal unless they are directly in line with the slots in the side of the hull.

The tilting equipment is such that as the leading edge of one fin—that on the side to which the ship has rolled—is tilted up, the leading edge of the other is tilted down. As the roll reverses the fins reverse their tilt. In this manner the upwardly tilted fin experiences an upward force from the water flowing past it while the fin on the other side is subjected to a downward force. The two forces acting at centres of pressure substantially coincident with the axes about which the fins tilt constitute a righting moment which opposes the heel of the ship. It is to be noted that the magnitude of the forces acting on the fins is proportional to the square of the velocity of the water impinging upon them. Hence when the ship is stationary relatively to the water the stabilising action of the fins is zero and at low speeds it is low This essential characteristic of the system hardly constitutes a serious defect in the case of a ship which on most of her trips is travelling in the open sea at or near her full speed. It does however imply that if the steering gear or the main engines broke down and the ship fell into the trough of the sea the stabilising gear would be ineffective as a means of stopping her rolling, possibly to the extent of building up a dangerous amplitude. The remote possibility of such a mishap occurring, it is argued, hardly justifies a shipowner in installing other and much more expensive forms of stabilising equipment which are independent of the forward motion of the ship.

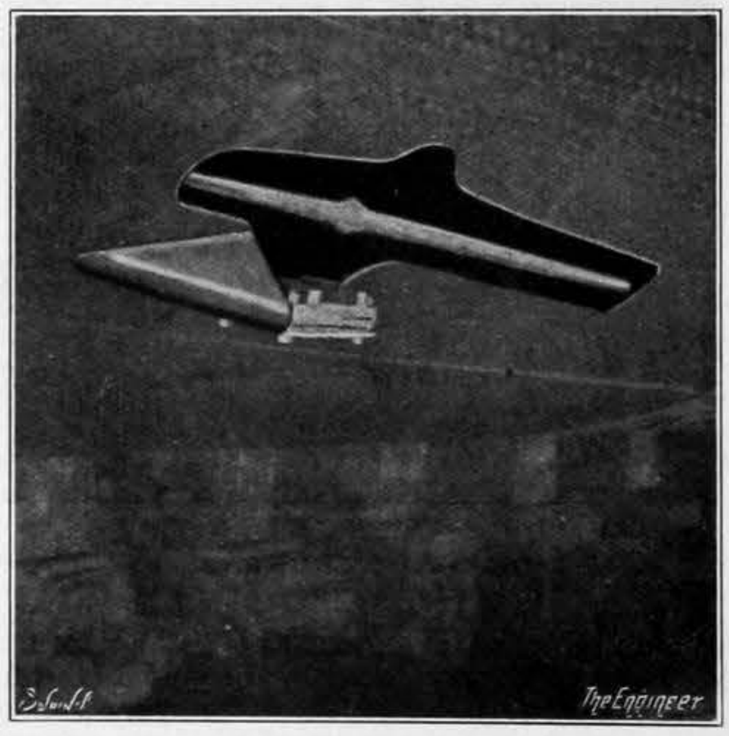
The origin of the control of the tilting motion of the fins is to be found in a small constrained gyroscope mounted in the chart room. This gyroscope spun electrically is arranged with its axis of spin athwartship. Rolling of the ship causes the axle to precess in a horizontal plane and to close almost at once one or other of two electrical contacts according to the direction of the precession. A relay there-



GENERAL ARRANGEMENT OF THE DENNY-BROWN STABILISING GEAR ON THE T.S.S. "ISLE OF SARK"



PORT-SIDE FIN IN OPERATIVE POSITION



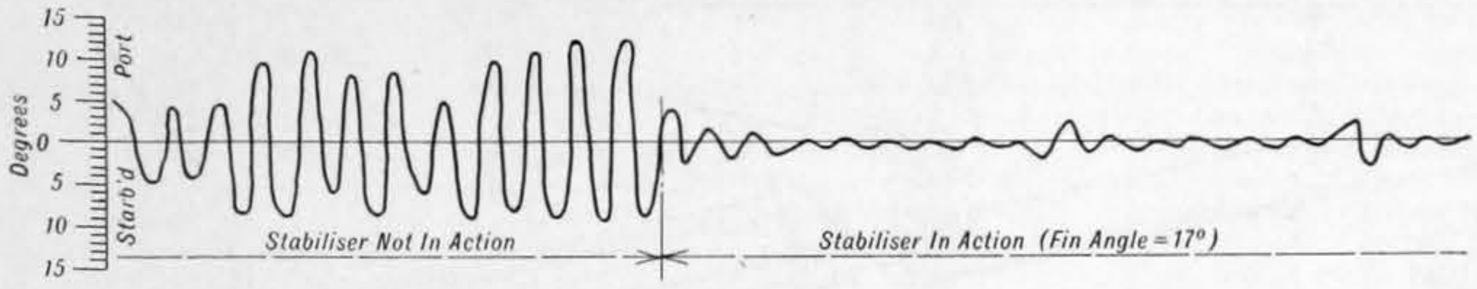
FIN WITHDRAWN

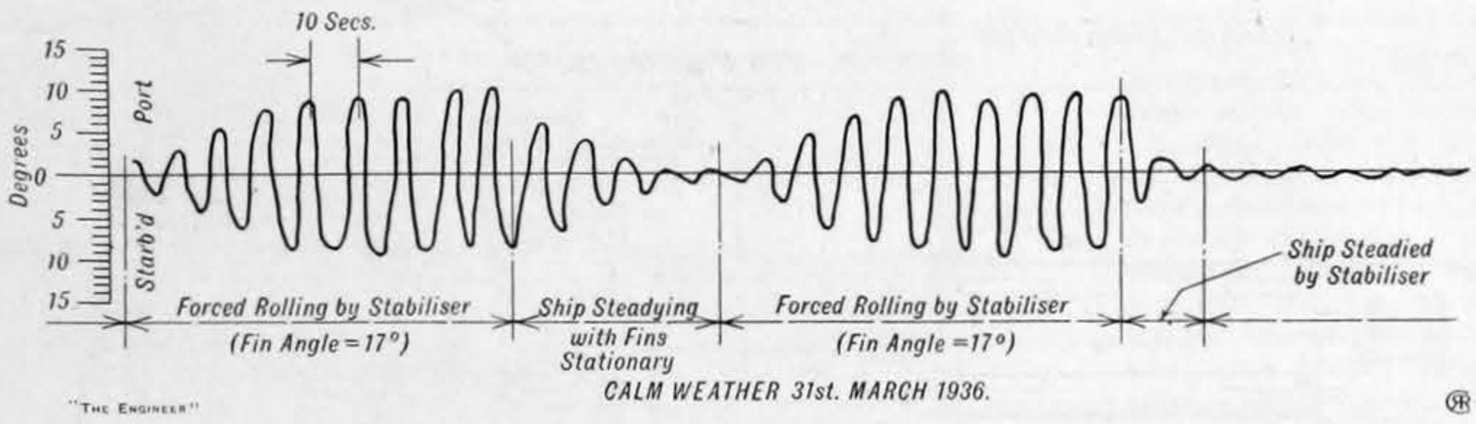
* The Flamm system was tried on the Rotterdam-Lloyd's 10,000-ton liner "Indrapoera" which by coincidence was lying at Southampton last week as the "Isle of Sark" passed down to her trials.

upon closes a switch by which a solenoid is energised and the pull of this solenoid is used to move a balanced valve by which fluid under pressure is supplied to a telemotor. The telemotor acting rapidly controls the stroke of a variable delivery electrically driven pump which supplies fluid to the fin-tilting cylinders. The control gear is fitted with the usual follow-up arrangement whereby the fins are tilted to an angle determined by the stroke of the telemotor. In order to operate both fins the control is duplicated in such a way that the fins move simultaneously but in opposite directions.

It is to be noted that the still water rolling period of the "Isle of Sark" is approximately 10 sec., she would do if the damping moment were at all times proportional to the velocity.

This brief analysis is sufficient to emphasise the importance of rapidity in the action of the tilt-reversing gear. It is in this connection that we see the chief practical improvement in the Denny-Brown system as compared with Dr. Motora's. Dr. Motora employed a steam-driven steering engine to tilt the fins and there seems to be no doubt that it was for the most part too slow in its action, and that it unduly prolonged the ineffective or partially effective interval at the start of the roll return. In the "Isle of Sark" provision is made for tilting the fins up or down through 25 deg. but normally at a





Hull.		*Fins.*	
Length	306ft.	Number	1 on each side
Breadth	42ft.	Length	7ft. 9in.
Draught	10ft. 7in.	Breadth	4ft. 6in.
Gross tonnage	2211 tons	Area	34 sq. ft. (each)
Speed	19 knots	Max. angle	25 deg.

RECORDS OF ROLLING UNDER NATURAL AND FORCED CONDITIONS

out to out and back again and on the average her rolling period among waves is approximately the same. Theoretically the action of the fins to be perfect should be such that the moment which they apply to the hull is at all times proportional to the velocity with which the ship is rolling and directed to oppose the velocity. The direction of the velocity changes once every five seconds and theoretically at the extreme out position of each swing both fins should be without tilt, the tilt gradually increasing to a maximum as the ship passes through the upright position. In practice no attempt is made to follow this procedure with exactitude. The fins are either fully tilted up or down or are in process of having their tilts reversed. The reversal of the tilt begins substantially at the instant at which the ship reaches



PORT-SIDE FIN TILTED

the full out position on a roll. It cannot be completed instantly. The actual time required for a full reversal of tilt in the "Isle of Sark" gear is we understand about 2 sec. Hence out of the 5 sec. occupied by an out-to-out roll the fins for the first second are tilted, to a decreasing extent, in a direction causing the forces on them to assist instead of to oppose the rolling velocity. During the next second they are tilting towards the maximum inclination allowed them and during the remaining three seconds they are held at the maximum angle. We may therefore say that for one-fifth of the time the fins are acting theoretically as destabilisers and that for the remaining four-fifths they are acting as stabilisers applying for the greater part of that time a damping moment in excess of the value theoretically required. In practice the ship responds more or less precisely as speed of 19 knots it is found sufficient to limit their movement to 17 deg.

The hydraulic equipment provided for withdrawing or projecting the fins is such that the fins can be run out in about one minute and withdrawn in about two minutes. In the event of failure of the hydraulic power hand-operated mechanism can be used to withdraw the fins. If for any reason a mishap occurred which prevented the fins from being withdrawn and if they became fixed at their maximum angle of tilt the ship would list but according to Sir Maurice Denny the list would not exceed 2 deg. and could be reduced by reducing the ship's speed.

Model experiments, confirmed to some extent we gather by observations on the "Isle of Sark," have shown that the amount by which the fins—given a constant degree of tilting and a constant ship's speed—are capable of reducing a given degree of rolling is constant. If, as was found, a certain movement of the fins at a certain ship's speed was capable of eliminating completely an out-to-out roll of 16 deg., then the same fin movement at the same ship's speed would reduce a roll of 26 deg. to one of 10 deg. out-to-out.

The power required to operate the equipment is slight. At the most it does not exceed 20 H.P. maximum with a mean value of 10 H.P. As for the effect of the fins on the speed of the ship it can, it seems, be dismissed as triffling if anything at all. Naturally the hydrodynamic lift is accompanied by a hydrodynamic drag which in view of the particular cross section of the fins that has been adopted is probably greater than it might be. Nevertheless this drag has to be set against the undoubted loss of speed which a rolling ship experiences. It is stated that in all probability a 19-knot cross-Channel steamer fitted with the Denny-Brown stabilising equipment suffers a loss of speed lying between zero and half a knot when the fins are in action as compared with the speed which she would have when rolling freely under the same sea conditions. Another point of criticism applicable to the use of fins for stabilising purposes concerns the risk of possible damage to them by impact with a submerged object or by contact with a quay wall. It is believed that the design of the fins and their shafts provides sufficient strength to enable them to withstand a considerable blow without damage. As for the possibility of trouble being caused by the ship coming against a quay with the fins extended, it is to be noted that in the "Isle of Sark" the tips of the fins in the fully out position lie more than 3ft. inside the perpendicular let fall from the side of the ship.

Although the fins are primarily, and originally were solely, intended to reduce or eliminate rolling it has been found in service that they exercise a very material effect on the reduction of pitching. Situated as they are well forward of the centre about which the ship pitches they are naturally capable of acting as bilge keels disposed to check pitching instead of rolling. When the vessel is pitching the fins are run out but not oscillated. It is perhaps possible that in the "Isle of Sark" this beneficial effect of the fins as a means of reducing pitching has been to some extent assisted by the fact that the ship has a Maier form bow.

On Thursday of last week during the calm weather which prevailed the fins were operated to roll the ship and then on reversing their action to bring her to rest again. It was noticeable that when the fins were so operated the rolling of the ship did not build up indefinitely but increased to a limiting value of about 10 deg. on each side of the vertical. No further increase of the rolling motion was incurred no matter for how long the fins were maintained in reverse action. This fact may perhaps be in some measure explained by the circumstance that the adverse early action of the fins when operated as stabilisers becomes a stabilising action when the fins are employed to roll the ship.

The structural alterations required in the "Isle of Sark" to adapt her for the equipment were not great. A little strengthening of the hull at the points where it was pierced for the fins was naturally required and water-tight chambers for housing the fins had to be built within the hull. The operating equipment was not difficult to accommodate as it is neither bulky nor heavy. For the most part it was comfortably housed in the engine or boiler room and in one of the ship's tanks.

The Institute of Metals.

No. I.

THE Twenty-eighth Annual Autumn Meeting of the Institute of Metals was held in Paris from September 14th to 18th, 1936, by the invitation of the Bureau International des Applications de l'Aluminium, with the co-operation of the Chambre Syndicale des Metaux à Paris. The general meeting of members was held in the Maison de la Chimie, 28, Rue St. Dominique, on Tuesday and Wednesday, September 15th and 16th, Mr. W. R. Barclay, President of the Institute, occupying the chair.

Monsieur J. Dalmais, President of the Bureau International d'Aluminium, welcomed the guests in the name of the bodies participating in the invitation —the Bureau International des Applications de l'Aluminium, Aluminium Français, Aluminium Industrie A.G., Aluminium Werke A.G., British Aluminium Company, Ltd., Vereinigte Aluminium Werke A.G., and the Chambre Syndicale des Metaux.

The President, acknowledging the welcome, said it was the first time that the Institute had met in France, and the members were very glad that their first visit should be to its delightful capital. He added that they were deeply grateful to the organisation over which Monsieur Dalmais presided for the immense amount of trouble which had been taken in connection with the meeting.

Dr. Richard Seligman asked Monsieur Dalmais to transmit to the French chemists the pleasure and the congratulations of the Institute on the successful outcome of their efforts represented by that House of Chemistry in which they were meeting.

The minutes of the previous meeting were then taken as read and confirmed, and the secretary read the following list of names nominated by the Council for election to the new Council to serve for 1937 :— President : W. R. Barclay. Vice-Presidents : Engineer Vice-Admiral Sir Robert Dixon, Lieut.-Colonel the Hon. R. M. Preston. Members of Council : W. T. Griffiths, Stanley Robson, A. J. G. Smout, D. Stockdale.

CONDUCTIVITY OF PURE ALUMINIUM.

A paper on "The Conductivity of Super-purity Aluminium : The Influence of Small Metallic Additions," by Gaston G. Gauthier (member), was then presented.

THE CONDUCTIVITY OF SUPER-PURITY ALUMINIUM.

This paper deals with the effect on the conductivity of super-purity aluminium (exceeding 99·99 per cent.) of additions of those elements which may occur as impurities in commercial aluminium.

It is shown that aluminium follows the universal law that the conductivity and the temperature coefficient of conductivity both increase with the purity ; Mathiessen's law has been confirmed. The data presented in this paper on the effect of small additions on the conductivity of aluminium are of value in that they have been determined under favourable experimental conditions, owing to the extreme purity of the basis metal and the large amount which has been available. This high purity has made it possible to determine, with a stated accuracy, the effect of each one of the added elements in the almost complete absence of other impurities. Further, the figures given for iron and silicon, for these elements with titanium and vanadium, and for magnesium and silicon, make

it possible to calculate the conductivity of aluminium of accurately known purity.

Norbury's law does not appear to hold in the case of aluminium.

DISCUSSION.

Dr. A. G. C. Gwyer said it was remarkable to realise that a stage had been reached at which an aluminium of next door to spectroscopic purity could be obtained. That was, of course, of very great interest, not only to those who are interested in aluminium, but also to those who desired to investigate the fundamental properties of metals. For example, workers who were interested in the subject of corrosion would be as eager to experiment with super-purity aluminium as they had been with spectroscopic zinc and other materials. The paper showed the effect of the individual elements which are commonly found in aluminium in lowering the conductivity. But he thought it would be of interest if the author could show the effect of silicon completely in solid solution. For example, even with quite small amounts of silicon present, of the order of 0·30 per cent., the conductivity was lowered to something of the order of 64 per cent. That was when the material was out of solid solution, in the graphitic form. When it was in solid solution the conductivity dropped to about 60 per cent. At the end of the paper the author classified silicon as one of those elements which had little effect. No doubt that was true with regard to silicon in the graphitic form, but in the ordinary way in which aluminium wire was produced by drawing the silicon appeared not in a graphitic form but in a mixture of dissolved and free, and therefore its effect was very much greater than would be expected from the author's conclusion.

Dr. L. H. Callendar said he noticed that the author annealled his metal for three hours at 320 deg. Cent., and then slowly cooled it for twenty-four hours down to 100 deg. Cent. He, the speaker, did not think that in the case of silicon that would be sufficient to bring about equilibrium in the metal, and he thought the author was scarcely justified in stating, as he did, that the solid solubility at 100 deg. Cent. was 0·06 per cent. silicon; the metal would not be in equilibrium at that temperature. He felt therefore that the author's figure of 0·06 represented rather the solid solubility at 300 deg. Cent., and not at 100 deg. Cent. Past experience showed that it would take something like 1000 hours annealing to reach equilibrium at 100 deg. Cent. The author did not refer to the presence of calcium or sodium in his metal; he would be interested to know whether he had obtained any results as to the effect of those elements on the conductivity.

Professor A. Portevin said that the results of the author's determinations were very valuable, because the influence of each element on the conductivity of aluminium was studied separately, thanks to the very high purity of the aluminium employed. It was very interesting to consider the small effect on the conductivity of aluminim of gallium. All natural sources of aluminium contained gallium, which was therefore found in commercial aluminium. It would be of interest to verify that super-purity aluminium did not show the super-conductivity mentioned by Tuijn and Onnes, because, according to the ideas of Kapitza and Bernal, all absolutely pure metals should be super-conductors, the abrupt drop of the resistance to zero being, according to them due to an instantaneous expulsion of impurities.

Dr. von Zeerleder said that the author compared his result with those of Bosshard, published in 1927, and found in the case of certain metals, and in particular silicon, iron, copper, and titanium, a difference between the results obtained by him with this super-purity aluminium and those obtained by Bosshard. He thought that that difference was largely due to the fact that Bosshard's metal had a purity of 99·5 per cent., so that it probably contained other impurities which were not determined exactly but which may have had a certain influence on the results of the tests of conductivity and on the effect of the other elements. On the other hand, he was of opinion that, as Dr. Callendar had indicated, the time of cooling was not long enough at the temperature employed by the author, because at 320 deg. Cent., especially with additions like titanium and manganese which went into solution in aluminium very slowly, it would be better to allow more than three hours for annealing and twenty-four hours for cooling. Moreover, to obtain a complete solid solution, especially with titanium, a temperature of 500 deg. Cent. was not sufficient. Those reasons, he thought, explained the difference between the results found by Bosshard and those obtained by the present author. In general the results for all the other elements were in very good agreement.

The following paper was then presented :—" The Complex Interdependence of the Properties of Alloys and the Industrial Conditions of their Manufacture, Testing, and Use," by Marquis R. de Fleury, Member, and Dr. H. Portier.

ALLOYS AND CONDITIONS OF MANUFACTURE.

A study of indirect factors affecting the quality of foundry castings, examination of their reciprocal action, and of the importance of their recognition in obtaining sound castings.

Utilisation of scrap in the foundry, lowering of the quality of alloys by successive remelting; the use of organised production; control of raw materials; influence of the process of solidification of alloys and of the factors of moulding and casting; influence of design of castings, and their size. Considerations regarding thermal treatment, modulus of elasticity of alloys, thermo-dynamic conditions, and the length of service.

DISCUSSION.

Dr. C. H. Desch: The paper, combined with the Autumn Lecture by Professor Chevenard yesterday, represents a contribution of a new kind to the " Proceedings " of the Institute, in that they discussed the application of scientific principles to the internal organisation of an industry. He wished to deal only with one point, namely, the influence of re-worked metal and of scrap on the conduct of metallurgical processes. That was a problem which necessarily became more and more insistent as the production of any metal or metallurgical product increased. In the iron and steel industry the production of steel exceeded, and exceeded in an increasing ratio, the production of pig iron, because the quantity of scrap used was so enormous. Metal which had once been used returned into industry, and in the ordinary open-hearth process a charge, for example, of 60 per cent. scrap and 40 per cent. pig was usual. That condition was bound to present itself in the other metallurgical industries. The quantity of scrap, old metal reworked, must continually increase; and that, as the authors clearly showed, introduced problems of some importance into the conduct of metallurgical processes. That was a question which would have to be faced very carefully by metallurgists, and, in view of the increasing purity of some of the metals, which was showing itself to be of vast importance, the gradual accumulation of impurities in the course of reworking would open up new problems of refinement.

Professor A. Portevin said that the authors at the beginning of their paper classified various factors which influenced the properties of light alloys in service. Personally, he would introduce other factors of a more human kind which affected the matter, such as ignorance, general or personal; the routine methods adopted; previous experience, and *amour propre* and the fear of responsibility. All those were important. When some defect occurred the metal concerned was examined by all the means at disposal with a view to discovering the cause of the accident. Nothing was perfect here below, so that such an examination probably revealed some impurity, heterogeneity, or inclusion, and by a possibly inaccurate association of cause and effect we were apt to say that it was that impurity or inclusion which had caused the accident, whereas it had probably been due to some error in the operation of the machine. The authors called attention to the chemical alterations which resulted from successive re-meltings. But it was necessary to be careful before declaring that an impurity present in a specified amount was harmful.

Mr. H. J. Maybrey said that as an industrial member of the Institute, a foundryman, he found that in the aluminium business the scrap question was becoming very serious. The only solution he saw was the making of secondary ingot material by the scrap metal merchants. Whether that would please the scrap metal merchants or not he did not know, but from the foundryman's point of view it seemed to be the only solution. The scrap which came into factories was so heterogeneous, so varied in composition and type, that it was almost impossible to guarantee any continuity of result.

Dr. P. G. Bastien thought it would be dangerous to exaggerate the part played by the depreciation of a metal in the course of its melting, and to believe that that deterioration was a geometrical function of the number of remelts, because the metallurgy of a particular metal could be considered as established only when it could be refined after melting was completed.

The President said that that was a particularly interesting subject, and one which he was very glad to hear discussed, because it lay on the borderline between metallurgy and engineering. The Institute was particularly indebted to authors who brought forward papers of the kind; they were valuable, not only for the information which they contained, but for the stimulus which they provided. The last paragraph of the paper deserved very careful study by reason of the advice which it gave to both metallurgists and engineers.

The Marquis de Fleury said in reply that if a firm which specialised in work of great precision utilised its scrap, the necessary precision would begin to fall off after a time. It would be better to supplement the principal manufacture of high output ratio by secondary manufacture having a lower output ratio; a factory which made only one class could not go on without trouble.

The following paper was then presented :—" Mechanical Properties of Aluminium and its Alloys After Prolonged Heating," by Professor Dr.-Ing. A. von Zeerleder, Member, and Dr.-Ing. R. Irmann, Met. Eng.

ALUMINIUM AND ITS ALLOYS.

The strength of pure aluminium and various aluminium alloys has been investigated after heating for long periods at 75 deg.–300 deg. Cent. The strength properties of the same materials were determined also in the state of complete stabilisation. The heating periods employed extended over approximately two years. After treatments of different duration at elevated temperatures, some specimens were cooled and tested at room temperature; others were tested at the treatment temperature. For complete softening at 250 deg. Cent., for instance, *i.e.*, to obtain the properties observed in completely stabilised samples, heating periods of at least six months are required in the case of pure aluminium and Anticorodal, and of more than two years for Avional and " Y " alloy. A still longer heating time is necessary in the case of the alloy " R.R. 59."

To determine the decrease in strength of any material after heating for long periods at elevated temperatures it is necessary, therefore, to carry out tests of long duration.

The values of the yield point observed in the normal short-time test after heating periods of one year form a basis for calculations for engineers. The permissible loads can be ascertained only by observation of the creep limit, and this property is being studied by the authors.

DISCUSSION.

Professor A. Portevin said that the paper was a very valuable and useful contribution to the question of the mechanical stability of the different alloys of aluminium. The authors confirmed the necessity for tests of long duration in the case of aluminium alloys. It was essential to know those facts, but such studies must be continued so as to bring to light the evolution and the laws of the different phenomena which governed the modifications of properties which had been found to occur. He hoped the research workers who had carried out the investigations described in the paper would try to find the law—mathematical, if possible—which would enable us to say that a certain result obtained from a short-time test meant that after two or three years the result would probably be such and such.

Professor D. Hanson: All those who spend their time in research in any science live in a world of shocks. In the earlier days, metallurgists were content to heat their alloys for two or three days; but slowly they came to realise that two or three days was not enough, and now they heat for one, two, three, or four weeks. The authors have now given them a shock, because it is quite clear that in the case of many of the alloys considered equilibrium at important temperatures such as 300 deg. Cent. cannot be reached even in one year. That was very disturbing; it was one of the major shocks of life! For instance, in the case of " Y " alloy at 300 deg. Cent., the Brinell hardness seemed to decrease in a linear fashion over the whole of the time between one hour of heating and 360 days, and there was nothing to indicate any cessation of that process. The authors had shown that such changes occurred, but if an alloy was to be used at 200 deg. or 300 deg. Cent. for a long time it was presumably in many instances subjected to stress for that long time, and tensile tests, hardness tests, and so on, which occupied the space of a few minutes or even a few hours, would not reveal the essential properties of those materials when they were used at elevated temperatures. In many metals—iron alloys, copper alloys, and so on—the tensile strength did not depend, within the range of temperature up to perhaps 500 deg. Cent. or higher, on the rate of testing, but in the case of the aluminium alloys it did depend on the rate of testing. It depended very much on the rate of testing at temperatures above atmospheric temperature, but even at the ordinary atmospheric temperature tests had shown that an alloy which was subjected to a prolonged load broke at a stress markedly less than that shown by the ordinary tensile test. In other words, creep phenomena manifested themselves at ordinary temperatures, and to a very marked degree at elevated temperatures, such as 100 deg. or 200 deg. Cent., in aluminium alloys. The authors were faced with the terrible problem of determining the real strengths of those alloys within the temperature range at which they were working for periods of application of load extending perhaps up to the length of their time of heating, one year. That was a terrible problem to have to face, but he thought they had brought it on themselves by showing the necessity for it!

Dr. R. Seligman, referring to what Professor Hanson had said, thought it rather shocking that he should be shocked by what was obviously not shocking at all, and about which he certainly should not be shocked. It was now more than twenty years since the whole subject was discussed before the Institute at great length by Sir Harold Carpenter, who did a series of experiments which for some curious reason had not been referred to by the present authors. Memories are well known to be short and time flies, and apparently that work had been completely forgotten.

Sir Harold Carpenter and his colleagues continued their work for five years, and showed in the case of pure metals very much the same results that the present authors had presented.

Dr. von Zeerleder, in a preliminary oral reply, thanked Dr. Seligman for the information he had given with regard to the work of Sir Harold Carpenter. He would go into that and discuss in it his written reply.

The following paper was then presented :—" An Anodic Treatment for the Production of Aluminium Reflectors," by N. D. Pullen.

ALUMINIUM REFLECTORS.

A description is given of a dual anodic process designed for the treatment of aluminium surfaces in order to produce a high degree of reflectivity. The first bath in which the electrolytic brightening is produced is a mixture of sodium carbonate and sodium phosphate in the approximate proportions of 3 : 1 having a strongly alkaline reaction. The second bath in which a reinforcing film is produced consists preferably of a strong solution of acid sodium sulphate. Data are given showing the reflectivity of aluminium surfaces treated by this method compared with a standard silver mirror and other surfaces such as chromium plate, nickel plate, &c.

DISCUSSION.

Mr. H. Sutton asked the author whether there was any difference when daylight was used instead of the

artificial light which he employed in his experiments, and if he could give in round terms an idea of the durability of the new type of aluminium mirror.

Dr. A. G. C. Gwyer referred to the extraordinary stability of anodic aluminium films to temperature. When the mirror finish was produced the sheets could be heated up to the melting point and yet retained their brightness absolutely unimpaired up to that point, whereas round about 400 deg. Cent. or so ordinary metal turned quite dull.

The President remarked that the discovery of the anodic film reactions on aluminium was a startling thing at the time and had led to very interesting developments, and now the discovery of transparent films suggested the possibility of valuable industrial service for reflecting surfaces and opened up a fascinating field.

Dr. R. Seligman reminded the meeting that the whole of the work originated with the Corrosion Research Committee of the Institute and that French metallurgists had now coined the word "bengoughiser."

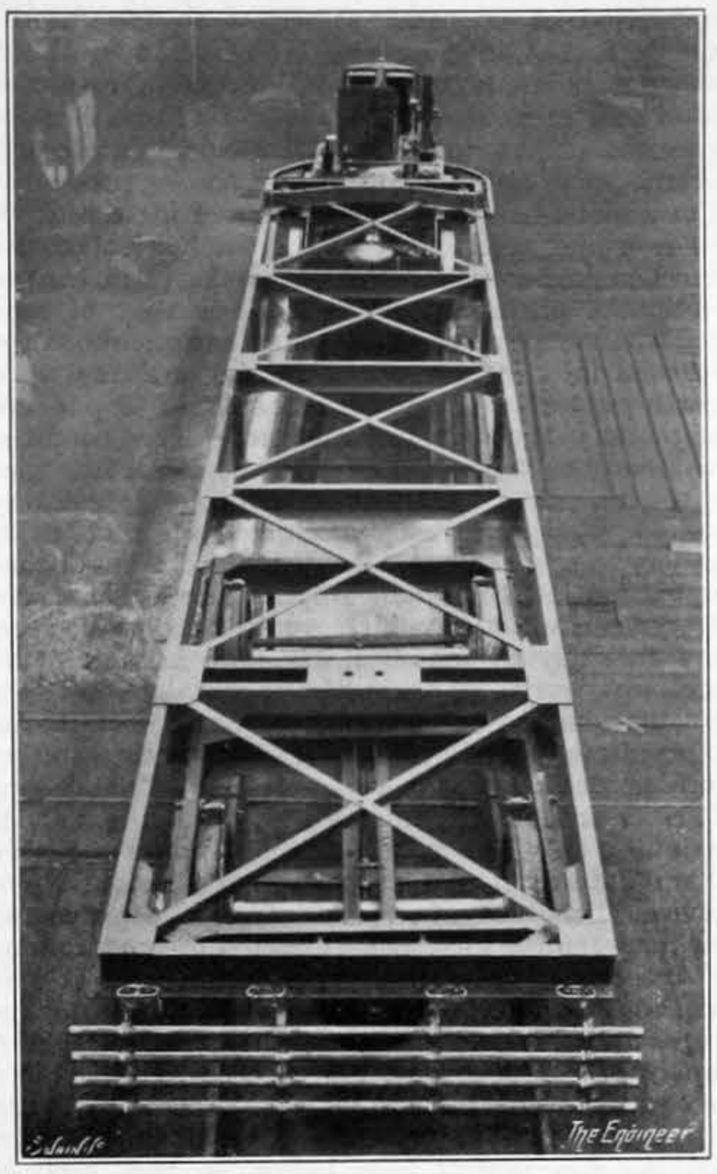
Mr. N. D. Pullen, in reply to the point raised by Mr. Sutton regarding the relative reflectivity values, said they had attempted to carry out some tests using daylight, but Warrington daylight was such an uncertain factor that all he could say was that the figures for different surfaces fell in the same relative order—aluminium was always brighter than nickel and chromium, and slightly less than silver. Some of the material had been out for 2½ months, but there was no sign of any corrosion so far.

There was one point in connection with the treatment which he had not mentioned in the paper, and that was that the electrolyte must not be stirred during treatment. Before the material was put in the electrolyte was stirred to get the temperature up to 80 to 82, but during the treatment the electrolyte must be quite still; in fact, it was necessary to put wooden baffle boards at the two ends on the cathode plates to keep the hydrogen stream away. A peculiar thing about the process was that there was any amount of hydrogen coming off, but one had to look very carefully indeed to find any gas on the anodes. Even using eudiometer tubes there was plenty of hydrogen, but no oxygen.

(To be continued.)

A New Railcar for Peru.

A LIGHT railcar of somewhat novel design has recently been exported to Peru for service on the Paita–Pauira section of the Peruvian Corporation Railway. It was built by Walker Brothers (Wigan), Ltd., to the inspection of Messrs. Livesey and Henderson, consulting engineers to the railway, and is the first of the firm's railcars to be exported. The design is based on a number of railcars supplied to the Irish railways, which have different final drive ratios to adapt them to the conditions of their work. The Peruvian Corporation car is geared for a maximum speed of 50 m.p.h., the San Paulo–Campo Limpo car 45 m.p.h., and the Bragantina car 40 m.p.h. In addition, although all three cars can be operated with the four wheels of the driving bogie coupled with side rods, only the Bragantina car is actually



RAILCAR CHASSIS FROM TRAILING END

so fitted, the other two obtaining adequate adhesion with a two-wheel drive. Such a system is made feasible as the cars which are designed to operate in one direction only are built on the principle of the "mechanical horse"—that is to say, the power unit is an independent four-wheeled vehicle on which the engine transmission, control system, and driver's cab are built, and to which one end of the passenger frame is articulated, a "concertina" joint providing access from the driver's cab to the passenger coach. By making the frame and the body in two independent sections the vibrations, noises, smells, &c., in the engine end are not carried over to the passenger portion, while lightness of construction of the main frame and trailing bogie is easily attained owing to the absence of driving strains and vibrations. We illustrate herewith the frame and the bogies. The lightness and simplicity will be noted, as well as the absence of accessories, control rods, &c., attained by eliminating the duplicated driving positions and by providing a single independent brake cylinder for each bogie to operate the vacuum brakes. The vacuum braking operates on all four wheels of each bogie, a screw-down hand brake being also fitted on the power bogie. The frame is carried on central pivots on both bogies, coiled springs in the bolsters correcting any tendency to side swing. It is a built-up channel section framework. A spring coupling for towing is fitted.

The power bogie is an independent unit capable of being driven on the line without the main portion when, for example, a breakdown makes a power bogie replacement necessary. It has plate side frames, into which horn block guides are fitted, and it is braced by channel cross members, and substantial front and back plates. Both the front and rear axles of this unit are fitted with "Timken" roller bearings, to which a constant supply of oil is given automatically from the axle casing and worm gear casing. The axle-boxes, which carry the roller bearings, work in horn blocks, and are bolted also to the worm gear casing, a torque arm thus being unnecessary. These bearings also take the radial and thrust reaction from the transmission of the drive. The suspension is by four half-elliptic springs mounted on the axle-boxes and supplemented by auxiliary coiled springs.

The engine is a Gardner 6 L W 100 H.P. oil-fuel unit fitted with an electric self-starter. Emergency hand starting is provided and all six cylinders are fitted with decompressors. The cylinders have a bore of 4¼in. and a stroke of 6in. A maximum and minimum r.p.m. governor comes into operation at tick-over speed and at 1700 r.p.m., at which speed the engine B.H.P. is 102 and the torque 314 lb.-ft. The draw-bar pull at 55 m.p.h. is given as 610 lb. and at 12·5 m.p.h. as 2500 lb., these figures being for a top speed of 55 m.p.h. and being in proportion to the back axle ratio provided. The radiator is fitted at the front end and designed for unidirectional operation. Hand-operated radiator shutters are fitted and a thermometer is provided on the instrument board.

Unit construction has been adopted, the engine being connected to the gear-box by a substantial bell housing into which is fitted the fly-wheel, and single dry-plate clutch. The power unit, comprising the engine fly-wheel, housing, and gear-box, rests on rubber blocks supported in cast steel brackets. Two supports on the engine, and two on the fly-wheel housing case, ensure adequate support for the engine, with complete freedom from vibration.

In the case of the Peruvian Corporation railcar, the drive is by means of a normal type four-speed and reverse sliding pinion gear-box. A propeller shaft equipped with Spicer universal joints takes the drive to the rear axle drive which consists of a worm and wheel carried in a cast steel casing. The worm shaft is mounted at the front end on a "Hoffmann" bearing, and the back end is equipped with double "Timken" roller bearings. Special means are provided to lubricate both bearings automatically by oil from the axle casing.

In the case of the two San Paulo cars a Cotal electrically controlled four-speed and reverse epicyclic gear-box is used. In this type of box no brake bands are used, a magnetic field being generated between iron rings to lock the necessary members of the box when required. The current used is small and is taken from the usual lighting battery at normal voltage. As a switch is all that is needed in the way of control, great simplicity is ensured, and no pumps, compressors, or other auxiliaries are needed.

Pedal-operated gravity sanding gear is provided in the driver's cab, and a large fuel tank operating on a gravity feed is used. The simplicity of the entire design is one of its leading features, and should reduce maintenance costs.

BRITISH STANDARDS INSTITUTION.

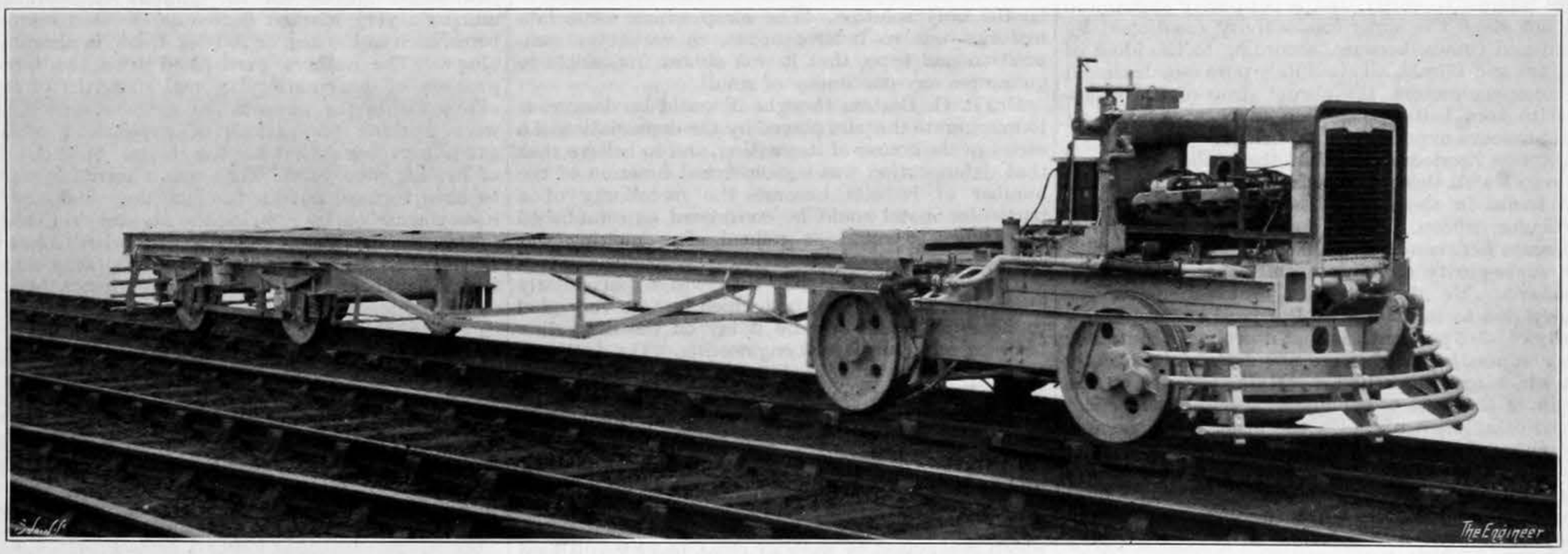
All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, *Victoria-street, London, S.W.*1. *The price of each specification is* 2*s.* 2*d. post free, unless otherwise stated.*

ELECTRICAL PERFORMANCE OF TRANSFORMERS.

No. 171—1936. The revision of British Standard Specification No. 171, Electrical Performance of Transformers for Power and Lighting, is now ready, having been issued for some time now have been running with remarkable regularity. Two similar cars are at present in course of construction on order for the San Paulo Railway of Brazil. It speaks well for the simplicity of the Walker Brothers design that although each of the three cars is built for a different gauge, no alteration in design was necessary.

The Peruvian Corporation Railway operates on 4ft. 8½in. gauge, while the San Paulo has two sections, one, "the Bragantina," being metre gauge, the other, from Campo Limpo to San Paulo, being 5ft. 3in. gauge. The two new railcars will operate a shuttle service at the gauge-changing station at Campo Limpo, the passengers coming into the station from one line being carried on immediately on the other line in a precisely similar vehicle. The importance of having similar vehicles running in connection with one another as a means of simplifying the journey as well as a means of accelerating the transfer of passengers will be appreciated by the traffic control department.

The three cars, in addition to the gauge difference, after several years' work on the part of the B.S.I. Committee responsible for the preparation of the specification. The new issue is even more comprehensive than the 1927 edition, and embodies various new and revised features. The most important changes deal with the basis of reference for the temperature of the cooling medium and the permissible temperature rises. Particular attention has been paid to the fact that the specification will be used extensively throughout the Empire, and, therefore, an attempt has been made as far as possible, without penalising the home user, to meet the overseas requirements. The specification is substantially in line with the international specification for transformers, prepared by the International Electrotechnical Commission—price 3s. 9d. post free.



RAILCAR CHASSIS SHOWING ARTICULATED POWER UNIT

UNDER the auspices of the Netherlands Chemical Association an international rubber chemical conference is to be held at Delft on October 2nd and 3rd.

Rail and Road.

IN order to devote his whole time to his new appointment as chief executive officer of the Commercial Motor Users Association, Mr. F. G. Bristow has tendered his resignation as secretary of the British Road Federation.

THE Chosen Government has announced its intention to build a transpeninsular railway line between Fusan and Keijo, at a cost of some 100 million yen. The proposed line will link Fusan, Urusan, Choyoi, Keishu, Hyosen, Gijo, Tan-yo, Genshu, Yohei, and Seiryori, on the eastern outskirts of Keijo.

IT is proposed to call a conference of all the interested local authorities to consider the promotion of a new Bill authorising the construction of a bridge over the river Severn. It will be remembered that the previous parliamentary Bill, which was promoted by the Gloucestershire and Monmouthshire County Councils, was rejected last May by a Select Committee.

A FLOOD-CONTROL project in the Muskingum valley, Ohio, in the United States, has made necessary the construction of 50·72 miles of railway lines to replace those which will be flooded. Costing some 6 million dollars the work will involve the location and construction of nine individual relocations for four different railways. Including 16·64 miles of sidings the new road beds will accommodate 67·5 miles of track.

ON Friday, September 18th, a train drawing up at No. 16 platform at Victoria Station, Manchester, crashed into a train standing there and smashed the guard's van. The stationary train had just arrived at the platform from Morecambe and Windermere, and all the passengers had alighted. The other was the Southport train from Hellifield. Platforms Nos. 15 and 16 were obstructed for about two hours, but no one was hurt.

A RECENT report on the economic and financial conditions in Yugoslavia says that the following railways are in course of construction :—Koprivnica–Varazdin, of standard gauge with a total length of 41 kiloms.; Sv. Janz–Sevnica, of standard gauge, the first section 7·5 kiloms. long ; Bilece–Niksic, of narrow gauge, with a total length of 71 kiloms.; Ustipraca–Foca, of narrow gauge, with a total length of 42 kiloms. One hundred new passenger coaches for standard gauge are expected to be obtained from Germany shortly, and the railway workshops at Kralsevo are being extended and re-equipped for the building of locomotives and coaches.

THE electrification of the Swedish State Railways has resulted in a reduction of the number of employees in stationary service by 50 to 60 per cent. over the whole system as compared with the number employed when steam power was used. According to T. Norinder the costs for stationary engine service on the Stockholm-Malmö line in the three southern sections were reduced by 32 per cent. between 1932 and 1935. Meanwhile, the railway engine work has risen by 16 per cent. owing to the higher operation figure in kilometres per electric locomotive in comparison with steam locomotives. By next year 45 per cent., or 3353 kiloms., of the country's system will be electrified.

A GRANT from the Road Fund has been made by the Minister of Transport towards the cost, estimated at £46,700, of building a new bridge over the river Findhorn, on the Inverness-Elgin trunk road A.96, near Forres. The bridge will take the place of the existing Findhorn Bridge, which is in a weak condition and is to be dismantled. It will be a steel arch structure with a clear span of 270ft. and a width between parapets of 40ft. On the bridge and approach roads a 30ft. carriageway, flanked by 5ft. footpaths, will be provided. The elevation of the proposed bridge has been approved by the Royal Fine Art Commission for Scotland and it is expected that the scheme will be completed early in 1938.

THE new through sleeping car services between London and Paris will begin on October 14th next. The night services will leave Victoria at 10 p.m. and Paris at 9.50 p.m., and arrive respectively at the Gare du Nord and Victoria at 8.55 a.m. and 8.30 a.m. The sleeping cars will be carried between Dover and Dunkirk by train ferry. Day services by the train ferries will begin on October 15th, leaving Dover and Dunkirk at 1.15 p.m. and 2.15 p.m. respectively. The 11 a.m. boat train from Victoria will connect with the outward ferry and the inward arrival at Victoria will be at 8.40 p.m. From October 3rd–4th until the through train ferry begins the train ferry boats will travel nightly between Dover and Dunkirk, and the present Folkestone–Dunkirk service by the French A.L.A. boats will cease.

THE Anti-Noise Committee appointed by the Minister of Transport in August, 1934, proposed in October last year that no new motor car, motor cycle, or lorry should be allowed to make more than 90 phons of noise when running at 30 m.p.h. on full throttle. The Committee found that in general the average car was not unduly noisy, unless the engine was raced, but that the average motor cycle, except at moderate steady speeds, was excessively noisy. The proposed regulation was accordingly drawn up, and, if necessary, was to be enforced by the use of phonmeters in the hands of mobile police. The reply of the British motor cycle manufacturers contains an undertaking to the Minister of Transport that no motor cycle making a noise " which could be described as offensive " will be allowed to leave the works in future.

EXPERIMENTAL public passenger-carrying services have been introduced on the L.M.S. Railway between Rugby, Leamington Spa, Coventry, and Nuneaton with the first British-built, rubber-tired railcar constructed by the Coventry Pneumatic Railcar Company (a branch of Armstrong-Siddeley Motors, Ltd.). This railcar was described in our issue of August 14th this year. Until October 2nd, and possibly after that date as well, the railcar will be maintaining additional passenger services in the above-named area, facilities for its trial under service conditions having been granted to the Railcar Company by the L.M.S. The railcar, which is carried on sixteen rubber-tired wheels, seats fifty-six passengers and has a maximum speed of about 75 m.p.h. It is driven by a 280 H.P. engine and is practically noiseless in running.

Miscellanea.

Too rapid setting of plaster of paris can be retarded by the addition of a mixture of phosphoric and citric acids or their salts.

THE petrol consumption of Great Britain during July last was 129,926,900 gallons and for the first seven months of the year over 777 million gallons.

THE Uphall Works of Scottish Oils, Ltd., are to be closed down and the work hitherto carried on there will in the future be done at Grangemouth, where the plant has never been worked to capacity.

A CONTRACT has been placed for the construction of a Portland cement factory in North Lincolnshire. The new factory ,which is expected to be ready for production in a year, will have a daily capacity of 250 tons.

IT is shown in the annual report of the Secretary for Mines that during 1935 there were 222,541 flame type safety lamps in use in mines in this country, as compared with 242,901 in 1934. The corresponding number of electric safety lamps in use was 397,206 in 1935 and 394,820 in 1934.

THE Council of the Incorporated Municipal Electrical Association has accepted the invitation of the Mayor and Corporation of Brighton to hold its next Annual Convention at Brighton, under the presidency of Mr. Frank Forrest, Chief Engineer and Manager to the Birmingham Corporation. The period of the Convention will be from May 31st to June 5th. There will also be an Electrical Exhibition, to be held at the Corn Exchange.

AN extract in the *Iron and Coal Trades Review* describes how the variation in carbon content of mild steel can be determined by magnetic analysis. A sample of steel in the shape of a rod is placed in a uniform alternating magnetic field and is probed at different points by a coil, the current passing through the coil being a measure of the carbon content at the particular point probed. The arrangement is calibrated by probing at points of known chemical composition.

IN our issue of August 21st last we described the first of a series of bridge breaking tests to be made by the Ministry of Transport and the Department of Scientific and Industrial Research on a 140-year old bridge near Derby. The second test of this kind has been made on an old arch bridge over the Stratford-on-Avon Canal at Happy Valley, Yardley Wood, Birmingham. When the tests have been completed the old bridge will be replaced by a steel and concrete bridge.

FEW subjects are of greater interest to electrical engineers at the present time than that of the tests which have to be performed on oil circuit breakers rated to give unusually large short circuit breaking capacities. In this connection official tests were carried out last week at the High-power Testing Plant of the General Electric Company, Ltd., Witton, on a 1,500,000-kVA circuit breaker, in the presence of representatives of the Central Electricity Board, the Consulting Engineers to the C.E.B., and the Sheffield Corporation Electricity Department, to whom the breaker is being supplied. Some idea of the magnitude of the currents involved in the tests under consideration may be gathered from the fact that the making current on this particular switch was over 200,000 amperes.

ON Tuesday, September 22nd, Mr. G. Wheelwright, of the Land-Wheelwright Laboratories, Boston, U.S.A., gave a demonstration at 27, Leadenhall-street, E.C.3, of the theory of polarised light and its scientific, industrial, and commercial applications. He first described the theory of polarisation by means of the familiar rope analogy and then described Polaroid as sub-microscopic crystals bound with a matrix of cellulose acetate. It might be laminated in glass for optical purposes. A number of still pictures were shown, which demonstrated the properties of the material for light reflection, and cloud control in photography. Later was shown a film which had been taken through Polaroid screens and when viewed through Polaroid spectacles the depths of the pictures were thrown up and the screen gave the impression of looking through a window at actual objects. Sun goggles of Polaroid cut out glare, saturate natural colours, and intensify the blue of the sky with the loss of but a small proportion of the light. For the purpose of strain testing models made in celluloid and examined by means of Polaroid show visually the directions and severity of the strain. The material may also be used very effectually as a means of cutting out headlight glare in motor vehicles. These are but a few of the many interesting demonstrations given by Mr. Wheelwright, who said that the material is at present made as a laboratory product, but will shortly be made commercially.

A METHOD for the chemical frosting of glass by a rapid dipping process is described in an extract in the *Chemical Trade Journal and Chemical Engineer*. The treatment bath is a solution of two parts of hydrofluoric acid, four parts of ammonium fluoride, and one part of soda. In preparing the bath the hydrofluoric acid and the ammonium fluoride are placed in a lead or gutta-percha receptacle, and allowed to stand for at least eight hours in a moderately warm place. The fluoride dissolves, but later separates out at the bottom of the bath as a layer of white mud. To prepare the bath, the contents are agitated and poured through a cloth into a lead vat, which is to be used for the glass treatment. The quantity of soda necessary is then added slowly and with agitation. The glass object for treatment should be first washed with distilled water containing 3 per cent. of hydrochloric acid. After draining, and before it is dry, it is transferred by pincers and plunged below the surface of the bath, moved about for a short time, and then placed on a wooden drainage table. Frosting takes place in two or three minutes. The article is washed with cold water, brushed, and then washed with hot water. The hands of the workers are protected by rubber gloves. By this process, it is stated, one man and four girls can treat 2000 to 2400 pieces in twenty-four hours. The quantity of soda indicated above gives a matt frost. If a lower quantity of soda is employed the frosting has a more silky appearance. The temperature of the treatment bath should be at least 16 deg. Cent., for if materially lower the frosting is not uniform.

Air and Water.

THE French research vessel " Pourquoi Pas ? " was lost in a storm off the Iceland coast on September 16th with all hands but one.

THREE motor ships of 9500 tons each have been ordered by the Commonwealth and Dominion Line. Two are to be built at Sunderland and one at Wallsend.

CAPTAIN C. E. MUMFORD, who has retired on account of ill-health from the position of marine superintendent for the Union-Castle Line, has been succeeded by Captain David Nicoll.

THE largest military aerodrome in Italy has been opened at Froli, on the Adriatic Coast. The aerodrome, which is the largest in the country, covers some 300 acres and is capable of accommodating 250 machines.

ON Monday, September 21st, the United States battleship " Texas " and the British tanker " Scalaria " collided in a fog off San Pedro, California. Reports say that the stern of the " Texas " was badly damaged.

THE Australian Minister of Defence has announced that a company with a capital of £600,000 is to be registered immediately for the production of aircraft. It is expected that the new company will be producing within a year.

IT is reported from the United States that the construction of a liner to replace the " Leviathan " is definitely in sight. The new ship will be a sister ship to the " Manhattan " and the " Washington," and is expected to cost about 2½ million pounds to build.

THE first air race to be held at Hereford took place on September 18th. It was a handicap flown over a triangular course of 30 miles, which was covered three times. The race was won by R. F. Hall, piloting an Avro " Cadet." He covered the course in 45 min. 34 sec. The second machine was a " D.H. Moth," piloted by Misses M. and S. Glass, and the third a " Puss Moth," piloted by A. F. E. Payen.

WE regret to have to announce the death of Mr. T. Campbell Black, the airman. He was killed on Saturday, September 19th, at Speke Aerodrome, Liverpool. When taxi-ing along the ground in the Percival " Mew " machine which had been entered for the race to Johannesburg a collision occurred with an R.A.F. Hawker " Hart," which had just landed, and he was fatally injured by the propeller of the larger machine.

ON Saturday, September 19th, the handicap air race from London to Cardiff was won by a monoplane " T.K.2," piloted by R. J. Waight, at a speed of 189·7 m.p.h. A Percival " Gull," piloted by C. E. Napier, came second, at a speed of 154·3 m.p.h., and a " Puss Moth," piloted by L. J. C. Mitchell, third, at a speed of 135 m.p.h. The highest speed of 189·8 m.p.h. was reached by the fourth machine, a " Miles Hawk," piloted by W. Humble.

THE Council of the Institute of Transport has made the following premium awards in respect of the session 1935–36 :—Dock and Harbour Gold Medal to Sir David J. Owen, for his paper on " The Future of Port Control with Special Reference to the Possibilities of Grouping " ; Inland Water Transport Medal to Mr. L. P. Alvin, for his paper on " Mechanical Traction on the French Waterways " ; " Coastwise Shipping Medal to Mr. E. R. Reader, for his contribution on " The British Coasting Trade."

IT is claimed that the wireless installations now being fitted in the new Empire flying boats of Imperial Airways are the most modern and efficient yet constructed for use in commercial aircraft. One feature is that the direction finding apparatus is embodied in the main set and is not, as hitherto, a separate piece of equipment. By use of this new equipment the operator will be able to tune in to any ground station operating within range and plot out the air liner's position at any time during a flight. Some twenty new wireless stations are being established at present on the Empire air routes.

TRIALS have just taken place of the " Eildon," a motor-driven collier, 255ft. in length overall by 37ft. by 16ft. 5in. to her raised quarter deck. She has a deadweight tonnage of 2100 and has been built by the Grangemouth Dockyard to the order of George Gibson and Co., Leith, for their home and Continental trades. She is claimed to be the first of all British motor-driven colliers and also the first Maierform vessel to be built in this country for collier purposes, and it is expected that her appearance in service will cause a great deal of interest. All deck machinery and auxiliaries are electrically driven and propulsion is by means of an Atlas Polar two-cycle engine rated to give a trial trip speed of about 10½ knots.

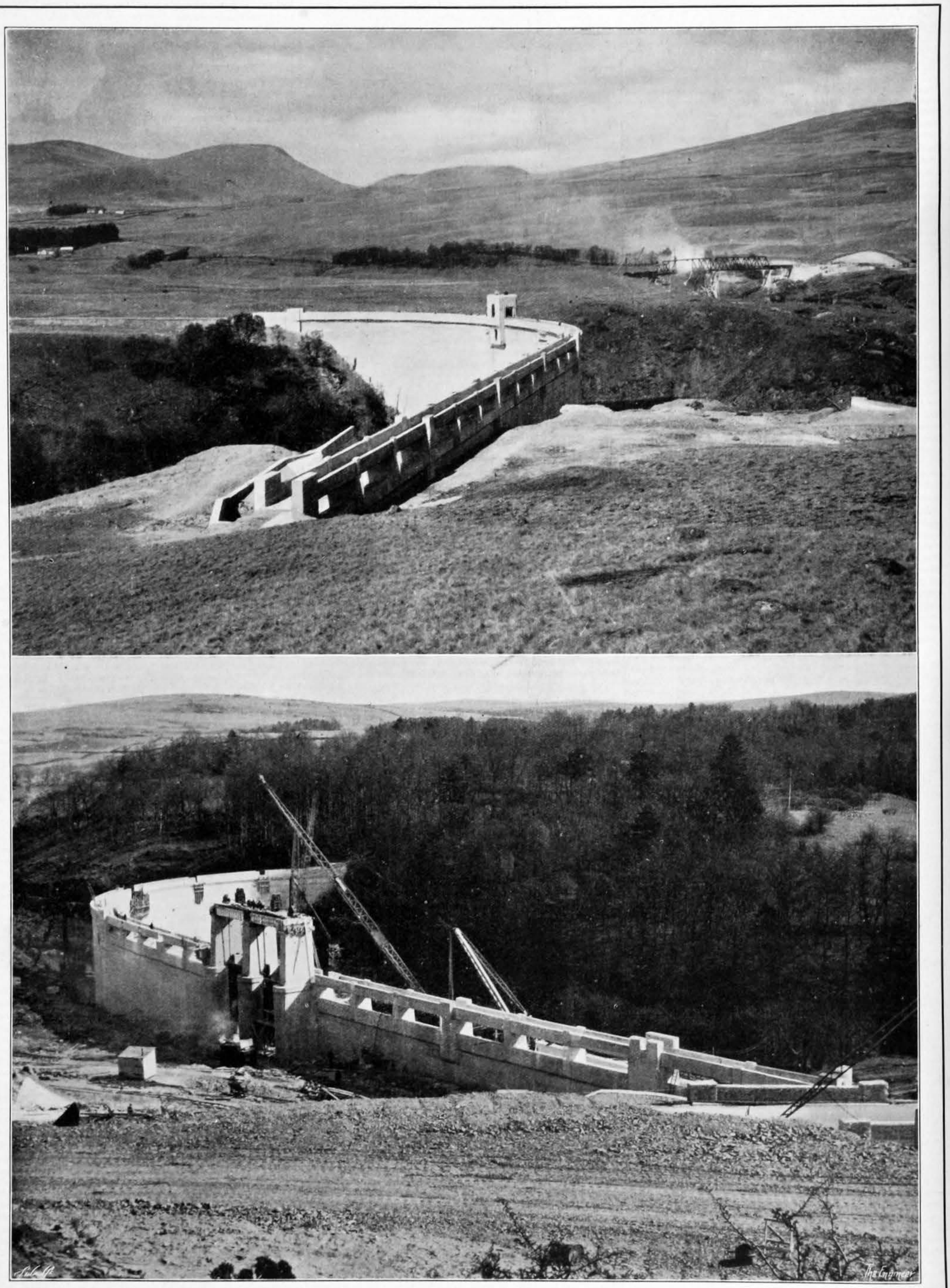
THE United States Secretary of Commerce recently stated that since June 30th, 1935, there has been no loss of life among passengers in any classified American passenger ship. According to a note in the *Journal of Commerce*, he said : " The Bureau of Marine Inspection and Navigation has accelerated putting into effect all the new rules and regulations made possible by the recently enacted legislation. Through its newly organised technical staff, it has had withdrawn from active service some forty odd ships, which were unable to meet specifications, and has also required some ships to undergo certain alterations before approving them for passenger transportation, while still others were definitely ordered out of the passenger service and placed in freight service."

WE understand that, following the successful operation of the Paxman-engined m.v. " Pomeroon," recently built for the Crown Agents for the Colonies, Davey, Paxman and Co. (Colchester), Ltd., have received a duplicate order for the supply of the main propulsion and auxiliary engines for a sister vessel to be built by Ferguson Brothers (Port-Glasgow), Ltd. The main propelling machinery will comprise two Paxman-Ricardo engines, each having a continuous rating of 180 B.H.P. when running at a speed of 1000 r.p.m., fitted with reverse reduction gears giving a propeller speed of 300 r.p.m. The auxiliary equipment will consist of a 33 B.H.P. and a 47 B.H.P. Paxman-Ricardo engine running at a speed of 1100 r.p.m. Each engine will be direct coupled to a generator and drive an air compressor through a friction clutch, the whole unit being mounted on a common bed-plate.

THE GALLOWAY WATER POWER SCHEME

SIR ALEXANDER GIBB AND PARTNERS, WESTMINSTER, AND MERZ AND MACLELLAN, WESTMINSTER, ENGINEERS

(For description see page 309.)



DEUGH DAM AND EARLSTOUN DAM

The Engineer

SEPTEMBER 25, 1936.

VOL. CLXII. No. 4211

Contents.

THE ENGINEER, September 25th, 1936. PAGE

A SEVEN-DAY JOURNAL ... 305
THE ART OF GEAR DESIGN. No. XI. (Illus.) ... 306
THE BRITISH ASSOCIATION. No. II ... 308
THE GALLOWAY WATER POWER SCHEME. No. III. (Illus.) ... 309
THE DENNY-BROWN SHIP STABILISER. (Illus.) ... 312
THE INSTITUTE OF METALS. No. I ... 314
A NEW RAILCAR FOR PERU. (Illus.) ... 316
BRITISH STANDARDS INSTITUTION ... 316
RAIL AND ROAD—MISCELLANEA—AIR AND WATER ... 317
LEADING ARTICLES—
The Automatic Stabilisation of Ships ... 319
Locomotive Tests ... 319
Defence Programme Contracts ... 320
LETTERS TO THE EDITOR—
Road Accidents and Road Design—Smoke from Domestic Grates—Science and Society ... 320
THE BUILDING EXHIBITION. (Illus.) ... 321
ROLLING OF THE S.S. "CONTE DI SAVOIA." (Illus.) ... 323
SIXTY YEARS AGO ... 326
GOVERNMENT INSPECTION OF DAMS IN AMERICA ... 326
AN AIR PREHEATER. (Illus.) ... 326
ELECTRICAL EQUIPMENT FOR SMALL HOISTS. (Illus.) ... 326
THE MODEL ENGINEER EXHIBITION ... 327
DEFENCE PROGRAMME CONTRACTS ... 327
RAILCAR OPERATION IN THE ARGENTINE ... 328
MARKETS, NOTES AND NEWS ... 329
CURRENT PRICES FOR METALS AND FUELS ... 330
FRENCH ENGINEERING NOTES ... 331
BRITISH PATENT SPECIFICATIONS. (Illus.) ... 331
FORTHCOMING ENGAGEMENTS ... 332
PERSONAL AND BUSINESS ANNOUNCEMENTS ... 332
CONTRACTS AND ORDERS ... 332
LAUNCHES AND TRIAL TRIPS ... 332

TWO-PAGE SUPPLEMENT—THE GALLOWAY WATER POWER SCHEME.

NOTICES TO READERS.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

*** *Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new address,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

THE AUTOMATIC STABILISATION OF SHIPS.

Two events of the past week have served to direct renewed general attention to the automatic stabilisation of ships at sea. First there was the demonstration of the Denny-Brown stabilising equipment fitted in the Southern Railway Company's 2200-ton cross-Channel steamer "Isle of Sark." Secondly at the International Meeting of Naval Architects at New York Dr. de Santis and Dr. Russo presented a paper giving authoritative information concerning the performance at sea of the Sperry gyro-stabilisers in the Italian 45,000-ton Transatlantic liner "Conte di Savoia." We give an account of the "Isle of Sark's" equipment elsewhere in this issue and also reproduce the main portions of the New York paper. The "Isle of Sark" was fitted with the Denny-Brown oscillating fin stabilising gear in the spring of this year and during the summer has been engaged, at least intermittently, on her normal Channel Islands service. The demonstration of the power of the equipment given on September 17th was less satisfactory than it might have been because of the almost dead calm weather conditions under which it had to be given. We have, however, been assured that the gear has actually been used to stabilise the ship in rough water while carrying passengers in the normal course of her duties. The "Conte di Savoia" has been running between Genoa and New York since November, 1932, and from the outset her stabilising equipment has been a subject of close study by her owners. As a technical member of the Italia Steamship Company's staff Dr. Russo has made thirty-eight Atlantic crossings in the liner and during these trips has observed the behaviour and effect of the gyro-stabilisers under almost every variety of weather conditions. While it may be too early as yet to pass final judgment on the "Isle of Sark's" gear, there can be no doubt that the New York paper gives us, for the first time, the main facts required for forming a sound assessment of the technical merits of the "Conte di Savoia's" equipment. Taken in conjunction the two ships, differing so greatly in size and in the nature of their stabilising systems, offer British shipowners an opportunity to lay aside the scepticism which has so far marked their approach to automatic stabilisation and to form concerning it an opinion which can now be based on practical experience rather than upon theoretical forecasts.

The "Isle of Sark" is a ship belonging to a class which from the earliest days of automatic stabilisation has been recognised as being particularly well adapted to it. The "Conte di Savoia," on the other hand, represents a very courageous extrapolation and it seems probable that she will remain the largest automatically stabilised ship for some years to come—at least so far as gyro-stabilisers are concerned. Sir Maurice Denny tells us that he can see no reason why the moving fin system should be confined to cross-Channel steamers and that it might quite readily be fitted in a much larger ship, possibly equipped with more than one pair of fins. Technical reasons can certainly be adduced to prove that the larger the ship the more satisfactory would be the action of the fins and the cheaper would be the relative cost of installation. This extension of the moving fin system to larger ships offers an interesting subject for discussion, but for the moment we will confine ourselves to actual achievements so far, remarking only that in our opinion the cause of automatic stabilisation will be best served by a gradual advance to larger sizes. Turning to the "Isle of Sark's" rolling record reproduced on page 314 we find that on May 7th this year while she was at sea with the stabiliser out of action she was rolling at times to 12 deg. to port and 9 deg. to starboard or 21 deg. out-to-out. An out-to-out roll of 10 deg., it may be remarked, is quite sufficient to upset a considerable number of passengers. When the stabiliser was brought into action the out-to-out roll was reduced to a maximum of 6 deg. This is the only record which we have seen of the performance of the gear at sea and consequently it would be wrong to accept it as typical. The facts recorded by Dr. Russo concerning the performance of the "Conte di Savoia's" gear clearly indicate that the success or otherwise of any stabilising equipment can be fully judged only from a number of records extending over many varieties of weather and covering, in particular, all angles, between zero and 180 deg., of the wave movement to the ship's course. On page 325 we reproduce nine rolling records of the "Conte di Savoia" covering a period from January, 1933, to February, 1934. It will be noted that the performance of the stabilisers was very variable and that it depended in a marked degree upon the speed of the ship, the state of the sea—whether regular or confused—and upon the direction from which the waves were received. Perhaps the best impression of the efficiency of the gyroscopes is contained in the authors' summarised figures for the first eighteen months of the ship's operation. They state that the average of all average rolls with the stabilisers out of action was 9·063 deg. out-to-out. With the stabilisers in use the corresponding figure was 5·143 deg. giving an average reduction of 44 per cent. It would be folly to pretend that this average result is other than disappointing. It seems however that the stabilising effect of the gyroscopes is affected in an exceedingly complex manner by certain of the general characteristics of the ship and by other factors to which insufficient attention may have been accorded in the first instance because of their obscurity. Noticeable in this respect is the interaction of the yawing of the ship on the stabilising efficiency of the gyroscopes and the disturbing effect of a stern quartering sea when the apparent period of the waves may become equal to, or greater than, the natural period of the ship. Recently, as the authors record, a structural alteration at the stern, an improved type of automatic steering gear, and the introduction of certain rules regarding the speed, trim, and ballasting of the ship have noticeably improved the stabilising efficiency. It remains to be seen whether some of the complex phenomena which have been noticed in the "Conte di Savoia" will also make themselves manifest in the "Isle of Sark," or whether most of them, as some certainly are, are ascribable to the fact that the stabilising equipment of the Italian liner is of the gyroscopic type.

No engineer can do other than take an interest in and wish success to all practical methods and schemes for the stabilisation of ships at sea. Unfortunately, as always, mere technical success is not sufficient by itself to ensure the adoption of any system. The shipowner must be convinced that from the strictly commercial standpoint the automatic stabilisation of his ships will yield him a profit in hard cash. He may look for some of that profit in the reduction of damage by stress of weather and the better speed in rough seas which automatic stabilisation carries with it. In the main however he will expect it to come from the increased patronage of the public. Colonel Szlumper jocularly remarked last week that if the "Isle of Sark's" stabilising gear is fully successful the public will, no doubt, appreciate the benefit of travelling by her to the extent of paying an extra ten shilling fare. From personal knowledge of the route which she serves we are convinced that many passengers would be willing to meet such an additional charge and would regard it as a sound investment or insurance premium. Further we know that the Southern Railway is certain to increase its already large Channel Islands traffic if it can do anything to improve the undoubtedly bad reputation which the passage enjoys. The public demand for automatically stabilised ships has not yet however arisen. The best way to encourage it will be to prove that automatic stabilisation can be accomplished in an assured and safe manner. On this point the public, it seems, still requires a considerable amount of education. We are not certain whether that object is likely to be promoted by the exhibition of a film showing the "Isle of Sark" rolling in a still sea; the non-technical mind may not find it easy to understand that at a touch of a switch the stabilising action of the fins—or a gyroscopic stabiliser for that matter—can be reversed into a rolling action. The technical mind accepts it as obvious, but even apparently intelligent members of the public seem unable, or unwilling to, understand the obvious. In a certain journal which, to judge by its title, takes veracity as its watchword, we find the stabilising gear of the "Isle of Sark" described as consisting of "great, fin-like bilge keels hinged to the hull and connected with a gyroscope, the action of which opens them flat in the water." Our contemporary expresses itself as concerned not so much for the passengers as for "the poor ship." Rolling, it says, is a natural movement of adjustment to the heave of the sea. "If a ship is deprived of the power to adjust herself to the sea, the sea will precious soon adjust itself to her." It is unfortunate that the cause of automatic stabilisation should be at the mercy of such faulty ideas.

Locomotive Tests.

THERE are three different methods of testing the capacity and efficiency of locomotives. The first and oldest is to run them for extended periods on scheduled trains, making notes of the consumption of coal and water and observing the operation of the mechanical details. Taken for all in all, there is no better method. It is the veritable *experimentum crucis*, for it tests the machine under the actual conditions of service, and discovers not only what it can do, but what it suffers in the doing. The second method is that known as the "constant speed" or "Continental." It is similar to the first, in that the engine is run on the open line, hauling a train. The principle of this test is the maintenance of steady conditions on the engine being tested by the employment of a second engine coupled to it. By carefully controlling the power developed by the secondary engine, the speed of the primary engine may be kept constant for many miles with varying gradients and casual resistances. In both these tests a dynamometer car is usually employed for the recording of observations. The third method is carried out on a stationary engine in a test house. It is the only one of the three that enables a complete scientific test to be made under laboratory conditions. But the conditions are quite unnatural and many of the causes which affect the running of a locomotive in service cannot even be simulated. Some of them, loss of heat by radiation, as an example, may be estimated, but others are too uncertain to be calculated or imitated. Indeed, it must be admitted that the test house test, like nearly all laboratory tests, is artificial. Fortunately, that practical defect is counterbalanced effectively by the accuracy with which a scientific investigation, not only of the engine as a whole, but of its details, can be carried out.

In a short but excellent paper, summarised in our last issue, which was read before Section G of the British Association, Mr. W. A. Stanier showed how the ingenuity of the engineers of the L.M.S. had enabled use to be made of the dynamometer car for rather exceptional work. Thus he recorded an investigation into the effect of worn parts on the economic working of locomotives, which was carried out by testing a 4–6–0 engine at various periods of its life; he mentioned also that the car had been used for braking tests—which have not very much to do with the locomotive itself—and that it was a great help when the four railways were studying the question of standardising locomotive types. In fact, he made out such a strong case for the dynamometer car that he almost seemed to be challenging the advantages of scientific testing stations like that at Vitry. He says, to give a particular instance, when describing the constant speed method: "It will be recognised

that this method of testing is practically identical with a stationary test plant in so far as the engine working is maintained under constant conditions, but it also has the practical advantage of including in the test the effect of wind resistance and radiation losses, so far as the locomotive is concerned." Now the merits of a running test cannot be questioned. The best and final test of the sufficiency of a locomotive is performance in service, which we have put first in our list. Moreover, of all tests, it costs the least money, for the engine is earning money all the time. But it takes many months to give results, and when they are given they are statistical rather than scientific—if we may make such a distinction. We are not unaware that the statistical method of research is making headway, and that in the hands of experts it is capable of achieving very notable results, yet it is not likely ever to displace the " scientific " method when that method can be applied. By " scientific " we mean, in this case, the isolation and study of one variable at a time. That can only be done under laboratory conditions, and if, as we hold, it is desirable that locomotives should be examined in that way, then there is no alternative to a fully equipped test house.

Mr. Stanier is in a position to speak with more authority on locomotive testing machines than any one in three out of the four C.M.E.'s of the grouped railways, for he was for many years in close touch with the plant at Swindon. His paper might give the impression that his experience had brought him to the conclusion that the most generally useful tests could be carried out on the road, but we suspect, in fact, that he would agree that every one of the three methods we have enumerated has its own special functions, and that for the full development of the locomotive all of them must be employed. The most conclusive of the three, we insist, is the test in actual service over a long period, for it is the only one that gives economic results. A locomotive must be regarded as a money-making machine, and it is by its ability in that direction that its qualities must be judged. Only a prolonged period of daily service is an adequate test of that quality. Neither the constant speed test nor the laboratory test can supply that information, but both are desirable as preliminaries to the service test. In the former, what we may call the macro effects of modification can be studied whilst in the latter the micro effects can be investigated in a thoroughly scientific manner. The greater and greater the progress made, the more and more important do minutiæ become. When we are dealing with large differences broad tests suffice; but as we get nearer and nearer to finality, closer and closer examination is necessary. Hence, however useful the dynamometer car may be in expert hands, it cannot remove the need for a laboratory.

Defence Programme Contracts.

FOR the next few years many engineering firms will be engaged partly or wholly upon the manufacture of material under the Government's Defence Programme. They will have to enter into binding contracts with the War Office, the Admiralty, and the Air Ministry. Some of them are already familiar with Government contracts, but many are not, and in any case the conditions which have been formulated for this programme differ materially from those of contracts which were placed during the war and which brought to some firms unconscionable profits, whilst they landed others, after the Armistice, on the borderland of bankruptcy. The present Government is determined that under this programme contractors shall not be saddled with unwanted equipment and buildings after the completion of the programme, and that they shall not make undue profits at the expense of the nation. A form of contract has, therefore, been drawn up and certain general conditions laid down, but it is recognised at the same time that special circumstances may call for special terms. The matter is of such great importance to the engineering industries that a clear explanation of the essential clauses is greatly needed, and we congratulate Mr. David Bremner, Director of the British Engineers' Association, both on the thought for his members which he has showed in the preparation of an article which we print on page 327, and on the lucidity which he has displayed in it. We desire also to thank him and the Association for their courtesy in giving us permission to print this article in advance of its appearance in the *B.E.A. Bulletin*. We are convinced that every engineering firm which is considering a Government contract under the Defence Programme will read this commentary with interest and advantage.

Letters to the Editor.

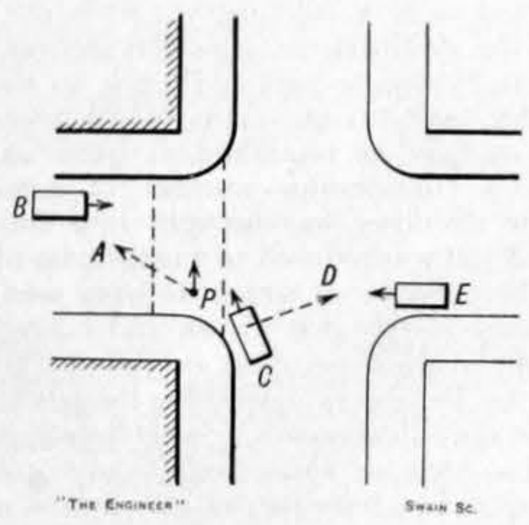
(We do not hold ourselves responsible for the opinions of our correspondents.)

ROAD ACCIDENTS AND ROAD DESIGN.

SIR,—In the excellent summary of the road problem which you gave in your issue of the 11th inst. you mentioned the " disastrous effect of leaving it possible for the reckless to maintain speed over an important crossing." May I crave space to point out two different approaches to the problem of traffic control that exist. One is American and aims at providing motorists with a broad and easy path free of all strain except that of obeying signals (supposedly). We are taking our cue from this.

The other is Continental and imposes a great strain on the reckless by forcing them to obey a navigating rule in built-up areas which has a marked effect on their standard of driving.

In consequence, while London is blockading even its side streets, where traffic is light, with signals, Paris manages the junction of two arteries like Raspail and



Montparnasse, where eight roads converge, without lights or police control.

The navigating rule is not that recommended at one time by the Automobile Association, but is the same as the rule at sea and is now used all over Europe. Even American cities are adopting it. Unfortunately many drivers in this country still go by the obsolete A.A. rule, with the consequence that at cross roads without signals the problem British pedestrians are up against is this:—Pedestrian P looking A-wards to avoid B is in danger from motorist C looking D-wards to see if he can cut in in front of E.

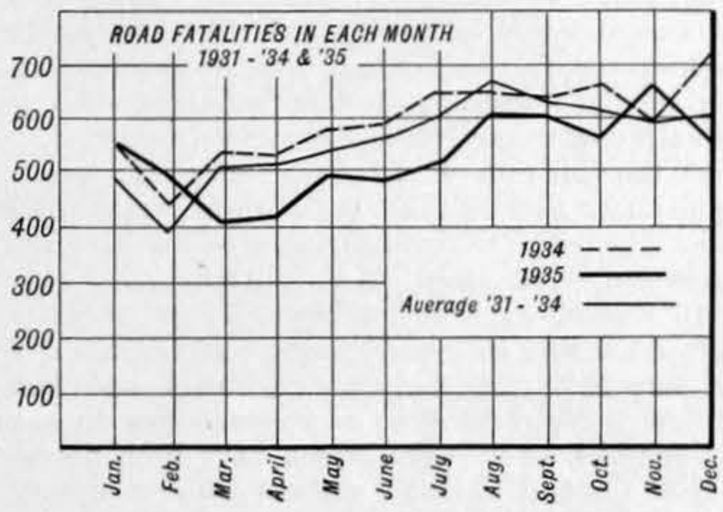
Thus, so long as we pursue our insular course, we have no alternative but to pile on signals until there is nothing left but to blast down all our cities and ancient monuments and build anew, by which time most motorists will be in the air.

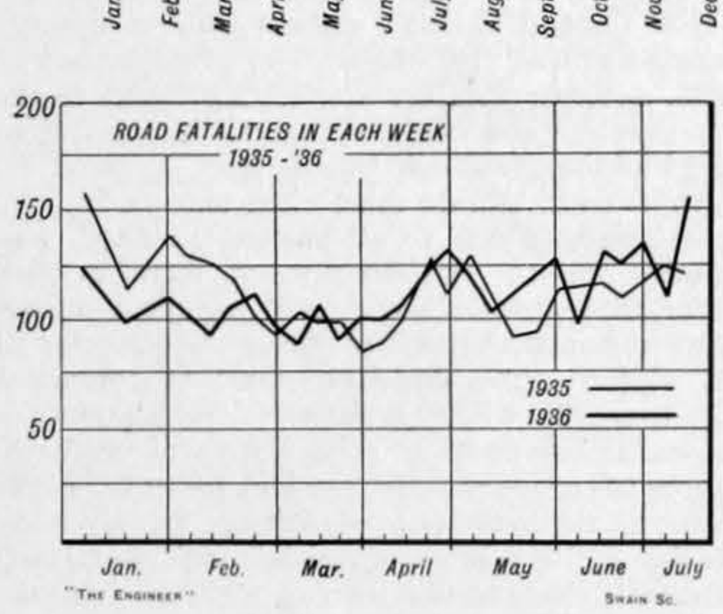
R. D. ARCHIBALD,
D.Sc., M.I.E.E., Assoc. M. Inst. C.E.

Devonport, September 21st.

SIR,—In a leading article, " Road Accidents and Road Design," in the current issue, you state that the reduction in accidents (in 1935) cannot by any means be traced to the 30-mile speed limit.

It is somewhat difficult to reconcile this statement with





the evidence afforded by a comparison of the monthly fatal accident figures for 1935 and the previous years.

If the average totals of fatal accidents in each month for the period 1931–34 be plotted against those for 1935 a very decided break between the two curves in March will be noted. For January and February, 1935, the totals of fatal accidents were about 15 per cent. above the average for the previous four years, but from March onwards they were, except for a peak in November, between 10 per cent. and 20 per cent. below the average for 1931–34.

An examination of the weekly totals for 1935 and this year, published by *The Times* as a graph, shows the improvement was continued during January and February, 1936, but ceased in March. Since then, of course, the figures this year compare with the period in 1935, when the speed limit was in operation.

These graphs show clearly that the improvement in the accident rate started suddenly, during the same month that the speed limit was brought into operation, and that it has been maintained at about the same rate. The increase of the accident rate of 1936 over 1935 from April onwards being roughly proportional to the increased number of vehicles registered.

If the curves be plotted for total accidents, 1931–35, a similar but less striking result is obtained.

An examination of the curves shows, I think, beyond reasonable doubt, that speed control, in the form of the 30-mile limit, was responsible for a great part of the reduction in accidents last year.

If the very mild and not very strictly enforced 30-mile limit in built-up areas achieved a 15 per cent. improvement in the fatal accident rate, it is surely clear that a more strictly enforced general speed control would lead to a much greater reduction.

H. L. BURTON.

Weybridge, September 14th.

SMOKE FROM DOMESTIC GRATES.

SIR,—In your issue of September 11th reference was made to a speech by Dr. A. G. Ruston at a conference of the Sanitary Inspectors' Association in which he declared that " 1 cwt. out of every ton of coal bought by the ordinary householder goes up the chimney unconsumed."

Dr. Ruston apparently assumes that all domestic appliances are both inefficient and smoke-producing. This is, however, very far from being the case. Great progress has been made recently in the design and efficiency of these appliances, and many of them, notably cookers, hot water boilers, and plant for central heating, are now entirely smokeless.

Smoke is admittedly a nuisance, but in the first place by no means all of it is produced by domestic fires, and to the credit of the open coal fire must be set its comfort and cheerfulness and the efficient ventilation it ensures.

This Council is financing research, which is now being carried on at the Government Fuel Research Station at Greenwich, into the possibility of burning ordinary coal smokelessly in the domestic grate, and I should like to take this opportunity of reminding your readers that the services of the Council's engineers are available, entirely free of any charge or obligation, to assist consumers of coal in reducing smoke emission and obtaining the best value for the money they spend on fuel.

FOR THE COAL UTILISATION COUNCIL,
WILLIAM R. GORDON,
Director.

London, September 14th.

SCIENCE AND SOCIETY.

SIR,—Sir Josiah Stamp's address to the British Association, as reported in your number of September 11th, contains points which should not be allowed to pass unchallenged by the engineering profession.

There appears to be an attempt to exonerate the economist—and presumably the financier or banker—and distribute the responsibility and blame for the present sorry state of affairs among doctors, business men, politicians, scientists, chemists, and engineers. No doubt they are responsible as individuals, but it is difficult to see how they are responsible in their professional capacity—with the possible exception of the politicians.

We are advised that " if we are to avoid trouble we must take trouble—scientific trouble," and yet engineers, when they take an interest in social affairs commence " performing miracles with fancy currencies and their blue prints reminiscent of the chemical engineer " and " have not much greater aptitude as amateur ministers of foresight than statesmen would have planning research." And finally there is the astounding statement that " economic and political prevision is the most difficult and precarious because it needs a technique different from his own and is not given by the light of Nature."

Surely all this amounts to an attempt to stave off the application of sound reasoning so badly required in politics and economics and to disparage the resulting conclusions. The engineer and others accustomed to deal with Nature and natural laws at close quarters are compelled by training and habit to practise logical reasoning and to distinguish between cause and effect so that they soon locate the trouble as one of distribution and the money system.

There are two points in Sir Josiah Stamp's address which show faulty reasoning. First, the statement that " machinery made more employment, in the long run, than it destroyed." No one should know better than Sir Josiah Stamp that the idea that the purpose of a machine

is to make work or create employment is erroneous and equally so whether we consider a single unit machine or the economic system as one large machine designed to fulfil a specific function as economically as possible. It is very much as though we tried to work on the assumption that the purpose of a motor car is to consume petrol. Further, the statement ignores the present low efficiency of the industrial system considered as a whole; no authority on the subject puts the figure higher than 10 per cent., so that it amounts to this, that nine out of every ten men working are merely busy chasing each other around and unconsciously masking the inefficiency of the economic system and the real labour-saving possibilities of machinery.

The other point in the address is the suggestion that only by the fortunate chance of a benevolent dictator can we have certain benefits which are possible, *e.g.*, 2in. added to the average stature and 7 lb. or 8 lb. to the average weight of the population. If a dictator can bring this result and democracy cannot, it is evidence that there is a defect in the mechanism by which the will of the people should be made effective. The greatest service that an engineer, or anyone else for that matter, can offer his fellows to-day is advice that will remedy this defect and make the will of the people effective—as it should be in a democracy.

P. R. MASSON,
A.M.I. Mech. E., M.I. Mar. E.

Birmingham, September 18th.

The Building Exhibition.

THE twentieth annual Building Exhibition which opened at Olympia on Wednesday, September 16th, is from the spectacular point of view certainly an example of the modern art of display. A large number of the stands have been specially designed by architects and all are of a type at once ambitious and striking. The main feature of an exhibition stand is to call attention to the products of the exhibitor, both by its own appearance and by the background which it forms for the goods displayed. In addition to these qualities everywhere in evidence, the stands have this year been utilised to attract attention in a particularly novel fashion by means of their height, and many of them extend upwards some 20ft. or so, thereby standing out from the lower majority in a manner likely to attract the attention. Three hundred and eighty-six exhibitors occupy the whole of the Grand Hall, including the annexe and gallery, and the ground floor of the National Hall. This is not a larger area than was occupied before, but a more tightly packed one, owing to the gangway space having been reduced to make way for sixty additional stands. It is believed to be the most comprehensive exhibition of architecture and building in the world and the largest and oldest privately-run trade exhibition in this country.

BUILDING RESEARCH.

The selection of outstanding features for description from an exhibition of this kind is not an easy task, but the Department of Scientific and Industrial Research has arranged what is certainly an outstanding display in the gallery. Most of the work on building research carried out under the Department is done at the Building Research Station, but certain investigations, in particular work on acoustics, are carried out at the National Physical Laboratory in close collaboration with the Building Research Station, while the study of timber is the task of the Forest Products Research Laboratory. All three organisations of the Department are taking part. The section of the exhibit for which the Building Research Station is responsible illustrates recent work on plastering materials, concrete aggregates, the driving of reinforced concrete piles, the measurement of small movements in structures, the weathering of building stones and the heating of buildings. The National Physical Laboratory exhibit deals with the reduction of noise in buildings, including, among other items, the reduction of impact noises, such as footsteps, by the use of a floating floor, the reduction of noise transmitted by ventilating ducts, and the use and testing of sound absorbing materials. The third section of the exhibit, supplied by the Forest Products Research Laboratory, covers the correct seasoning of timber for use in various parts of buildings, woodworking, insect pests, dry rot, and wood preservation. A feature of the exhibit is the number of models shown, and in the section on architectural acoustics the visitor is able to test for himself, by working models, the efficiency of various methods for reducing noise. Some of the exhibits are illustrated by short cinema films.

Another exhibit of interest is that of the British Granite and Whinstone Federation, which is an organisation of the leading granite and whinstone quarries in Great Britain. One of its first activities has been to form a Research Committee in order to co-ordinate the work of research departments attached to quarries within the Federation; to follow the course of Government and other research in relation to the Federation's products; and to provide useful technical data both for members and for prospective and actual users of the stone. Investigations recently carried out into the behaviour of concrete have emphasised the importance of the choice and the grading of the aggregate, and the particular suitability of hard stone of the granite type has been proved in theory and in practice. It is significant how often recently, when a first-class concrete has been required for important constructional work, the engineer has specified an aggregate of the granite type, even when it has meant transporting the stone some hundreds of miles. Practical tests, tested specimens of concrete, and photographs of some of these works are the chief features of the Federation's display. The permeability of concrete and mortars and the movement of concrete and mortar owing to change of moisture content are demonstrated daily at the stand. Specimens are shown after testing in compression, under impact—showing the effect of toughness—in fire, and after being in the sea for ten years. A clue to why concrete made of granite and whinstone gives particularly good results in these and other tests is contained in a series of coloured photomicrographs of fine powders and thin sections of concrete.

The necessity for rapid communication within the modern large office building is a matter of the first importance, and one way in which this problem is solved is demonstrated in a convincing manner at the stand of the Reliance Telephone Company, Ltd., a subsidiary of the General Electric Company, Ltd. Here are found Reliance telephone systems to suit the particular needs of any organisation. Full direct instantaneous intercommunication is provided simply by pressing a button or turning a dial. Various G.E.C. automatic telephone exchanges, with capacities from five to one thousand lines, can be seen under actual working conditions.

WOOD-WORKING MACHINERY.

Perhaps one of the outstanding sections of the Exhibition this year is devoted to wood-working machinery of various kinds, and undoubtedly a great effort has been made to bring these machines up to date, both as to automatic working and as to safety in use, thus rivalling the machine tool and the press tool, both of which have shown the lead of recent years in these matters. A typical example is the hand and power feed planing machine exhibited by Thomas Robinson and Son, Ltd., of Rochdale, and illustrated in Fig. 1. The principal feature of the machine is the patent cutter block. It has a relieved back and

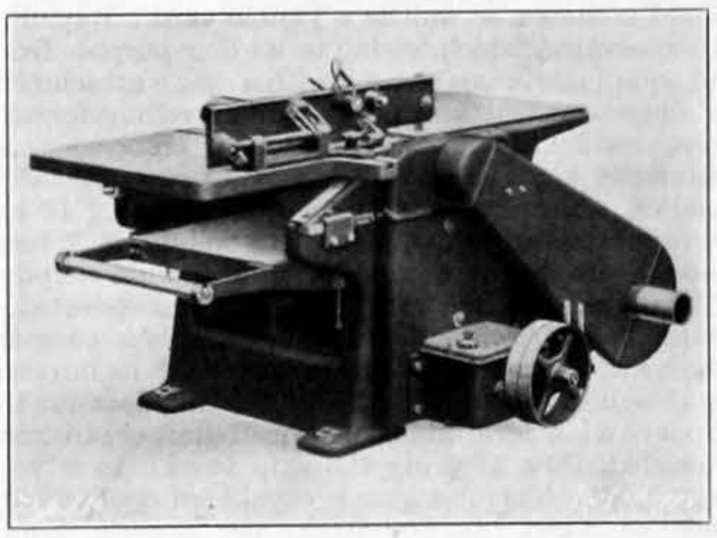


FIG. 1—PLANING MACHINE—ROBINSON

operates with a shearing action stated to give easier and cleaner cutting than the more ordinary circular block. This is accounted for by the slightly oval section of the cutter block, which leaves behind each cutter a gradually diminishing space between the cutting circle and the body of the block. When the cutter block is running, a vacuum is formed in this space which has the effect of sucking the timber down to the table as it passes over the cutters. Ample clearance is provided for honing or whetting-up the cutters. The block is provided with a pair of plain cutters and will take mould cutters up to 5in. wide at the front.

The cutter spindle is mounted in heavy ball bearings enclosed in dustproof housings, and is balanced dynamically at its running speed. The pressures, both before and after the block, are of the concentric type, mounted so that it is impossible for them to foul the cutters. They can be easily removed for moulding.

The power feed rollers are of steel, 3½in. diameter, and cover the full width of the table. They are driven by an enclosed roller chain. The front roller is loaded by weights and levers to obtain a uniform pressure. Three rates of feed, namely, 16ft., 33ft., and 46ft. per minute are provided through a self-contained, gear-box. The fence is arranged to cant up to 45 deg., has quick parallel adjustment across the table, and can be locked in any desired position. A telescopic cutter guard is used. The top in-feed table is made wider than the cutter block, and provides ample support for stock being rebated. For pattern-making it can be canted slightly to give the necessary strip or draw.

The thicknessing or lower table is carried in vertical slides and the supporting screws are mounted on ball thrust bearings. Large anti-friction rollers, 3in. diameter, which extend the full width of the table, are provided. They are mounted on ball bearings, and can be adjusted simultaneously by means of a hand wheel and screw. Extension rollers are fitted at the in-feed and out-feed ends. The upper tables for hand feed planing are provided with steel lips, so that the gap over the cutter block can be reduced to a minimum.

Another interesting machine shown by Thomas Robinson and Son, Ltd., is the precision saw bench, illustrated in Fig. 2, a useful feature of which is that

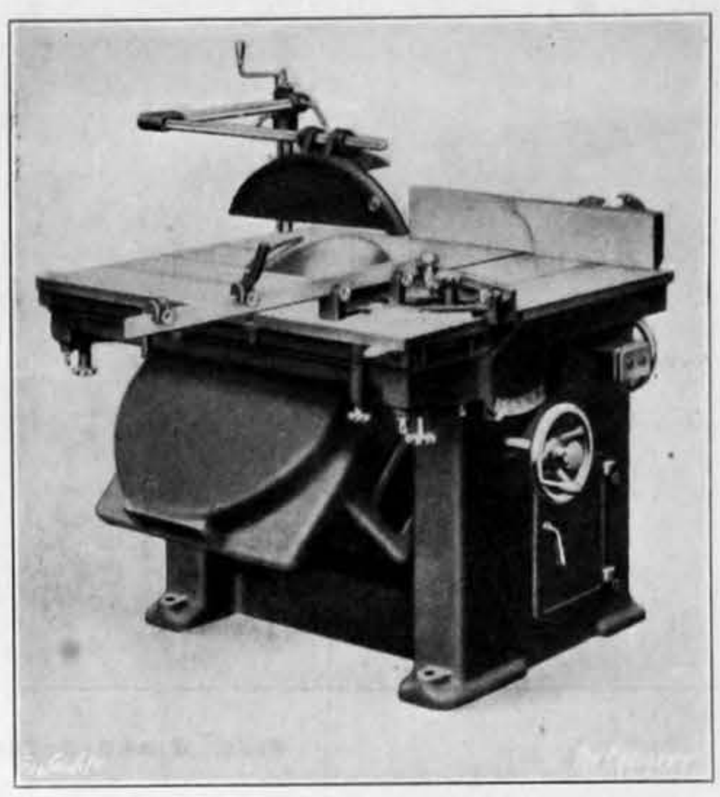


FIG. 2—SAWING MACHINE—ROBINSON

the saw spindle cants up to 45 deg., with the table in the horizontal position. The motor is mounted directly on the saw spindle, and is of 4 H.P. The spindle bearings are heavy-duty ball type, enclosed in dustproof housings. The table has a front part, which can be moved on rollers or can be locked in position by means of a spring stop. It is designed so that accurate alignment with the back or stationary portion of the table is always maintained. The saw gap may be opened up to 4in., to allow a cutter block to be used for moulding, tonguing, grooving, beading, &c., or a special saw may be used for grooving, &c. The top saw guard is of special design, and is raised and lowered by crank handle and screw. The hinged front plate can be turned over, enabling the saw to be removed without the guard having to be raised bodily. An adjustable nose piece is also provided.

Another interesting stand in the wood-working machinery section is that of Wadkin and Co., of Green-lane Works, Leicester. Here one of the most interesting exhibits is the combined surfacing and thicknessing machine, illustrated in Figs. 3, 4, and 5.

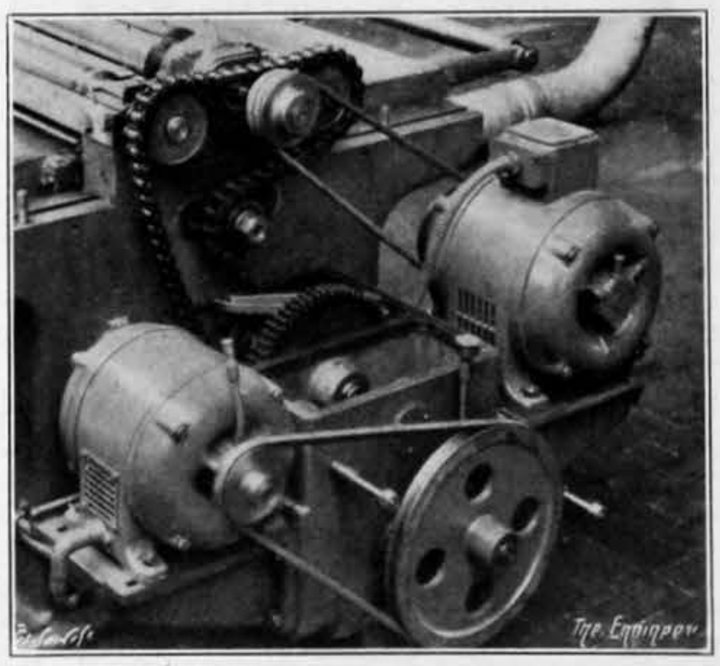


FIG. 3—THICKNESSER DRIVE—WADKIN

The tables are accurately ground to a dead flat finish, and have horizontal draw-out motion for convenience in changing and sharpening cutters. Each table has also a rising and falling motion, and the table edges adjacent to the cutters are fitted with steel lip plates. Index scales are provided on both tables to indicate the exact amount of the vertical movement in relation to the cutter block. When required, the front table can be arranged to cant for taper planing. This screw method of canting not only allows the table to be adjusted to the correct height with a minimum of trouble, but the raising screw also serves to lock the table down on to machined faces, thus maintaining

proper alignment. The cutter block is of the circular safety type arranged to give a shearing cut. It is of the two-knife pattern, and designed to support the knives up to the edge. It consists of a steel forging carried in ball bearings, and has a 5in. diameter cutting circle. A special arrangement allows it to take moulding cutters without upsetting the ordinary planing knives. A cutter setting device allows the knives to be set in or out of the block by micrometer screw motion.

The thicknessing table is mounted on broad slides on each side of the main frame, and is raised and lowered 9in. by hand wheel. An index scale registers the exact thickness of timber being planed.

Carrier rolls are provided at both ends of the table for supporting long work. In addition, the table is provided with two anti-friction rollers, both being arranged with a small vertical adjustment obtained simultaneously on both rollers by means of one-hand wheel at the feeding-in end of the machine.

As shown in Fig. 3, the rollers are driven by a single chain. The gear-box provides for three speeds of 20ft., 30ft., and 46ft. a minute, and the speeds can be varied whilst the feed is in operation. All the gears are steel, machine cut and run continuously in oil.

The fence cants up to 45 deg. and is designed to give rigidity in all positions. It is quickly adjustable across the table by hand wheel, and the method of holding and guiding it avoids the need for a vee slot in the table. Lever handles lock it in any desired position on the table.

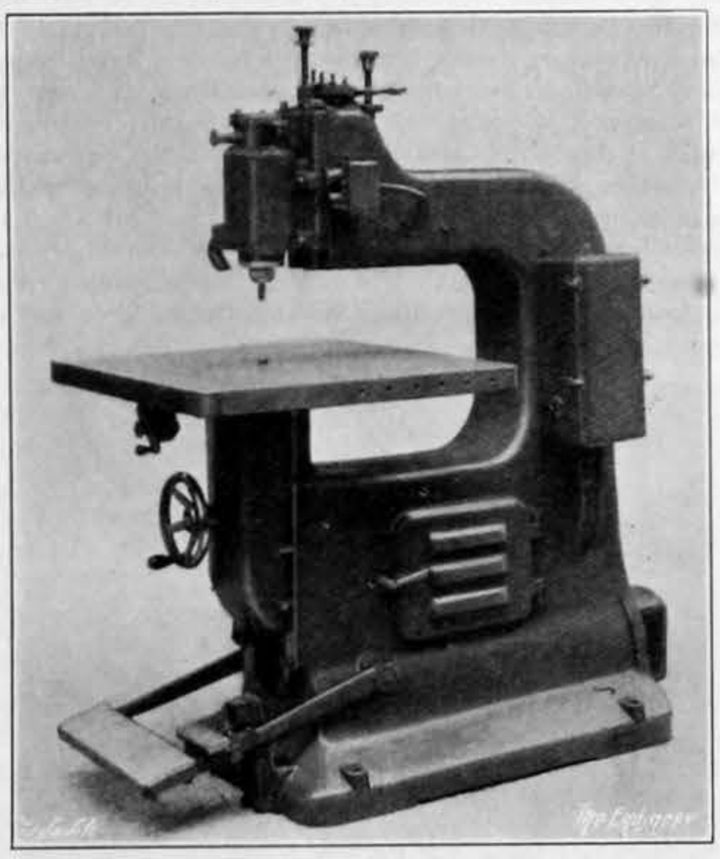


FIG. 6—ROUTER—WADKIN

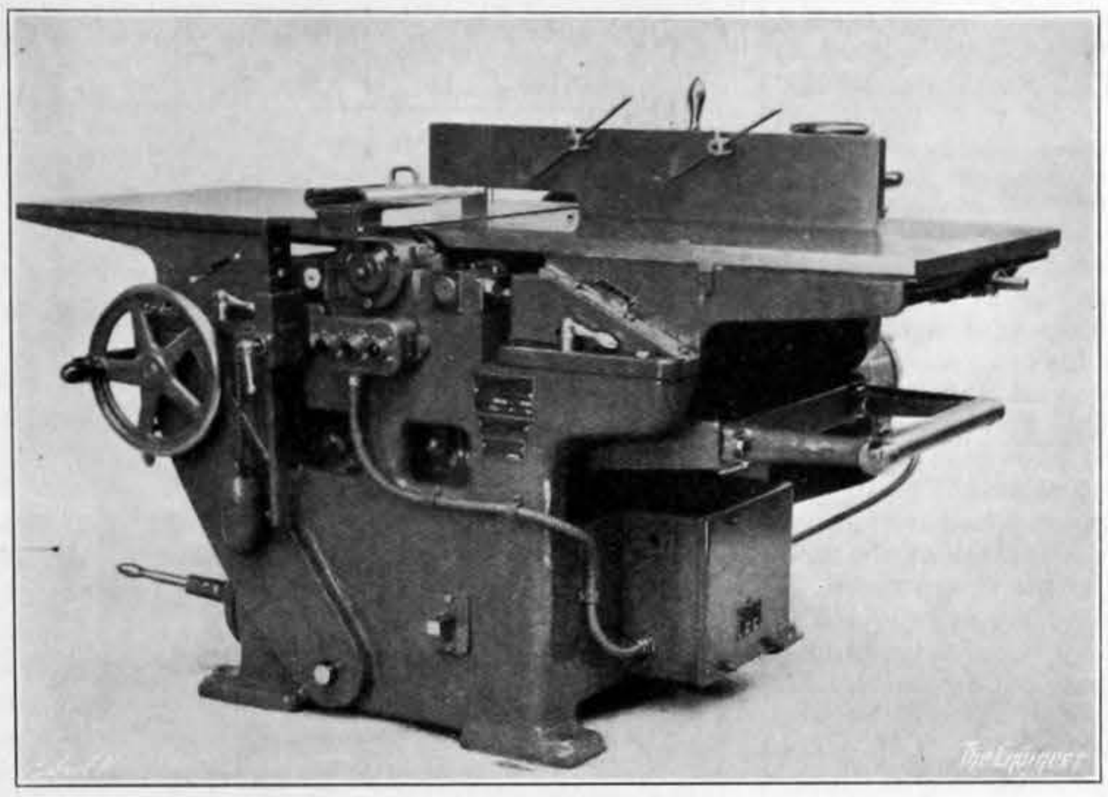
Another interesting machine exhibited by Wadkin and Co. is the high-speed router illustrated in Fig. 6. The head, as shown, consists of a rotor built on a ground steel spindle running in ball bearings, the lower bearing being placed close enough to the cutter to obviate whip.

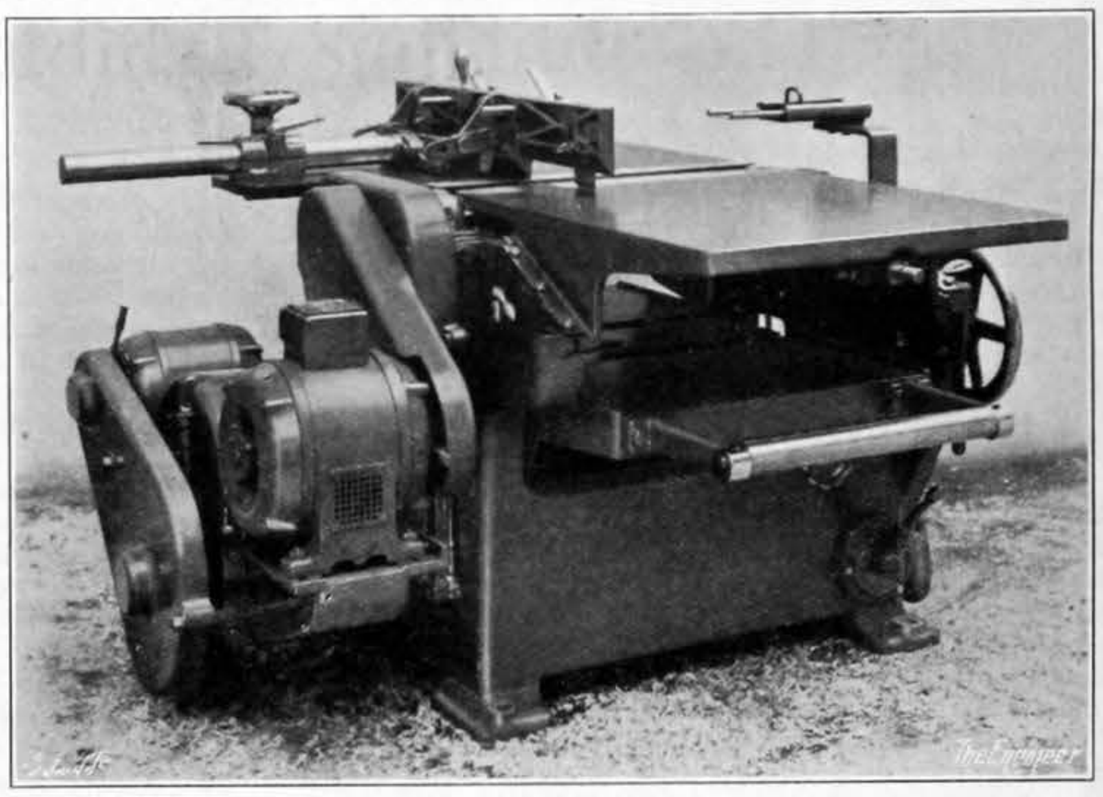
The head slides on a film of oil on wide vee slideways, and is brought down and locked by a foot treadle. A touch on an auxiliary toe pedal disengages a ratchet holding the head, which is counterbalanced so that it rises out of the work automatically.

A range of four stops control the head movements, any of which can be selected by hand lever. A further stop gives equal depth of cut, irrespective of variations in the thickness of the stock. All chips are dislodged from the face of the work immediately they are made by a blower incorporated in the head.

A brake is fitted on the cutter spindle to bring it to rest when required, and an improved form of positive cutter lock lessens the time taken to change cutters. The table is heavily ribbed to prevent distortion. It is carried on broad machined slides and adjusts up and down by hand wheel and screw. A centre plate is let into it to allow the cutter to sink below the table for moulding. The former pin is infinitely variable up to a given maximum, to allow of different sinkings with superimposed templates or formers, using a parallel pin. Alternatively, a two-diameter pin can be used, which, in conjunction with the variable height, allows of cutting two different recesses of the same contour, as well as sinking and undercutting. A hand lever immediately under the front of the table adjusts the pin instantly to the required height, and also causes it to disappear below the table surface after use.

The motor is a B.T.H. squirrel-cage unit, controlled by a Brookhirst contactor operated by push buttons. the stop button can be locked to prevent unauthorised use of the machine.





FIGS. 4 AND 5—SURFACING AND THICKNESSING MACHINE. FRONT AND BACK VIEWS—WADKIN

BUILDERS' PLANT AND EQUIPMENT.

Turning to the section devoted to the builder and to the machines displayed for his use, concrete mixers and allied machines are much to the fore. Concrete in various forms is the most popular building material to-day and is available in a variety of types, colours, and forms, as bricks and in sheets for special duties, and in various ornamental types. On the stand of Ransomes and Rapier, Ltd., an extensive range of mixers is shown, as well as a ⅜ cubic yard "RapieR" 410 excavator, which, owing to its four-purpose front end equipment, may be used with a single attachment for sewer construction, pipe laying, levelling foundations, road grading, site clearance, craneage, and practically any form of earth moving encountered in building contracts and estate development. It has proved exceedingly popular. Its weight is 7 tons. Two travel speeds are provided, while a fluid coupling of the Vulcan Sinclair type can be incorporated if desired. A 6/4 cubic feet tilting drum type concrete mixer with barrow hoist is also shown with its interesting design of power loader. All winding gear for the skip is at a low level and no overhead shaft or structure is needed, thus allowing the skip to rise to a very steep angle. This machine is capable of dealing with loads of 5 cwt. at 100–200ft. per minute simultaneously with mixing. It is fitted with a 5 H.P. Lister engine.

R. H. Neal and Co., Ltd., of Plant House, London, are also exhibiting an excavator, this time of ¼-yard capacity. This is a half-circle slewing model, particularly suited for building work, as it can work much closer to obstructions than the full-circle model, owing to the absence of tail swing. The same bucket can be used for skimmer, back-acter, and navvy, and although only a nominal ¼-yard cube capacity, the high speed of working gives it an output claimed to be equivalent to most ⅜-yard machines. The machine shown is powered by a "Lister" C.I. engine.

There are also shown the latest models of the "Rapid" tubular mast platform hoists, with rotating platforms, and special geared winches, and a new platform hoist, specially designed for use with tubular scaffolding, and the firm's totally enclosed concrete mixer.

The stand of the British Oxygen Company is set out to show the utility of oxygen and dissolved acetylene in the building trades. Actual equipment on view to demonstrate the value of these gases includes welding, cutting and lead burning plant, oxygen cutting machines, and flare lights. In addition, a comprehensive selection of welding and hard facing materials is available for inspection and test, as well as specimens of work done with the aid of the equipment. Demonstrators, who are all experts in their particular fields, are at hand to show visitors the operation or technique of any oxy-acetylene application of interest. Fig. 7 shows a typical oxy-acetylene cutter at work on a chassis frame.

BUILDING MATERIALS.

The building materials section includes some interesting exhibits, and here G. A. Harvey and Co. (London), Ltd., are exhibiting an office manufactured from steel partitioning double-cased and with sound-insulating material between. It is claimed to afford the architect and contractor an easy and efficient means of dividing floors in the modern building, which to-day are structurally a series of fire-resisting floors supported on steel stanchions. With permanent partitioning, the architect and tenant are often involved in costly inconvenience when it becomes necessary to vary the allocation of floor space to suit individual requirements. With these steel partitions this problem is simply solved, as the units are interchangeable and enable any rearrangement to be effected at a negligible cost.

Another interesting stand in the materials section is that of Pilkington Brothers, Ltd., of St. Helens, Lancashire, who are exhibiting "armour plate" and toughened glass. The firm is also exhibiting a range of glass bricks for building purposes, called by the name "Insulight." The toughened glass, which is available in a range of twelve tints, is of heat-resisting quality and, it is thought, should have a wide application for flood lighting and stage lighting. It is claimed to be twice as strong as ordinary glass of the same thickness and at temperatures as high as 150 deg. Cent. is said to be unaffected when sprayed with cold water. The glasses are of two kinds: toughened Stippolite selenium glass and toughened coloured sheet glass. They are about ⅛in. thick and are supplied in sheets 24in. by 18in.

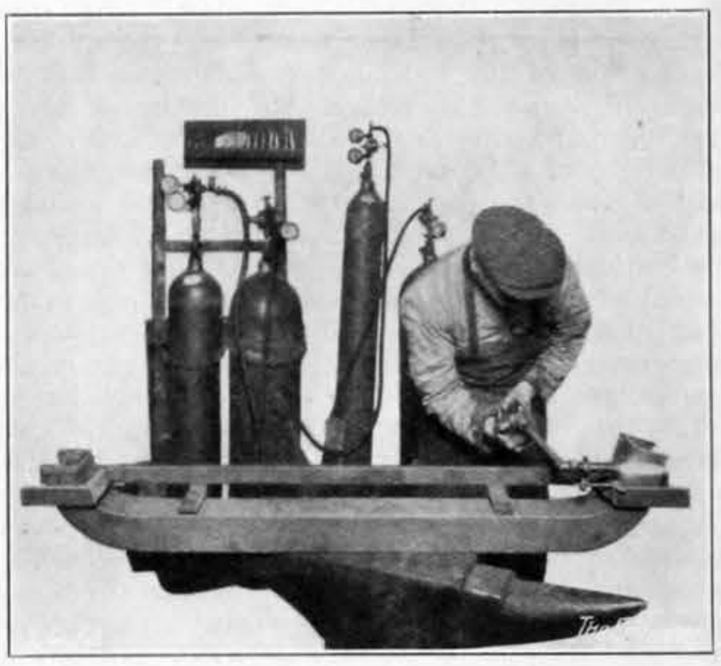


FIG. 7—OXY-ACETYLENE CUTTING—B.O. CO.

The "Insulight" glass brick is hollow and the internal space is partially vacuous, thus increasing insulation against sound, heat, and cold. It is sealed with metal and the mortar bearing surfaces are coated with a special gritty material, which ensures a high degree of bond between the mortar and the glass. Erection, it is stated, presents no technical difficulties. Glass masonry is claimed to have all the hygienic advantages of glass, the surface being non-porous and incapable of absorbing odours, water, or grease, or of transmitting air or gases.

The amount of light transmitted by the various patterns varies from 73·4 per cent. to 84 per cent., and owing to the surface variations this is well diffused.

UP to the end of August eighteen vessels aggregating 76,000 gross tons have been launched this year on the Tyne.

Rolling of the s.s. "Conte di Savoia."*

By Dr.-Ing. R. DE SANTIS and Dr.-Ing. M. RUSSO.

As is well known, the Italian turbine-driven liner "Conte di Savoia," which was placed in the express passenger service between Genoa and New York in November, 1932, is fitted with a Sperry gyro-stabiliser plant, comprising three independent equal units arranged in a separate compartment located directly forward of the engine-room at an average distance of about 50·50 m. from the stem. Fig. 1 shows the longitudinal profile and general dimensions of the vessel; the shaded area

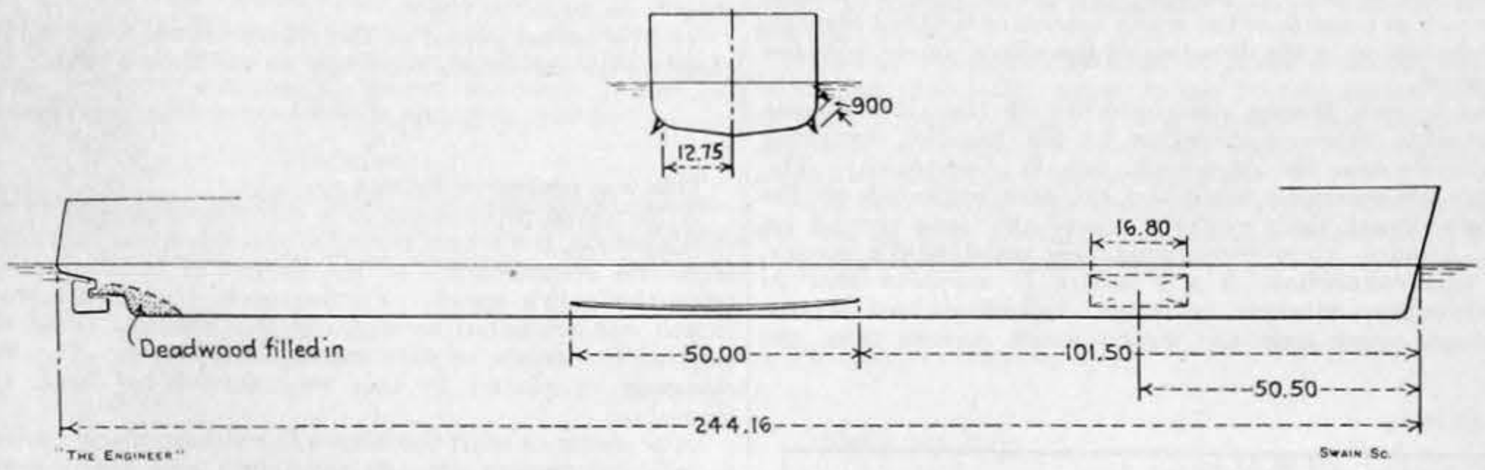


FIG. 1—LONGITUDINAL PROFILE OF THE CONTE DI SAVOIA

at the stern indicating the filling out of deadwood effected in 1934 in order to make the vessel steadier on its course when sailing in a rough following sea.

Table I shows the characteristics of the ship and of the gyro-stabiliser plant:

TABLE I.

A.—*Ship Data.*

Water line length (L_g)	244·10 m.
Maximum breadth (l)	29·20 m.
Conditions at time of departure:	
Displacement, fully loaded (D_o)	41,750 metric tons
Mean draught, fully loaded (i_o)	9·50 m.
Metacentric height, fully loaded (r-a) $_o$	0·96 m.
Complete roll period (τ_o)	26 sec.
Drifting area (A_o)	2,224 square metres
Average conditions during a crossing:	
Displacement (D)	40,100 metric tons
Draught (i)	9·20 m.
Metacentric height (r-a)	0·63 m.
Roll period (τ)	28 sec.
Drifting area (A)	2,137 square metres
Rudder area (σ)	27·50 square metres
Value of the ratio (σ/A_o)	1/81
Bilge keels:	
Length (λ)	50 m.
Breadth	0·90 m.
Total effective surface	90 square metres
Value of the ratio (λ/L_g)	1/4·88

B.—*Characteristics of the Sperry Stabilisers.*

Number of independent equal gyroscopes	3
Weight of rotors	344 tons
Diameter of rotors	3·96 m.
Polar moment of inertia of the rotors	3 × 198,052 kilo. metres squared
Maximum number of r.p.m.	910
Corresponding rotation speed	95·4 radians per second
Maximum kinetic moment of the rotors	3×18,894,160 kilo. metres squared (radians) per second
Maximum precessional speed when the gyroscope is in a vertical position	0·28 radian per second

Maximum anti-roll gyroscopic couple:

$$3\times\frac{18,894,160}{9·81}\times 0·28 = 1,620,000 \text{ kilo. metres}$$
$$= 1,620 \text{ ton metres}$$

C.—*Weight and Space Taken up by the Stabiliser Plant.*

	Tons.
The weight of each gyroscope is as follows:—	
Gyroscope, precession gear, and brakes	156
Motor generator set	11
Auxiliaries (switchboards, oil and water pumps, filters, coolers, and piping)	50
Total	217
Total weight of the gyroscopic plant	651
Two turbo-dynamos (850 kW) for feeding the three motor generator sets	40
Grand total	691

The weight of the stabiliser plant corresponds to 1·72 per cent. of the average displacement of the ship.

The volume of the compartment housing the plant totals 1900 cubic metres, or 1·4 per cent. of the gross tonnage of the vessel.

QUENCHING POWER OF GYROSCOPES IN STILL WATER.

A test was prescribed by the purchasing contract for the purpose of evaluating and determining the quenching action caused by the stabilisers on the rolling motion of the ship.

Quenching power is meant as the difference between the increment or decrement of free roll and the forced increment or decrement when the stabiliser is in operation during the first half period of roll after the ship has left the position of maximum inclination.

For practical reasons it was preferred to measure the decrement instead of the increment of the roll.

The test was carried out as follows:—

(*a*) The value of r-a was first determined by inclining the ship while lying at anchor in still water.

(*b*) The three gyroscopes were then successively put in operation in forced precession and in synchronism with the natural period of roll of the ship until the maximum angle α of heeling was reached. The gyroscopes were then stopped and the curve of natural decrement of roll was drawn.

(*c*) The ship was then brought back to the maximum heeling angle α above mentioned, and one gyroscope was put on to extinguish the oscillatory movement of the ship. In this manner the curve of forced decrement of roll was obtained.

The two curves mentioned in (*b*) and (*c*) served to determine:

(1) The ship's rolling period.

(2) The decrement α-β between the side angle of the ship α (measured from the mean vertical), and the subsequent angle β attained at the opposite side, with free rolling ship.

(3) The analogous decrement α-γ with stabilised ship.

(4) The quenching power of each stabiliser. This was given by:

$$(\alpha-\gamma)-(\alpha-\beta)=\beta-\gamma.$$

The contract fixed a quenching power of 4·7 deg. with the three stabilisers in operation at 910 r.p.m. on the assumption of a "characteristic product," for ship under full load (metric tons of displacement × feet of metacentric height × seconds of complete rolling period), not exceeding 2,160,000.

Owing to the practical difficulties of having the ship with full load, it was agreed to put her at least in the following condition:—

D = 34,000 tons, τ = 24 sec., r-a = 0·8ft., which figures correspond to a characteristic product of 652,800.

With the ship under these conditions, only one of the three gyroscopes (rotor at 910 r.p.m.) should have produced a roll quenching power of 4·7 deg. For the purpose of these tests, however, it was finally agreed to assume that the quenching power would vary in inverse proportion to the actual characteristic product and in direct proportion to the actual number of rotor revolutions.

RESULTS OF THE TEST.

Locality of the Trials; Genoa Offing.

Displacement (D)	38,000 tons
Metacentric height (r-a)	2·295ft.
Period (τ)	28 sec.
Resultant characteristic product	2,441,880 ton foot seconds

Following the procedure previously mentioned we obtained:

α = 19 deg. after ten simple oscillations
$(\beta-\gamma)_1$ = 1·03 deg. with No. 1 gyro in operation
$(\beta-\gamma)_2$ = 1·20 deg. with No. 2 gyro in operation
$(\beta-\gamma)_3$ = 1·08 deg. with No. 3 gyro in operation

Therefore, average β-γ = 1·103 deg. with the rotors at 800 r.p.m.

Contractual quenching power, determined as above, for each of the three gyroscopes:

$$4·7\times\frac{800}{910}\times\frac{652,800}{2,441,880}=1·104 \text{ deg.}$$

The actual quenching power during the tests corresponded almost exactly to the contract requirement.

SEA TRIALS, CONTRACT TERMS.

The stabiliser plant is equipped, within the same room, with a Sperry roll, pitch, and precession recorder providing a permanent record of the periodic amplitude of the ship's roll, pitch and yaw and angle of precession of any one of the three stabilisers. This recorder also indicates the time at equal intervals of ten seconds each. The instrument generally consists of a gyroscopic pendulum whose natural period is so long that the comparatively short period of the ship's motion will not affect it. The indication of the yaw is introduced by a small motor controlled by the repeating system of the gyroscopic compass. With a similar device, *i.e.*, with a repeating motor operated directly by the precession of the stabiliser, the indication of the angle of precession is introduced.

The recordings of the apparatus and their reference to the constant intervals of time provide a continuous diagram which not only permits the measuring of the amplitude and period of the movements, but also comparisons of the behaviour of the vessel with and without stabiliser action. Fig. 2 shows a specimen of a recorder diagram with the reference scales indicated.

According to the contract, during the sea trials a sufficient number of diagrams were obtained with free and stabilised roll so as to present a complete picture of all sea weather conditions which might cause free rolling, ranging from 6 deg. to 22 deg. measured from the vertical.

The comparison experiments were carried out according to the following procedure:—

(*a*) During the first fifteen minutes of the tests a record diagram was taken representing the movements of the

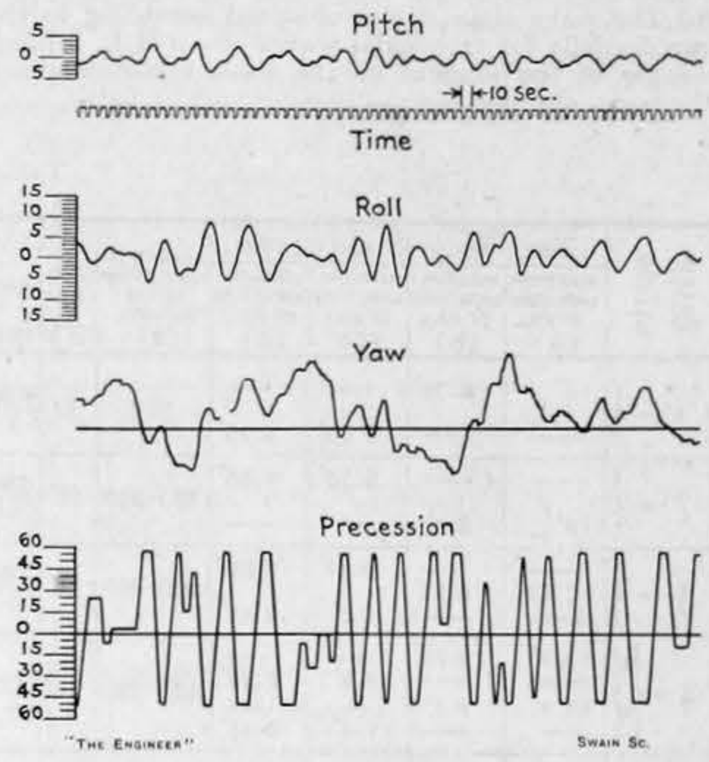


FIG. 2—SPECIMEN OF ROLL-PITCH RECORD

vessel with the stabiliser off (rotors in motion and precession zero).

(*b*) During the subsequent fifteen minutes a corresponding diagram was taken representing the stabilisers in regular precession.

(*c*) The average values of the rolling (ship's free roll and ship's stabilised roll) were obtained by measuring from these diagrams the total amplitudes of the complete oscillations from side to side, calculating the arithmetical average and dividing by two.

The gyro-stabiliser plant was to be considered satisfactory, if the simple rolling did not exceed 3 deg. as the grand average of all the trials thus conducted.

REMARKS AND DATA COLLECTED IN NAVIGATION (SEE TABLE II).

For each comparison trial, besides taking diagrams such as Fig. 2, the following characteristics of the ship, stabilisers, sea, and wind, were either calculated or noted.

Free Ship.—(*a*) The maximum transverse amplitude of roll (total rolling angle from side to side) was measured on the part of the diagram reproducing roll.

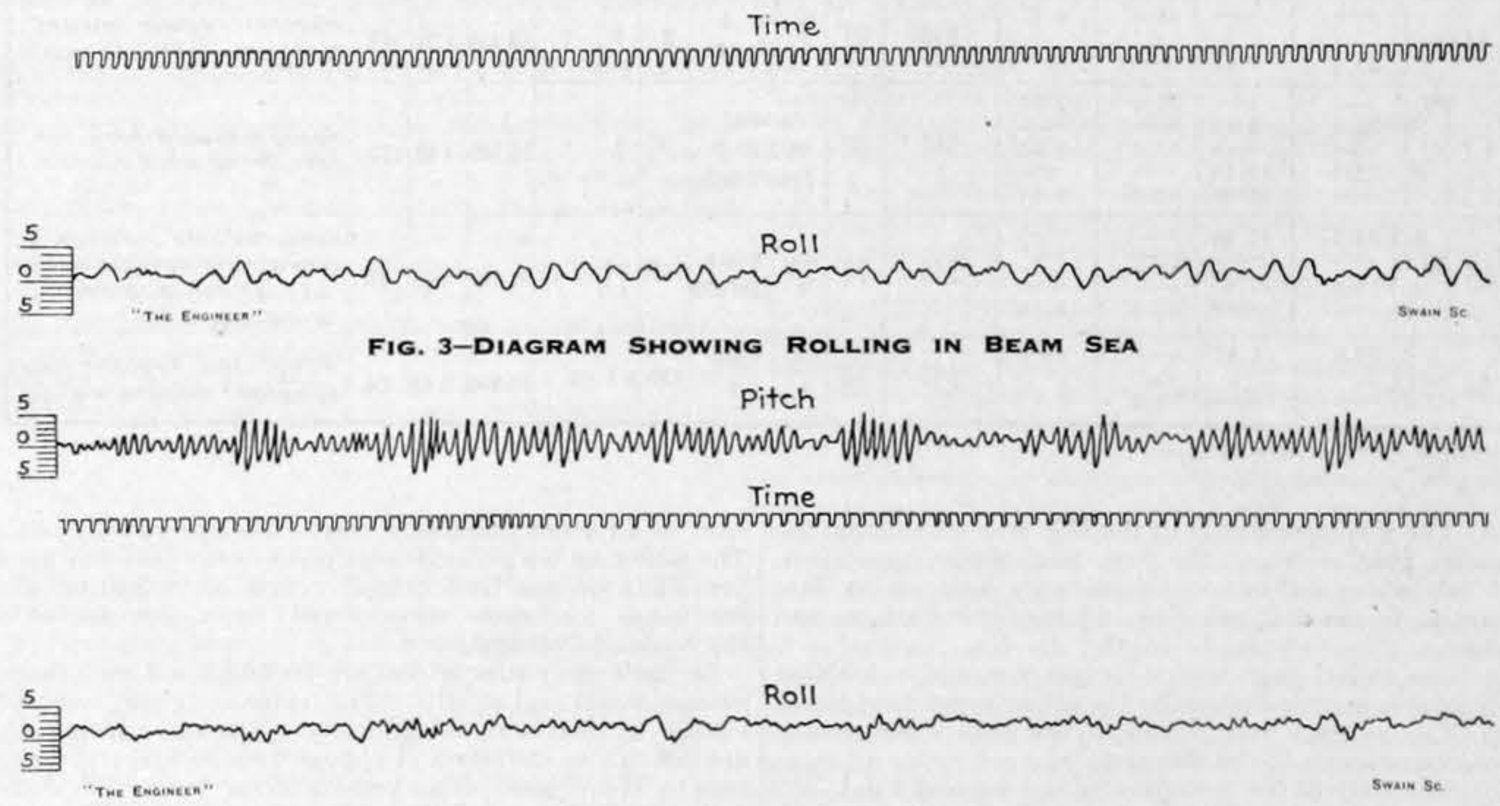


FIG. 3—DIAGRAM SHOWING ROLLING IN BEAM SEA

FIG. 4—PITCHING AND ROLLING IN WAVES ACTING ON THE BOW

(*b*) The average roll was obtained by measuring on the portion of the said diagram all the total rolling angles.

Stabilised Ship.—(*c*) As in (*a*).

(*d*) As in (*b*).

(*e*) The number of rotor revolutions was noted by periodic readings of the continuous revolution counter.

(*f*) Average course of the vessel.

(*g*) Strength and direction of the wind as judged by the deck officer on watch.

(*h*) Strength and direction of the sea as noted on the bridge.

(*i*) The actual average length of waves L (as average of several observations) was determined as follows:—

(1) The wave crest was sighted from the upper deck with a semi-circular sighting instrument, thus determining

* From a paper presented at the international meeting of the Society of Naval Architects and Marine Engineers, New York, September 14th to 19th.

the angle α of the wave direction with the intended course of the ship.

(2) The period of encounter T_a (*i.e.*, the time required by a wave to reach the point where the previous ones encountered the hull) was determined with a chronometer.

(3) The average speed of the ship C was calculated both on the number of propeller revolutions and the usual calculations of the ship's staff.*

(4) With the aforesaid elements the actual wave length was obtained according to the following formula :—

$$T_a = \frac{L}{V + C \cos \alpha},$$

where V (speed of advance of the wave) is connected with the length L by the following formula :—

$$V = \sqrt{\frac{g\,L}{2\,\pi}}.$$

(*l*) The height *h* of the waves (average of several observations) was obtained by observing from the lower decks (when the ship was in a wave trough), the position of the wave crest, and roughly comparing it with some known height of the hull. In view of the evident difficulty of obtaining reliable measurements, the observations were conducted from two points ; the averages thus obtained were generally very close.

(*m*) The wave slope θ was obtained according to the known formula for trochoidal waves—$\theta = \pi\,H/L$, θ being the angle of the tangent at the wave inflection point to the horizontal line.

greater difficulty. In Table II the doubtful or missed observations of the wave particulars are indicated with interrogation points. In the same table are recorded the results of fourteen official comparison tests with free and stabilised ship. The ship's speed was held constant for all the tests at about 26·5 knots with negligible fluctuations from trial to trial.

Fig. 5 shows portions of diagrams corresponding to some of the observations recorded in Table II.

Analysis of the Observations : General Remarks on Winds and Waves.

The usual Atlantic route followed by the " Conte di Savoia " from Gibraltar to New York is along the 38 deg. N. parallel, while for the return trip it is approximately along the 40 deg. N. parallel in order to take advantage as much as possible of the south branch of the Gulf Stream, which, acting in the direction of the ship's course, aids her progress.

As is well known, the intensity of the Gulf Stream gradually decreases along the 40 deg. parallel, becoming negligible near the Azores (30 deg. W. Greenwich). The ship's observations confirmed the fact indicated on the pilot's charts that westerly winds and seas prevail on the Atlantic zone comprising the usual ship's routes. In this connection, it will suffice to mention that in thirty-eight Atlantic crossings, including two winter seasons, rough seas and strong winds coming from the

Table II.

Observation	Free Roll (a) Maximum amplitude of roll	Free Roll (b) Medium amplitude of roll	Stabilized Roll (c) Maximum amplitude of roll	Stabilized Roll (d) Medium amplitude of roll	(e) Number of revolutions of the rotors	(f) Ship's course	(g) Wind	(h) Sea	Particulars of waves (i) L_m	(l) H_m	(m) θ degrees	Particulars of ship (n) D_{Tons}	(o) $(r-a)_m$	(p) τ seconds	Weather Conditions (q)
1	15° _	4.38°	—	—	900	90°	W.SW 5	W.SW 4	?	?	?	39.500	0.66	28	Confused sea - Moderate squalls.
	—	—	7.00°	3.05°											
2	—	—	6.50°	1.85°	880-890	90°	SW 4	SW 4	110	4-5	~7°	39.500	0.68	26.5	Rough sea-Regular waves high constant wind.
	16° _	6.6°	—	—											
3	—	—	6.50°	2.035°	880-890	90°	SW 4	SW 4	104	4-5	~7.50'	39.800	0.68	26.5	Steep regular waves high constant wind.
	12.50°	4.88°	9.0°	2.45°											
4 a	13.0°	5.24°	—	—	880-890	90°	SW 4	SW 4	120	4-5	~6.40'	39.800	0.68	26.5	Rough increasing sea. Strong wind.
4 b	13.5°	6.2°	11.5°	3.05°											
5	15.5°	6.6°	—	—	910	95°	W 3	W 3	?	?	?	39.600	0.67	25.5	Rough following sea regular waves-high wind.
	—	—	6.0°	2.39°											
6 a	18.7°	6.72°	—	—	880-890	115°	SW 5-6	SW 6-7 CONFUSED	180?	8?	~8° ?	40.270	0.71	23.6	High irregular sea. Strong wind squalls.
6 b	26.5°	9.64°	17.8°	5.83°											
	—	—	17.1°	6.91°											
7 a	26.3°	12.3°	—	—	880-890	89°	SW 6-7	SW 7-8 CONFUSED	190?	8?	7.30'	39.570	0.64	29	Storm. Heavy irregular waves confused direction. Wery fierce and irregular wind.
7 b	21.6°	8.86°	24.0°	10.5°											
7 c	24.1°	12.91°	23.7°	7.1°											
	—	—	22.4°	8.72°											
8 a	27.5°	11.8°	—	—	910	90°	NW 5	NW 5	160	6-7	~7.30'	39.900	0.62	26.5	Heavy sea. Regular waves strong constant wind.
8 b	28.5°	11.7°	15.0°	4.4°											
8 c	18.5°	8.1°	15.5°	4.5°											
8 d	—	—	—	—											
9 a	—	—	15.5°	5.4°	910	95°	NW 5-6	NW 6-7	170	7	~7.30'	41.000	0.71	26.5	Heavy sea regular waves strong wind.
9 b	31.0°	12.1°	27.0°	6.90°											
9 c	—	—	—	—											
9 d	24.0°	12.9°	17.0°	5.45°											
10	15.0°	6.7°	—	—	910	90°	NW 5-4	NW 5	120	5	~7.30'	41.000	0.71	24	Rough sea. Regular waves light wind squalls.
	—	—	10.5°	2.4°											
11	—	—	16.0°	4.8°	910	90°	WNW 6 CONFUSED		?	?	?	40.400	0.71	23	Moderate regular waves. Continuous light wind squalls.
	21.5°	7.97°	—	—											
12 a	—	—	22.0'	7.57°	910	90°	WNW WSW 7 CONFUSED		?	?	?	39.500	0.68	30	Heavy following irregular sea - Strong wind squalls.
12 b	24.0°	9.93°	18.0°	6.49°											
12 c	27.5°	13.24°	18.0°	6.41°											
12 d	—	—	—	—											
13 a	28.5°	12.90°	—	—	910	90°	NW 6	NW 6 CONFUSED	170?	7?	~7.30'	39.500	0.61	30	Heavy confused sea irregular waves. Main wave's direction 45° at the quarter wind squalls.
13 b	25.0°	11.6°	20.0°	8.5°											
13 c	—	—	22.0°	8.05°											
14	19.0°	6.92°	—	—	910	90°	SW 6	SW 6	190	6-7	~6°	39.800	0.59	24	Rough sea. Regular waves Constant moderate wind.
	—	—	9.0°	2.7°											

"The Engineer" Swain Sc.

(*n*) The displacement D of the ship was taken from the capacity plan on which the fuel, fresh water, provisions, and salt water ballast conditions were kept up to date according to the daily ullaging in the double bottoms and tanks.

(*o*) The initial metacentric height r-a was calculated with reliable approximation by the above-mentioned plans.

(*p*) The average roll period of the ship τ was taken from examination of the diagrams.

(*q*) Summary of the condition of the sea and wind.

At times the wave characteristics were not taken with the required precision, owing to the peculiar sea conditions. Also, as it was important to avoid disturbing the passengers by carrying out experiments during day time, some observations were obtained at night under

* Note.—Table indicating the strength of the wind and sea during the trials :—

	Wind.	Sea.
0	Calm	Calm
1	Light breeze	Smooth
2	Moderate breeze	Slight swell
3	Moderate wind	Swell
4	Fresh wind	Rather rough
5	Strong wind	Rough
6	Stormy wind	Very rough
7	Gale	High
8	Strong gale	Very high
9	Hurricane	Raging

east, or adjacent quadrants, were encountered only twice. The following is a general description of the seas and winds prevailing on the Gulf Stream course as compared with the usual conditions encountered from the Azores to the coast of Portugal.

In the former zone waves are accompanied with rather violent winds and squalls, which constantly and suddenly change in direction and intensity. The wave formations are difficult to identify and appear with broken and foamy tops. There are often simultaneous trains of waves differing in characteristics and direction. At times such directions are even opposite and can be recognised by small short waves of irregular profile overriding and deforming the larger formations. This kind of agitation is usually termed by seamen " confused sea." The forces due to such a confused sea, being the continuously variable resultant of several components of a non-periodic character, cause the ship to assume complex and disordered movements which will be better analysed in the section on " Stern Quartering Sea."

On the contrary, in the Atlantic zone, extending approximately from the Azores to the Portuguese coast, well-defined wave systems prevail during stormy seas accompanied by strong winds of continuous character. The features of these wave systems may be easily estimated. It is in this zone that the classic " dead sea " (residuum of preceding storms) often appears with large waves having regular profile and constant direction and period. The result of the action on the ship is a regular oscillating pendulum movement.

Characteristics of the Waves.

From our observations we have found :

(*a*) In actual practice the wave formations are seldom regular. Groups of waves of approximate uniformity are followed by other groups or individual waves which differ from the preceding ones. It is difficult, generally, to ascertain whether the succession of such differing groups follows even an approximate law. In all events such irregularity is remarkable along the route plied by the " Conte di Savoia " on her Gulf Stream course.

(*b*) The actual maximum wave length encountered seldom exceeded 200 m., the longest waves observed during a westbound crossing having lengths of 300 m. As to minimum wave length, none was observed shorter than from 90 m. to 100 m.

(*c*) The actual period of the waves encountered agreed closely with the length according to the known ratio :

$$T = \sqrt{\frac{2\,\pi\,L}{g}}.$$

This was proved as follows :—

With waves progressing in a direction opposite to the ship's course, the actual period of the wave was calculated from the measurement of the period of encounter and from the ship's speed. Furthermore, the actual wave length was evaluated by sighting the position along the ship of the crests of two subsequent waves. The two elements calculated in this way served to check the formula.

In accordance with the above the values of the periods were about twelve seconds maximum and about seven to eight seconds minimum.

(*d*) Though, as above stated, the observations on the heights of the waves, particularly along the Gulf Stream, were particularly difficult, nevertheless, at least, as far as the observations on which it is possible to rely are concerned, heights of 10 m. to 11 m. represent a maximum value as regards waves 180 m. long.

(*e*) The maximum wave slope found was about 10 deg. for waves 100 m. to 200 m. long.

Relations Between Waves and Ship.

As the current theory has established, practical navigation has confirmed that accentuated rolling occurs when there is resonance between the wave period and the actual transverse period of the ship. In speaking of the effects of resonance with wave period we do not mean the real period, but the apparent one or period of encounter of the wave with the hull. The latter evidently depends on the ship's speed and on the wave direction as compared with the ship's course direction (see " Remarks and Data Collected in Navigation "). We considered the " Conte di Savoia's" complete period of roll, in average conditions of navigation, as about twenty-eight seconds, basing this value on the results of the oscillating trials in still water. We may add that more than once in the Atlantic and in the Mediterranean, in order to determine the natural decrease of roll, with running ship, there were conducted artificial rolling trials by the stabilisers ; thus it was easy to get the real value of the ship's period, which resulted very closely to that previously determined of about twenty-eight seconds.

Beam End Sea.

The maximum size of the wave formations already mentioned having beam direction do not cause the " Conte di Savoia " to have rolling movements of remarkable amplitude.

The wave periods differ so much in respect to the average ship's period (twenty-eight seconds) that coincidence between the two periods is not at all possible. In order to realise synchronism with a beam sea, waves 800 m. long would be required, while during the thirty-eight Atlantic crossings in which we have participated the maximum length of 300 m. has never been surpassed, as above stated. We may add that a sea of this kind was judged by the commander of the " Conte di Savoia " as one of the worst he had met with in more than thirty years of navigation.

A beam end sea—that is, perpendicular or nearly so to the ship—is very rare and causes in practice a rather regular rolling ; also, the amplitude of the movement with the largest possible waves remains generally at a low value and approximately constant.

This oscillatory movement has a frequency intermediate between the frequencies of the waves and the ship. Furthermore, when the waves encounter the hull the previous movement is interfered with by a succession of quick beam shiftings of very small amplitude (a fraction of a degree) having the character of forced oscillations.

A portion of a diagram showing the roll movement described above is reproduced in Fig. 3. The sea, which appeared almost regular, had the following average characteristics :—L, 160 m.; H, about 6 m.; T, ten seconds.

It is interesting to note that the actual average roll period was 18·8 sec., which is approximately intermediate between the wave and the ship's periods. The transverse amplitudes of roll (very small) averaged hardly 1·91 deg., and therefore the use of the stabilisers would have been superfluous. On the other hand, owing to the small rolling angle and to the irregular movement, the stabilisers would have performed with intermittent precession and therefore low efficiency.

Another remarkable observation is that the course with a beam end sea remains practically unaltered, as the small deviations which occur can be easily corrected by the rudder.

Bow Quartering Sea.

The influence of a bow quartering sea on the movement of the ship is a more or less accentuated pitch, while the maximum amplitudes of roll are hardly perceptible and of a regular character. The wave formations from the fore quarters, even if of considerable size, in their encounter with a hull proceeding at high speed, as the " Conte di Savoia," cannot have much effect on the rolling. In this connection it is sufficient to note the following :—

(1) The noticeable shortening of the apparent wave

periods makes the possibility of synchronising with the ship's own period, already excluded for beam sea, more remote.

(2) The decrease of the wave slope, which according to theory is proportional to wave impulse, causes a smaller transverse moment. In fact, the formations are cut obliquely and the transverse component of the slope decreases until it is eliminated when the wave direction coincides with the ship's direction.

The rolling is manifested with an irregular succession of transverse shifts having periods approximately equal to the apparent average wave period. From time to time a rare larger roll, having a longer period, is followed immediately by a series of small rolls; in general, a close correspondence can be noted between rolling of greater amplitude and maximum pitch angles.

The transverse movement of the ship encountered with all the bow waves, and particularly with those originating right from the bow, proved in all cases altogether negligible and did not require the use of stabilisers.

Fig. 4 shows the roll in waves having a period of encounter equal to seven seconds acting on the bow.

PITCHING.

The ship's own period of pitch (measured when encountering small bow waves) maintained itself within narrow limits of about seven to eight seconds. The pitching

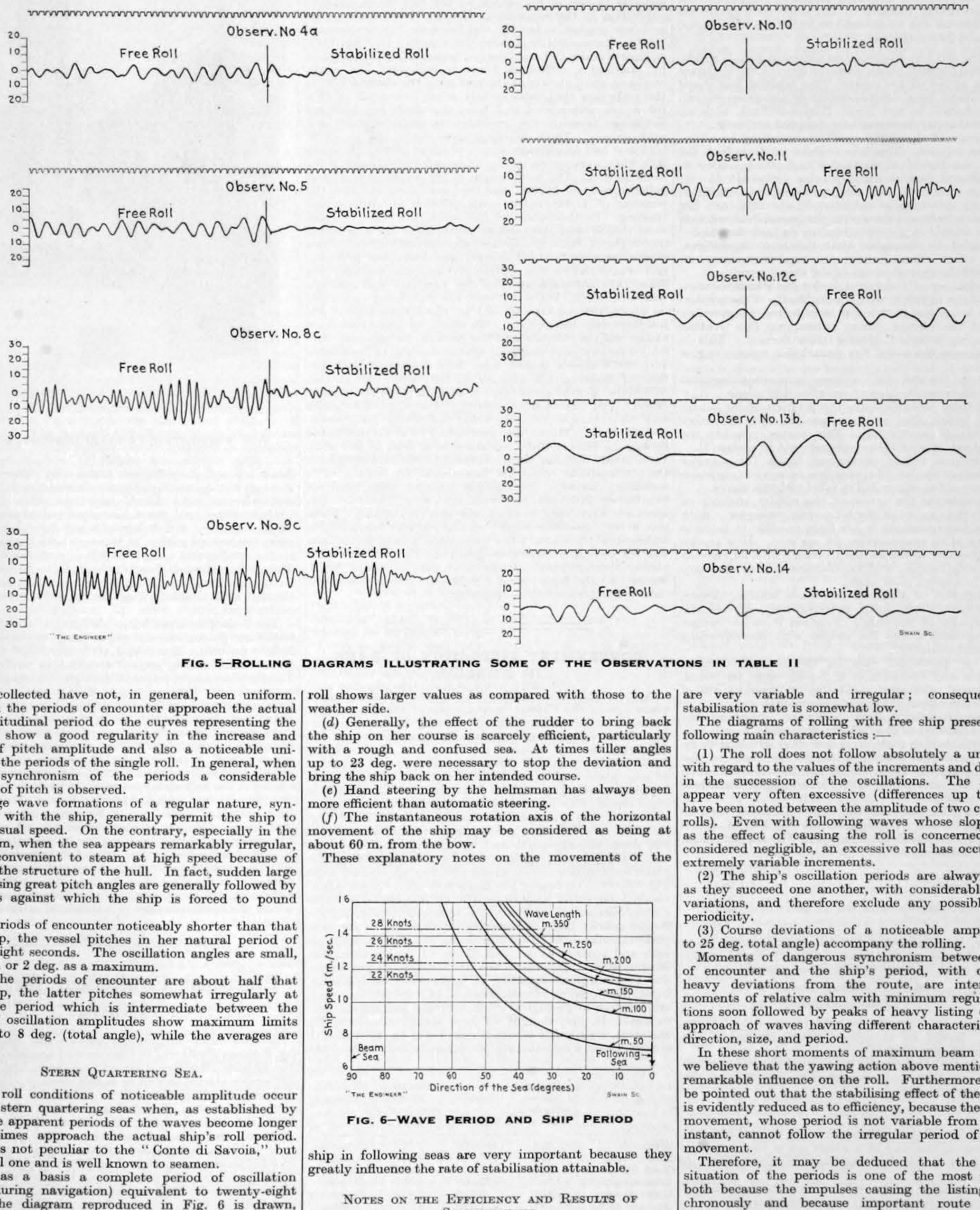


FIG. 5—ROLLING DIAGRAMS ILLUSTRATING SOME OF THE OBSERVATIONS IN TABLE II

diagrams collected have not, in general, been uniform. Only when the periods of encounter approach the actual ship's longitudinal period do the curves representing the movement show a good regularity in the increase and decrease of pitch amplitude and also a noticeable uniformity of the periods of the single roll. In general, when we have synchronism of the periods a considerable amplitude of pitch is observed.

The large wave formations of a regular nature, synchronising with the ship, generally permit the ship to hold her usual speed. On the contrary, especially in the Gulf Stream, when the sea appears remarkably irregular, it is not convenient to steam at high speed because of danger to the structure of the hull. In fact, sudden large waves causing great pitch angles are generally followed by small ones against which the ship is forced to pound heavily.

With periods of encounter noticeably shorter than that of the ship, the vessel pitches in her natural period of seven to eight seconds. The oscillation angles are small, *i.e.*, 1 deg. or 2 deg. as a maximum.

When the periods of encounter are about half that of the ship, the latter pitches somewhat irregularly at an average period which is intermediate between the two. The oscillation amplitudes show maximum limits of 7 deg. to 8 deg. (total angle), while the averages are small.

STERN QUARTERING SEA.

Typical roll conditions of noticeable amplitude occur only with stern quartering seas when, as established by theory, the apparent periods of the waves become longer and sometimes approach the actual ship's roll period. This fact is not peculiar to the "Conte di Savoia," but is a general one and is well known to seamen.

Taking as a basis a complete period of oscillation (average during navigation) equivalent to twenty-eight seconds, the diagram reproduced in Fig. 6 is drawn, from which it is possible to determine for various wave lengths the angle between the wave direction and the ship's course when synchronism occurs, such angles being functions of the ship's speed.

As appears from the results of the observations conducted on board the vessel and recorded in Table II the actual wave lengths producing appreciable rolling vary within narrow limits, from 100 m. to 200 m. Within these wave lengths and at the ship's average speed of 26·5 knots, synchronism is produced with wave angles of about 35 deg. to 50 deg. with the ship's course, so that the danger sector covers an arc of approximately 15 deg.

Before examining more closely the results of stabilisation it is useful to deal with the usual movements observed on board the vessel in an agitated sea, whose direction with the theoretical ship's course forms an angle less than 90 deg.

(*a*) Continuous and periodical deviations from the pre-established route occur. The values of the angular deviations are proportional to the sea force, being noticeably affected by resonance of the periods. With the same average size waves and the same encountering angle the effect on the yawing is remarkably greater when crossing the Gulf Stream.

(*b*) Each complete deviation of route is accomplished in a time practically equal to the corresponding period of each double rolling. The horizontal and transverse moments are thus co-periodical, while the maximum respective amplitudes also correspond.

(*c*) When yawing, the ship tends to fall parallel with the waves, thus the angle of leeward deviation is less accentuated than that to windward. Also, the leeward roll shows larger values as compared with those to the weather side.

(*d*) Generally, the effect of the rudder to bring back the ship on her course is scarcely efficient, particularly with a rough and confused sea. At times tiller angles up to 23 deg. were necessary to stop the deviation and bring the ship back on her intended course.

(*e*) Hand steering by the helmsman has always been more efficient than automatic steering.

(*f*) The instantaneous rotation axis of the horizontal movement of the ship may be considered as being at about 60 m. from the bow.

These explanatory notes on the movements of the

FIG. 6—WAVE PERIOD AND SHIP PERIOD

ship in following seas are very important because they greatly influence the rate of stabilisation attainable.

NOTES ON THE EFFICIENCY AND RESULTS OF STABILISATION.

(*a*) Normal sea with average period of encounter lower than the ship's period. (Observation No. 14, Table II.)

Under these conditions the rolling appears rather regular with small and constant increments, while the course deviations are not of remarkable amplitude. The oscillation period is intermediate between the period of encounter (twenty-two to twenty-three seconds and the ship's period (about twenty-eight seconds). The stabilisation is very good, the roll reduction ranging up to a maximum of 70 per cent.

(*b*) Almost regular sea with average period of encounter equal to the ship's period—observations Nos. 8 and 9, (*a*), (*b*), (*c*), (*d*), Table II.

Under these conditions the ship's free roll is of a rather regular nature, *i.e.*, groups of oscillations of a gradually increasing trend and not having uniform frequency are interfered with by transverse maximum peaks caused by the action of waves, which suddenly change in size and direction from the normal type characterising such a sea. The average oscillation period can be considered near enough to the ship's own period, which is of constant value passing from the free to the stabilised ship. The course deviations of a few degrees (4 deg. to 6 deg. on each side) with free ship arc reduced by stabilisation.

Aside from the sporadic peaks mentioned, the stabilisation of the ship with the above sea may be considered satisfactory; the comparison trials show reductions of the rolling from a maximum of 60 per cent. with not very strong seas to a minimum of 50 per cent. with stormy seas.

(*c*) Irregular sea (confused). (Observations Nos. 6, 7, 12, and 13, Table II.) In this case the phenomena are very variable and irregular; consequently, the stabilisation rate is somewhat low.

The diagrams of rolling with free ship present all the following main characteristics:—

(1) The roll does not follow absolutely a uniform law with regard to the values of the increments and decrements in the succession of the oscillations. The differences appear very often excessive (differences up to 15 deg. have been noted between the amplitude of two consecutive rolls). Even with following waves whose slopes, as far as the effect of causing the roll is concerned, may be considered negligible, an excessive roll has occurred with extremely variable increments.

(2) The ship's oscillation periods are always different as they succeed one another, with considerable irregular variations, and therefore exclude any possible uniform periodicity.

(3) Course deviations of a noticeable amplitude (up to 25 deg. total angle) accompany the rolling.

Moments of dangerous synchronism between periods of encounter and the ship's period, with consequent heavy deviations from the route, are interposed by moments of relative calm with minimum regular oscillations soon followed by peaks of heavy listing due to the approach of waves having different characteristics as to direction, size, and period.

In these short moments of maximum beam inclination we believe that the yawing action above mentioned has a remarkable influence on the roll. Furthermore, it should be pointed out that the stabilising effect of the gyroscope is evidently reduced as to efficiency, because the precession movement, whose period is not variable from instant to instant, cannot follow the irregular period of the ship's movement.

Therefore, it may be deduced that the resonance situation of the periods is one of the most dangerous, both because the impulses causing the listing act synchronously and because important route deviations occur which introduce new transverse forces (centrifugal forces) in addition to the foregoing. In view of this it appears useful to modify the average period of encounter by changing the speed of advance or the route direction (see formula in "Remarks and Data Collected in Navigation"). The benefit realised by an adequate reduction

of the ship's speed is apparent from the following results observed in service :—

Ship's speed, knots.	Average amplitude of roll, deg.	Maximum amplitude of roll, deg.
26·5	12·30	31·0
24·5	8·60	20·5
23·5	4·98	24·5
22·5	4·60	17·0

It should be noted further that a reduction of the speed not only diminishes the period of encounter, but also increases the ship's period, and therefore has a twofold effect in preventing a dangerous state of synchronism.

General Results of the Stabilisation of the Ship.

The general results attained with the stabiliser plant during the first eighteen months of operation of the "Conte di Savoia" were as follows :—

Average of all averages of free ship, 9·063 deg. (total angle); averages of all averages of stabilised ship, 5·143 deg. (total angle); with an average reduction of the roll of 44 per cent.

Improvements Developed by the Owners to Increase the Anti-rolling Qualities of the Ship.

From a practical point of view, and as a direct consequence of the observations made, the Italia Steamship Company adopted the following means of improving the general anti-rolling features of the ship, with particular consideration to the most unfavourable sea conditions, *i.e.*, confused following sea :—

(*a*) Filling out the deadwood as shown in Fig. 1, which, by increasing the drift plane, partially reduces the tendency of the ship to fall off her course. The position and shape of this fin have been determined after numerous experiments conducted in the Rome National Tank with an experimental apparatus especially designed and built.

(*b*) Decrease of the ship's speed when subject to a confused following sea. This has enabled us to reduce the extent of the period of encounter and consequently to avoid the resonance with the ship's own period of roll.

A further result has been a reduction of the centrifugal force due to the incipient deviation of the ship from her course, which force combines with the lateral fluid reaction and forms an inclining couple tending to heel the ship.

It is useful to remember that the centrifugal force, when all other circumstances are unaltered, increases according to the second power of the ship's speed.

The slackening of the speed under the above circumstances will not interfere with the regularity of the service, as the few hours lost in this way may be recovered before the end of the voyage during subsequent fair weather by developing a speed greater than normal. This is possible because the vessel has remarkable reserve engine power.

(*c*) To trim the ship by the stern as much as possible in order to increase the area of the after drift plane.

(*d*) To ballast so as to lower the position of the centre of gravity within the limits compatible with the other requirements of navigation. This makes possible the decrease of the arm of the couple referred to under (*b*).

(*e*) To reduce within convenient limits the number of revolutions of the lee-side propellers in order to minimise the tendency of the ship to fall parallel with the waves.

(*f*) To accelerate the action of the rudder, making its response to the control of the helmsman prompter. With mechanical improvements it has been possible to increase the velocity of its manœuvring 28 per cent. It is known that the efficiency of the rudder increases with its velocity of angular rotation, *i.e.*, with the decrease of time necessary to turn it to a given tiller angle.

(*g*) Installation of a special automatic steering device. Such apparatus, functioning gyroscopically, detects the angular velocity of the ship's deviation from her course and consequently steers the rudder with corresponding readiness and intensity.

(*h*) To use particular care for the most convenient arrangement and distribution of liquid cargo on board, so as to avoid additional oscillatory movements out of phase with the action of the stabiliser plant.

All these procedures have noticeably improved the stabilising efficiency of the "Conte di Savoia."

It is worth noting that for a new ship which is to be stabilised particular attention should be paid to the factors affecting the route stability. In this connection the rudder area and power of the steering gear should be as large as possible.

As recorded in Table I, the ratio of rudder area to drifting area for the "Conte di Savoia" is 1 to 81, which agrees with the usual ratio adopted for similar ships, such as the following :—

"Europa"	1 to 82
"Ile de France"	1 to 71
"Rex"	1 to 77
"Empress of Britain"	1 to 73
"Lusitania"	1 to 87

However, we think that the following formula given by W. J. Lovett in his book "Applied Naval Architecture" is quite suitable for high-speed vessels :—

$$\text{Rudder area} = \frac{\text{Drifting area}}{\text{Block coefficient}} \times \frac{1}{90}.$$

According to this formula the rudder area of the "Conte di Savoia" would be 41 square metres instead of the actual 27·50 square metres.

We believe that this greater value would have improved the course stability and consequently the rate of the stabilisation of the ship.

Conclusion.

According to all the information we have obtained, the behaviour of the ship in a rough sea is very complex and depends on many very important factors varying in time and space.

Numerous studies on the subject have been published recently, of which the following may be mentioned :—

G. Rabbeno, "Stabilizzazione delle navi," Annali Vasca Nazionale Roma, 1933.

Basset and Hodgkinson, "New Studies on Ship Motion," "Transactions" of the Society of Naval Architects and Marine Engineers, 1935.

In these praiseworthy studies, the authors have presented their interpretation of this complex problem. It is not our intention to discuss their views, but to submit the results of our extensive investigations conducted with the "Conte di Savoia," so that students of this important practical problem may benefit by our experience with the largest gyroscopically stabilised ship. We trust that this information may be of assistance.

SIXTY YEARS AGO.

The name "Hell Gate" is to-day associated chiefly with a bridge and a power station. Sixty years ago it still retained the significance attached to it by the early navigators who attempted to approach what is now New York by way of Long Island Sound and the East River. Near the entrance to the river they encountered a reef projecting for 300ft. from the Long Island side. At low tide the reef for nearly the whole of its length lay not more than 12ft. below the surface. When the tide ran fast and the wind was high the water flew over the rocks in immense breakers and boiled and bubbled in a thousand eddies. The name given to the reef by the early navigators in later years offended the susceptibilities of some refined Americans, who proposed to alter it to "Hurl Gate." Fenimore Cooper who laid the scene of a sensational incident in one of his novels at the reef led a vigorous opposition to the suggestion. To-day the name remains as it was originally, but the reef has gone. It disappeared on the afternoon of September 24th, 1876. In July, 1869, engineers under General Newton began the attack upon it by building a cofferdam between high and low water marks at the junction of the reef with the shore. Within this cofferdam they sank a shaft or pit to a depth of 33ft. below low water level and from this shaft ten headings radiating beneath the roughly triangular-shaped reef were driven. These headings were from 10ft. to 22ft. high and had an average length of about 270ft. At every 30ft. they were connected by cross galleries of roughly the same section. The total length of the headings and cross galleries reached 7425ft., and the excavation involved the removal of 47,461 cubic yards of rock by drilling and blasting. In the course of this work 39½ miles of holes were drilled with the aid of compressed air and about 59,000 lb. of blasting powder, nitro-glycerine, and other explosives were fired. The spoil was drawn out by mules and was lifted to the surface by a steam derrick. By June 1875 the excavation of the headings and galleries was completed. The whole reef was then being supported on about 160 columns formed by the intersection of the headings with the galleries. To effect the final demolition of the reef the columns and the roofs of the passages were drilled for explosive charges. On the morning of September 12th 1876 fifteen picked men were entrusted with the task of inserting the charges in the holes. Altogether, 52,206 lb. of explosives were placed in position in 4462 holes. The insertion of mercury fulminate detonators and their connection to cables completed the underground work. The cables were taken to a wooden house containing twenty-three batteries, or a total of 960 cells. From a safe distance electrical communication throughout the excavations could be established by means of a secondary battery. Before the charges were fired on September 24th, all the workings were flooded. The spectacle when they went off was not very grand. There was a very moderate report and not a very considerable upheaval of the water, but a tremor like a mild earthquake was felt over a considerable distance. The reef was completely shattered and for the most part collapsed downwards into the headings and galleries. Loose *débris* was subsequently removed by dredging.

GOVERNMENT INSPECTION OF DAMS IN AMERICA.

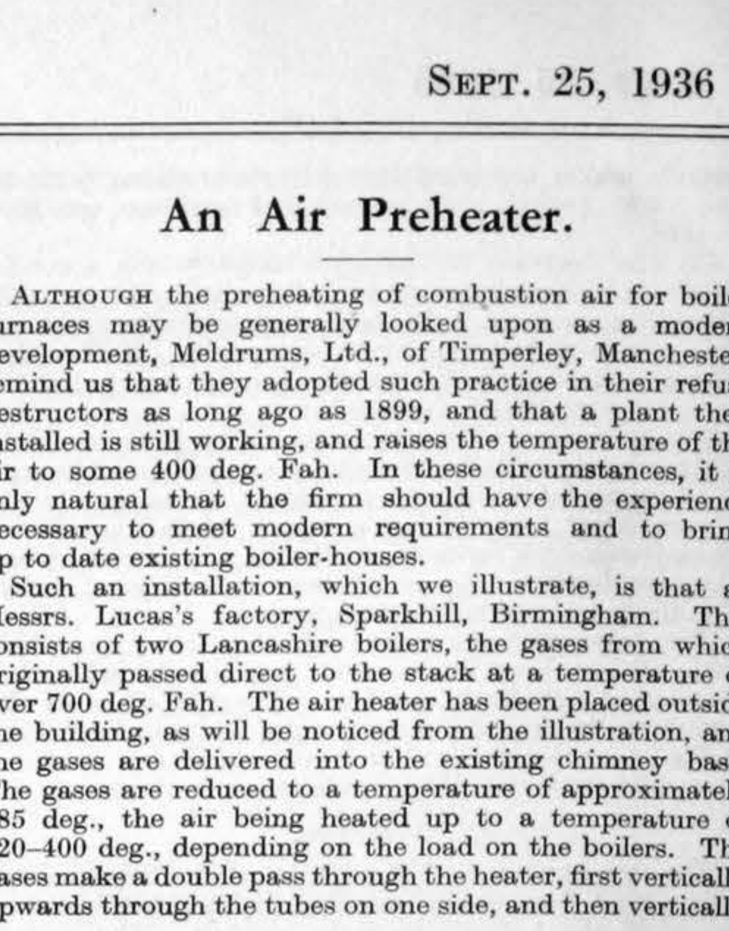
As a result of a series of failures of dams some years ago in the United States, some of the States have passed laws for the inspection of existing dams and requiring official endorsement of plans for new structures. In California the law required the inspection of all existing dams within a period of three years, and also the approval of new plans and supervision of the construction work, supplemented by periodical inspection of the condition of all dams. The only exceptions are those dams that are owned by the Federal Government. Under that law, the California State Engineering Department has inspected 830 dams already built, and has checked and inspected some 400 jobs of repair work, besides approving the plans for 120 new dams, whose cost has aggregated some £12,000,000. Of nearly 600 dams now under State supervision, the great majority—379 in number—are earth embankments, of ordinary or hydraulic construction; 50 are gravity dams of masonry or concrete, 39 are loose rock embankments, 59 are arch dams, 34 are of the multiple arch and buttress types, and 27 are of timber or miscellaneous types. Defects in the dams inspected are largely due to inadequate capacity of waste weirs or spillways, insufficient quality of materials and of construction work, and neglect of geological studies of the foundation conditions. In the designs of new dams submitted for approval, a curiously common defect was the provision of curved waste way channels or spillways, even where the overflow water would have a high velocity of flow. Such design is so contrary to requirements of safety that it had to be revised for approval. Of the principal types of dams, the largest are as tabulated above.

	Height above river bed. Feet.	Storage. Acre-feet.	Elevation above sea level. Feet.	Name.
Hydraulic fill	295	100,000	775	Calaveras
Rolled earth	194	100,000	1,371	Caialco
Rock fill	320	56,000	1,481	San Gabriel
Concrete gravity	350	222,000	575	Pardee
Concrete arch	355	5,900	2,015	Pacoima
Multiple arch	141	1,290	1,711	Dalton

An Air Preheater.

Although the preheating of combustion air for boiler furnaces may be generally looked upon as a modern development, Meldrums, Ltd., of Timperley, Manchester, remind us that they adopted such practice in their refuse destructors as long ago as 1899, and that a plant then installed is still working, and raises the temperature of the air to some 400 deg. Fah. In these circumstances, it is only natural that the firm should have the experience necessary to meet modern requirements and to bring up to date existing boiler-houses.

Such an installation, which we illustrate, is that at Messrs. Lucas's factory, Sparkhill, Birmingham. This consists of two Lancashire boilers, the gases from which originally passed direct to the stack at a temperature of over 700 deg. Fah. The air heater has been placed outside the building, as will be noticed from the illustration, and the gases are delivered into the existing chimney base. The gases are reduced to a temperature of approximately 385 deg., the air being heated up to a temperature of 320–400 deg., depending on the load on the boilers. The gases make a double pass through the heater, first vertically upwards through the tubes on one side, and then vertically



AIR PREHEATER FOR LANCASHIRE BOILERS

down through those on the other side. They are drawn through the system by means of an induced draught fan and delivered into the chimney base. The air is forced horizontally round the tubes also in two passes, the air at the delivery end being adjacent to the tubes which carry the hottest gases. In this way both the gases and the air for combustion make a double pass through the heater. The air is collected from the top of the boilers, where it is at a considerable preliminary temperature, and delivered through steel ducting along the top of the boilers to the boiler front.

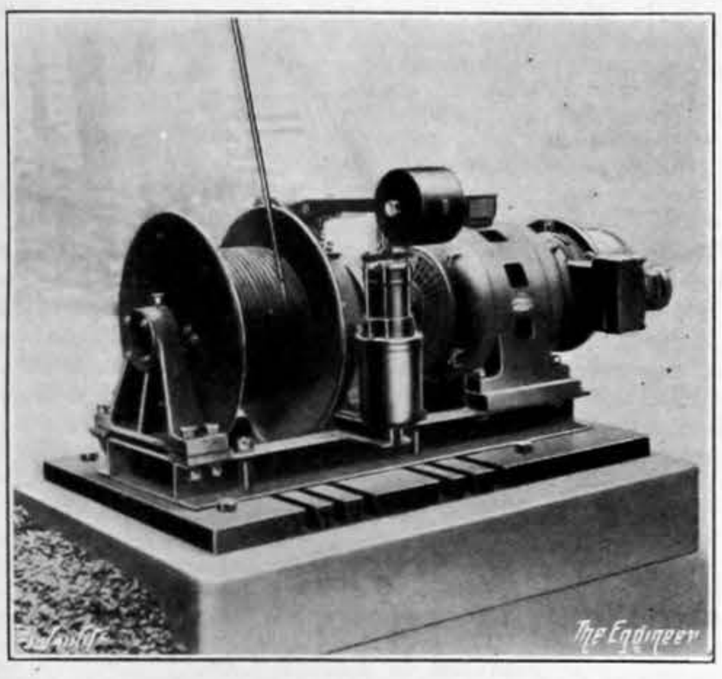
The boilers are fitted with "Meldrum" sprinkler stokers with fixed grates, and the stoker fronts are of the Meldrum hollow pattern. Secondary air is circulated through the fronts and enables perfect combustion to be obtained. The fire-bars are of a special mixture to stand the high air temperature. Each stoker is driven by its own motor, mounted directly on the stoker front. The drive is through worm reduction gear and the motors drive by chain.

As regards the saving by use of this plant, the coal consumption on these two boilers originally averaged 20 tons per day, and consisted of double screened nuts. The price of this coal at the time of fitting the stokers was 21s. 6d. Owing to the colliery settlement, the price to-day would be 22s. 6d. It was found, however, that a cheaper class of fuel, namely, "peas," could be used with these stokers and hot air draught, at the price of 17s. 3d. per ton, and the consumption was reduced to 16 tons per day. The saving represented by the combined improved efficiency and the cheaper fuel represents a total of over £2000 per annum. At the same time the duty of the boilers has been increased, and a very much greater output is now possible, whilst the steam pressure is maintained at an even figure.

Electrical Equipment for Small Hoists.

A new hoist for mining service has been designed by Holman Brothers, of Camborne, in collaboration with the British Thomson-Houston Company, Ltd. Intended for service abroad as well as in this country, it incorporates features which give complete safety for lowering men, even in the hands of unskilled operators. As will be seen from the accompanying illustration, the hoist is very compact, and although (without control gear) it weighs only 1110 lb., it is capable of exerting a mean rope pull of 2300 lb. at a rope speed of 200ft. per minute with a 15 H.P. motor. The control gear, together with a B.T.H. electro-hydraulic thrustor, enables full control for raising and lowering to be obtained from one control gear handle without the necessity for manœuvring brakes or clutches. A B.T.H. 15 H.P. slip-ring motor with totally enclosed, dustproof brush gear, is coupled to the drum through a flexible coupling and high-efficiency, totally enclosed, oil bath gearing. The brake is normally "on" and is lifted by the thrustor only when the motor is energised.

Consequently, the brake is instantly applied when the controller is brought to the "off" position, and, it is claimed, there is no shock, as the thrustor operates smoothly yet without dangerous delay. The specially designed control gear is very compact, comprising a circuit breaker with ammeter, a controller, and resistances, enclosed in one case suitable for mining service. With an equipment operated by unskilled labour overspeeding when lowering is usually a difficulty on A.C. supplies, but this, it is claimed, is avoided by the design of the control gear, and by the automatic brake operation. When solenoids are used for brake mechanisms, it is possible to burn them out through overload if the brake



ELECTRIC MINE HOIST

is wrongly adjusted, but no such thing is possible with a thrustor. Furthermore, the makers state, the upward "push" of the thrustor, as compared with the upward "pull" of the solenoid, simplifies the design of the brake mechanism in certain respects.

THE MODEL ENGINEER EXHIBITION.

THERE is one aspect of the Model Engineer Exhibition, which is now open at the Royal Horticultural Hall, Westminster, but closes on Saturday, that has, we believe, escaped general attention. And that is its historical value. Enthusiasts will always go in for the pure modelling of contemporary machinery and plant—that is to say, its reproduction on a miniature scale—and often, as is exemplified in the present Exhibition, these models are really faithful. Such models can be retained in museums for the information of future generations quite conveniently, while the actual machines almost inevitably get scrapped with the march of progress.

This year there are some notable examples of perfect modelling, including especially a triple-expansion marine set combined with an exhaust turbine, on which Mr. Mulhorn, of Booth, Lancs., is said to have expended 5000 hours of labour. We desired to know how he contrived the blading of the turbine, but could not find the "modeller." There are many other excellent models, including one of an engineering workshop with its engine, and many petrol engines, but what struck us most, as ever, was the preponderance of locomotives, some of them exhibited in their embryo state, in the enthusiasm of their builders. It would, however, we think, be worth while to foster an attempt to produce less orthodox designs. Some of these tiny locomotives are intended for traction purposes, and it is quite conceivable that on a small scale a vertical boiler and engine with screw gearing would be far more effective than the normal locomotive. Again, there is the Shay locomotive used in the logging camps of America. We cannot recollect ever having seen one modelled.

Another impression gained from a tour of the Exhibition was an increased interest in nautical affairs. There are some excellent models of old-fashioned historical vessels, alongside really beautiful model sailing racers. It was noteworthy that some of these racers were fitted with modern steel masts, but to an old-fashioned sailor they do not look so graceful as those of wood. An interesting exhibit is a chart showing the named rigs of many Scottish fishing boats.

Aeroplanes, naturally, provide an ever-increasing field for the modeller, and there is one of a low-wing monoplane with a wing spread of 8ft. 6in., which is intended for an attempt on the height record. There is also the usual exhibit of the Royal Air Force, including some really excellent examples of fitting work, and a number of officers are in attendance who are most courteous in answering questions about training and prospects in the Force.

The number of stands devoted to the tools and machines required by the model engineer is not, perhaps, quite so great as usual, but that is made up for by the comprehensive nature of those that are there.

We congratulate Mr. Marshall on his exhibition, and imagine that with his association with the electrical Press, his next exhibition will be even more extensive and popular.

THE LATE MR. A. C. HAY.—The death took place on September 13th, at his home in Glasgow, of Mr. Adam C. Hay, who for many years was managing director of R. and J. Dick, Ltd., belting manufacturers, Glasgow. Mr. Hay was connected with the company for upwards of fifty-eight years. He entered its service as a boy, and in later years was appointed foreman, and subsequently manager of the belting department. He became a director of the firm in 1908, on the flotation of the company, and later managing director. For six years previously he had been a partner in the firm.

The Defence Programme.

CONDITIONS OF CONTRACT.

(THE BRITISH ENGINEERS' ASSOCIATION.*)

THE big armament and other engineering firms who are experienced contractors to the Admiralty, the War Office, or the Air Ministry do not need any advice from us concerning conditions of contract. But under the Defence Programme large numbers of contracts for war material will be placed with engineering firms possessing little or no experience of such contracts or of manufacturing the particular kinds of articles which they will now be required to produce on a considerable scale. In many such cases new machinery and even new buildings will be necessary for the execution of the contract, and this introduces unusual complications into the conditions of contract.

In view of the importance of the matter, we have been at some pains to inform ourselves, and we believe that the information and advice given in this article may be helpful to some of our members in dealing with conditions of contract to which they are unaccustomed.

Because it would serve no practical purpose to do so, it is not proposed to review clause by clause the general conditions of contract used by the Admiralty, the War Office, and the Air Ministry. Their respective printed conditions of contract for normal use are firmly established and are unlikely to be altered. To the extent that they are applicable to any particular contract, they are not open to argument and the tenderer must accept them if he wants the order. A large proportion of defence programme contracts, however, will be the subject of special conditions of contract suited to the particular circumstances of the case. In the main, these special conditions are needed because of some departure from the normal purchasing procedure, as, for example, the financing by the Government of new machinery and plant required by the contractor for the execution of his contract.

It is to certain questions arising on special conditions of contract that we will now direct our attention.

BREAK CLAUSE.

Apart from other considerations, it is necessary for political reasons that the Government in entering into contracts for war material should provide against the possibility of their commitments exceeding the national needs in certain eventualities which cannot be predicted. It is customary to make this provision by means of a break clause, and it is of vital importance to the contractor that he should give his careful consideration to the wording and implications of such a clause, when preparing his tender and negotiating a contract, with the object of providing against the risk of the economic basis of his contract being upset by premature stoppage of production or by changes in the volume of work and the period of its production. The saving to the Government effected by the operation of a break clause should not be at the expense of the contractor, and he will be well advised to see that he is protected in this respect. This protection, however, must necessarily be limited to compensation for expenditure actually incurred, including irrevocable liabilities properly undertaken in respect of a contract, but which have not yet matured for payment. There can, of course, be no compensation for the loss of an expected profit on the cancelled part of a contract.

In some cases the risk to the contractor has been removed or minimised by dividing the contract into two or more consecutive periods of time, each corresponding to a specified output, and providing that the contracts department concerned, not less than three months before the expiration of a period, shall give notice thereof if it be the intention not to require the output contingently contracted for in respect of the next ensuing period. This, of course, means that there would be no break during a period of planned production on account of which the contractor had entered into financial commitments. This is a valuable precedent to be borne in mind.

Contracts under the present defence programme are due to be completed by March 31st, 1939.

CAPITAL EXPENDITURE RISKS.

The Great War left in its train some disastrous losses of capital expended on additional buildings, machinery, and plant to meet the abnormal war demands to which peace-time requirements were never likely to approximate.

The impossibility of employing them profitably after the war converted a large proportion of these temporary assets into heavy liabilities. With this lesson in their minds, engineering firms are naturally very fearful of increasing their capital commitments for the purpose of expanding their productive capacity to meet the defence programme requirements. If the Government had not decided to relieve the contractor of this risk, where necessary, it is doubtful whether it would have been possible to carry out the defence programme within the prescribed time.

The Government have boldly met this difficulty by undertaking to finance approved additions to the contractor's machinery and plant, on the condition that they are to be and to remain Government property. Another condition is that the contractor shall maintain this Government property in serviceable condition and hold it at the disposal of the Government for six years from the date of his first contract. The maintenance expenses to be borne by the Government. It is recognised that it would be an extravagance to allow potentially productive machinery, &c., to remain idle, if at any time it should be possible for the contractor to use the whole or any part of it for the execution of commercial contracts. Furthermore, the reasonable use of such machinery and plant would be the best way of maintaining it in good serviceable condition.

For these reasons it has been provided in special conditions of contract that the Government, as and when occasion arises, may give permission for the whole or part of the productive equipment, which is the property of the Government, to be used by the contractor in consideration of his paying an agreed rental.

THE LOCATION OF GOVERNMENT FINANCED NEW MACHINERY AND PLANT.

As stated above, machinery and plant financed by the Government will remain the property of the Government, and it is only with the consent of the contracts department concerned that it may be used by the contractor for any purpose other than the execution of a Government contract. It will therefore be advantageous to so place and segregate such new equipment that the suspension or curtailment of its operation may cause the least possible disturbance of the economical administration and operation of the contractor's works. Such segregation will not always be practicable. In some cases unavoidable intermixture and possibly even partial interdependence of machinery and plant owned by the contractor and by the Government respectively may present serious difficulties, in ways which will be obvious to any works manager. By careful thought and planning every effort should be made to minimise the number of such cases and the difficulties associated with them where intermixture is unavoidable.

RISK OF LOSS OF OR DAMAGE TO GOVERNMENT PROPERTY.

Clause 4 of the general conditions of contract of the War Office reads as follows :—

> "Risk of loss of or damage to Government property. The contractor guarantees the due return of all Government property issued to him, and will be responsible to the full value thereof to be assessed by the Secretary of State for all loss thereof or damage thereto from whatever cause happening while in the possession or control of the contractor, his servants, workmen or agents."

It is clear that the contractor might find himself in difficulties if he accepted this condition, as worded, in respect of Government-owned machinery and plant used by him for the execution of a Government contract, because it would have been subjected to wear and tear for which no allowance is provided. This difficulty has been recognised by the Contracts Department of the War Office, and it has been met in special conditions applicable to this class of contract by amending the wording in such a way as to require the contractor to return Government property "in serviceable condition."

Attention should be given to this point when entering into contracts, and it should be borne in mind that the contractor's risk of loss of or damage to Government property is insurable.

PRICE VARIATION CLAUSE.

In principle, the need for a price variation clause in certain circumstances is recognised, but in contracts now being made for completion within this financial year, *i.e.*, before March 31st, 1937, engineering wages and steel prices are regarded as having been fixed for that period. In these respects it is therefore unnecessary to provide for price variations. In the case of some costs items, *e.g.*, non-ferrous metals, where the prices are subject to considerable unpredictable variations, a suitable price variation clause is usually included in the contract.

A price variation clause should be equitable. It is not intended to profit either party at the expense of the other party. As the wording of some price variation clauses is open to misconstruction, we have drafted the following clause which is thought to be devoid of ambiguity :—

> "This tender is based on the rates of wages and the prices of materials now ruling, and in the event of its being accepted and a contract being placed, any increases or decreases in the said rate or prices to the extent that they increase or decrease the costs actually incurred by the contractor in the execution of the contract shall be fully compensated by countervailing increases or decreases in the contract price or any part thereof in respect of which a separate price has been quoted in the tender."

Contractors, however, are not all of one mind on the subject of price variation clauses. In fact, there are strong differences of opinion, not only in regard to the wording of a clause, but also concerning the desirability of making any provision for price variations. In these circumstances it would be improper for us to express any opinion of our own on the question of policy, the decision of which must be left to the free discretion of the tenderer or contractor, subject only to the wishes of the purchaser.

The wording we have suggested is merely submitted for the consideration and guidance of contractors who may find it necessary either to propose or to accept a price variation clause.

CONTRACT PRICE.

When the nature of the contract permits, the normal system of inviting competitive tenders is adopted, and the price is fixed before the contract is placed. But the typical case with which the average engineering contractor will be concerned under the defence programme is one in which he contracts to make and supply articles for war purposes lying outside the scope of his ordinary manufacture, and for which he is incompetent to fix a price with reasonable accuracy.

The practice in these cases varies. In the case of the War Office it is for the tenderer to prepare estimates of cost to the best of his ability, and then, in consultation with the contracts department, to agree upon a fixed maximum price, including an agreed allowance for profit. But it is a condition insisted upon by the Government that the contractor's costs and profit shall be subject to examination, and if it be found that the maximum price would in fact yield more than the approved profit, a redressment is made. In no circumstances will the Government pay more than the maximum price fixed in the contract, and any loss due to the estimated costs having been exceeded must be borne by the contractor.

On the other hand, it is recognised that unless there be some inducement to the contractor to exercise his skill and energy to reduce his costs, a very moderate standard of performance might become the rule, and the Government would be deprived of the benefit of possible economies.

For these reasons, in appropriate cases, any savings effected are shared between the Government and the con-

* This article will be printed in the next number of the British Engineers' Association. In view of its importance and through the courtesy of Mr. David Bremner, we are enabled to print it at once.—ED. THE E.

tractor in proportions agreed upon when the contract is made.

CHARGES (ONCOST ON PRODUCTION, DISTRIBUTION, AND GENERAL).

The attention of the reader is directed to the article entitled "The Defence Programme: Industry and Prices," which appeared in the March–April issue of the *B.E.A. Bulletin* (Vol. 17, No. 2, page 24). With regard to "Charges," some points of importance to the contractor are put forward on pages 27 and 28. When negotiating contracts otherwise than by way of ordinary competitive tendering where the contract will be let at a definite tendered price, it will usually be necessary to submit detailed estimates of costs and to discuss them with one of the principal officials of the contracts department concerned. It is important that at this stage the question of the various proposed charges and their validity should be fully and frankly discussed, and a clear understanding arrived at as to the permissible charges, otherwise serious difficulties are likely to arise at the later stage when cost accounts and the amount actually to be paid by the Government have to be agreed. We believe there is no reason to anticipate arbitrary and unfair treatment of "charges" items, provided that the tenderer or contractor presents an honest case and is competent to explain how his figures have been arrived at.

PROFITS.

What are profits and how are they to be computed? This question presents difficulties not always apparent at first sight. It is desired to avoid the financial exploitation of the nation's defence needs by those who are called upon to supply the things to satisfy them. In other words, the public expects the Government to buy their war material at economical prices, and to that end to resist and defeat any attempts at "profiteering." When speaking of this matter in its various aspects, it is customary for use to be made of numerous words and phrases lamentably lacking in definition and precision, amongst which are the following:—Profiteering, extravagant profit, fair and reasonable profit, legitimate profit.

The truth is that "profit" is a relative term and a variable quantity. A dictionary definition of profit is "excess of returns over outlay," *i.e.*, it is relative to outlay and in quantity it may vary between wide limits fixed only by usage, which in its turn is merely an expression of the lessons of experience. There is no such thing as an absolute rate of profit possessing a special ethical sanction. It is therefore impossible to give any precise definition to such phrases as "fair and reasonable profit" or "extravagant profit," though every educated business mind has, by experience, acquired a judgment, a sense of the proper proportions and fitness of things, which enables it to perceive the upper and lower limits of permissible profit in a given kind of transaction, of which the particulars are known. For example, the man in the street would have little difficulty in making up his mind that a profit of 100 per cent. on some munition of war would be a crime against the Government and the people; also that, on the other hand, a profit of 1 per cent. would be a crime against any reasonably efficient contractor.

It is hoped that enough has been said to make it clear that, at any rate, for the immediate purpose of defence programme contracts, it would be a sheer waste of time to theorise about the ethics of profit making or to attempt to define a particular rate of profit and the method of computing it which would be the one and only right and proper profit for general application to the defence programme contracts.

There will be a large variety of cases in which the requirements and the conditions will differ greatly, and although it will be possible to group them in a much smaller number of categories or classes, each of these will have to be dealt with on its merits.

THE COMPUTATION OF PROFITS.

Only in a minority of cases (chiefly aircraft and engines for same) will defence programme contracts account for the entire output of a contractor during any period. Consequently, the profits, as given in the profit and loss account and carried into the balance sheet, will not be the profits to be examined and approved in connection with any particular D.P. contract. The whole of the activities of the contracting firm might show a loss, whilst a D.P. contract executed during the financial year might have yielded a profit. Alternatively, the balance sheet might show a handsome profit, in spite of the fact that D.P. contracts carried out had resulted in a heavy loss.

The only profits with which the Government Contracts Departments will properly be concerned will be the profits on each particular D.P. contract, as ascertained from the contractors' accounts relating to that contract. The easiest case will be where it has been possible to segregate and operate as a separate entity machinery and plant financed and owned by the Government, and which alone are used in the execution of a particular D.P. contract. The most difficult case will be where a D.P. contract has been carried out with machinery and plant owned partly by the contractor and partly by the Government, and intermixed in the same building. In such cases the calculation, allocation and agreement of the appropriate "charges" will present difficulties and will require careful and competent consideration.

SOME GENERAL OBSERVATIONS.

Government contractors for war materials, in this country, are exceptionally fortunate in having to deal with technical and purchasing departments endowed with the highest standards of competence and probity.

Engineering firms who are not accustomed to doing business with the War Departments will find almost invariably that they can rely on receiving fair and reasonable treatment, and valuable assistance in overcoming the initial difficulties of entering into a new and strange field of activity.

It must be recognised that the business methods of Government Departments are necessarily more rigid and precise than those of the average commercial purchaser, also that the expenditure of public money calls for special safeguards involving an elaborate system of record keeping and accounting in which the contractor has to play his part at some expense.

All this, however, is more than compensated for by the considerable value of the orders and the certainty of payment for work properly executed in accordance with the contract.

We shall be happy to give our members any further advice or assistance in our power. D. A. BREMNER.

Railcar Operation in the Argentine.

Two oil-electric railcars were shipped by Sir W. G. Armstrong Whitworth and Co. to the Buenos Aires Western Railway in the autumn of 1934. The work carried out by these units was described by the chairman of the company at its annual general meeting, and the notes have been handed to us by the makers.

The following table gives the general particulars of the two cars:—

	450 H.P. Articulated.	140 H.P. Single.
B.H.P.	450 B.H.P.	140 B.H.P.
Tare weight	67½ tons	31½ tons
Luggage space	55 sq. ft.	65 sq. ft.
Starting T.E. (4·5 adh.)	14,000 lb.	6,850 lb.
Number of passengers in railcar	48	48
Speed	60 m.p.h.	40 m.p.h.
Transmission	Electric with constant power control	Electric A.B.E. simplified system
Engine	Armstrong-Sulzer	Armstrong-Saurer

SERVICE OF ARTICULATED CAR.

This car started work in the Argentine in September, 1934, and after various trials was commissioned to operate a special service from Buenos Aires to Lujan for the Eucharistic Congress, covering 4760 miles in the fortnight. On October 13th, a regular daily service was begun between Buenos Aires and Bragado of 273 miles per day. This continued until December 1st, when a preliminary engine inspection was carried out to ascertain that the engine was "finding itself" satisfactorily. The daily mileage was then increased to 335 and the service increased from six days per week to seven, the route being Buenos Aires to Neuve de Julio. On February 4th the service was again extended to Carlos Cassares, some 32 miles further from Buenos Aires, thus raising the daily mileage to 400 miles.

On April 2nd, the car was withdrawn for the periodic engine examination, having completed 53,000 miles. In the course of this examination fifteen piston rings and twelve carbon brushes for the generator were replaced, together with one big-end shell, the white-metal of which showed signs of cracking, and which it was considered wiser to replace.

The same service was resumed on April 12th and was maintained until the second engine inspection, which took place after the vehicle had covered 89,000 miles, and was completed in seven days (July 15th to 21st inclusive). On this occasion two piston rings and another big-end shell were changed.

The same service of 400 miles per day was resumed on July 24th, and continued until November 5th, when, after covering 126,000 miles in thirteen months without any failure of the power equipment, the vehicle was withdrawn for general overhaul. Such failures as did occur were entirely confined to hot boxes, &c., and had no relation to the type of motive power employed.

The replacements were as follows:—

Set compression rings and upper scraper rings (lower scraper rings returned to service).
Two valve springs.
Set carbon brushes for traction motors.

The greatest ovality recorded in checking up the crankshaft was less than $^{1}/_{1000}$in.

Up to the general overhaul no valve or valve seating had required truing, but only slightly seating down with grinding compound. At the general overhaul some of the valve seats were lightly recut, but none of the valves required more than light grinding in before returning to service.

During the overhaul incipient signs of failure proved almost negligible—various electrical connections were remade, a resistance element changed, and a certain number of flexible connections replaced, in order to ensure the highest possible degree of reliability once the machine was returned to service.

From the start of work in the Argentine until the overhaul (126,000 miles), the average fuel consumption was 4·59 miles per gallon, while the lubricating oil, including complete changes at the specified intervals and also for new oil after the overhaul, worked out to 445 m.p.g., or 1·04 per cent. of the fuel used.

COSTS OF THE ARTICULATED CAR.

Data are now available from which the complete costs of the 450 B.H.P. car can be arrived at, and they are shown in Tables I and II below, in which it will be noted that the charges of certain modifications are included. These were chiefly the improvement of dust exclusion from the power equipment and alterations to the springing to adapt the vehicle to higher speeds than those for which the original design was got out:

TABLE I.—*Shop Overhaul Costs of 450 B.H.P. Railcar.*

	Mileage, approx.	Man hrs.	Relative British cost.	Material.
			£	£
Preliminary inspection	11,000	247	14·1	1·05
1st engine examination	42,000	330	26·1	22·0
2nd ,, ,,	37,000	338	26·8	17·5
General overhaul: Power equipment	36,000	2,771	154·0	107·2
Account from works for repainting, wheel turning and sundry modifications, 3,000 dollars, divide, say	—	2,080	115·5	87·5
	126,000	5,766	336·5	235·25

Cost for 126,000 miles, £571·75, or 1·09d. per mile.

	£	Pence per mile.
Labour, cleaning	60·1	0·265
Inspection:		
Power, equipment	25·1	0·110
Coachwork and mechanical	14·1	0·062
Axle-boxes	25·2	0·111
Material, cleaning, tools, &c.	16·9	0·075
Remainder	21·0	0·093
		0·716
Fuel, 52,439 litres	199·5	0·881
Lubricants (all purposes)	30·0	0·132
Driver at £14·45 per month, covering, say, 5,600 miles per month		0·62
Guard, say, as driver		0·62
		2·253

Throughout these costs the charges for material have been translated from dollars to £ at par (11·45 dollars to £), and the cost of material is, therefore, equivalent to the prevailing cost of such material in England. Labour has, however, been translated according to custom at the rate of "a shilling's worth of work costs 1 dollar," using actually 17·3 dollars to £, which is a conservative figure. The summary of the data given in the tables is as follows:—

Operating cost	2·253d. per mile
Shed ,,	0·716d. ,, ,,
Overhauls and shop work	1·090d. ,, ,,
	4·059d. ,, ,,

SERVICE OF SINGLE CAR.

The 140 B.H.P. vehicle, after running preliminary trials and demonstrations, took up a regular duty on January 7th connecting Haedo, which is on the electrified section of the Buenos Aires Western Railway, with Tablada. This is a shuttle service and the introduction of the oil car effected considerable economies in that, under Argentine law, no passenger train is allowed to be pushed, and, consequently, shunters had to be stationed at both these stations to assist in coupling and uncoupling the steam locomotive when changing from end to end of the train. The railcar, being self-contained and reversible, did not require this additional labour, which at best was not fully employed.

In January, 1935, an accident occurred on the electrified section, necessitating the temporary cutting off of current between two stations. The railcar was called upon to run a shuttle service and bridge the gap as a temporary measure.

On March 15th, the first engine inspection was carried out after the car had travelled 8350 miles. Its duty was resumed again on March 18th.

On May 6th the service was changed and the car ran from Haedo through Tablada and on to Marmol, where the Buenos Aires Western Railway connects up with the Buenos Aires Great Southern Railway. This change of service gave a mileage of 1150 miles per week, and again constituted a shuttle service, involving 4·3 mile sections.

The Haedo-Marmol service has been maintained up to the present, though in July, 1935, the engine was converted to the new standard design of the Armstrong-Saurer range, namely, by the application of the direct injection dual turbulence cylinder heads, the advantages of which are clearly demonstrated by the average fuel consumption figures before and after conversion, which compare as follows:—

Miles per gallon originally	5·3
,, ,, ,, after conversion	7·0

It is also interesting to note that on the Haedo-Marmol service the car is regularly called upon to haul a cold storage van containing foodstuffs, and that its ability to do this has again resulted in a considerable economy in operation for the railway company. The car has now completed some 47,000 miles and has gained the support of the travelling public, to whom it is known as "cucaracha"—flying beetle.

COSTS OF THE SINGLE CAR.

The operating costs of the 140 B.H.P. car cannot be quite so clearly classified as in the case of the 450 B.H.P. since it is not possible to segregate the cost of cleaning from routine maintenance of the power equipment. Sufficient data over a short period of fifteen weeks, are, however, available and shown in Table III, but this, unfortunately, does not include an engine examination:—

TABLE III.

Period eight weeks.

Mileage	17,820.
Fuel consumed, 2,800 gallons, miles per gallon	6·6
Cost of fuel, 573 dollars, pence per mile	0·672d.
Lubricating oil consumed, 66·1 gallons, ratio lubricating oil to fuel, per cent.	2·45
Cost of lubricating oil, say, 3s. 6d. per gallon, pence per mile	0·156d.
Cost of lubricating all purposes, 202 dollars, pence per mile	0·238d.
Labour: Maintenance, cleaning, 875 dollars, pence per mile	0·672d.
Material, 96·5 dollars, pence per mile	0·113d.

From the data given in Table III the operating cost can be arrived at by including driver's wages, cost of overhauls, &c., from other records of the same vehicle:

Item.	Cost per mile. d.
Fuel	0·672
Lubricating oil and grease, all purposes	0·238
Driver, 250 dollars per month driving, say, 25 days in the month—daily mileage 200	0·75
Guard, say, as driver	0·75
Maintenance material	0·113
Maintenance and cleaning labour	0·672
Engine examination (approx. each 20,000 miles): Man hours, 150 at average cost 0·96 dollars per hour, 144 dollars; add 50 per cent. for inspection and supervision, 216 dollars	0·168
Total, per mile	3·363d.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The International Steel Position.

During the last few months the position of the Continental steel makers has greatly improved, although they are not enjoying the same rush of activity which the British works have experienced for more than a year. Conditions in the German steel trade perhaps more nearly approximate the situation in this country, whilst in France, although the works are well off for orders, the industrial position naturally creates uncertainty and has a disturbing effect upon business. Judging, however, from the export business which has been transacted lately by the French makers, the iron and steel trades of that country have been less affected by the prevailing conditions than have some of the other industries. In Belgium the works greatly improved their position as regards the orders on their books during July and August, and although the activity has slackened, they still have several weeks' work in reserve. In August the total booked by Cosibel, the Continental steel works selling organisation, was 196,000 tons, of which 70,000 tons were for home consumption. At the end of the month 44,000 tons were unspecified. A feature of the Belgian situation is that the home trade lately has been taking about 40 per cent. of the total tonnage booked, compared with about 25 per cent. to 30 per cent., which was formerly regarded as normal. Like the British, the Belgian steel trade is passing through a transitional period and for the first time in the history of the industry the re-rollers and the steel makers have reached an agreement which is apparently working smoothly. Export prices are controlled by the Cartel by arrangement with the British steel makers, and recently quotations were advanced for several South American markets. Some surprise was occasioned by this movement, as until latterly the Continental makers have had to give substantial concessions to meet American competition. Last week important Cartel meetings at which the British steel makers were present were held in Paris. The operation of the Cartel for thin and galvanised sheets was reviewed, as well as the position of the British merchants. It is understood that whilst progress was made on all these subjects no final settlement was reached. It was expected that the licensing of steel imports into Great Britain would be put into force on October 1st. It is probable, however, that some delay will occur, as certain points have still to be settled. This week representatives of the British and Continental steel makers met officials of the Board of Trade to discuss the subject.

The Pig Iron Market.

Now that the first rush of autumn buying has passed the market for pig iron has settled down on rather quiet lines. Consumers have placed heavy forward contracts, but in most districts more business is offering than the makers care to accept. It is suggested that some of this is the result of a desire on the part of ironfounders to build up reserves. The attitude of the makers, however, is not sympathetic, as their whole production is required for the satisfaction of users' immediate needs. On the North-East Coast activity in the market has died down and little has been heard of new business, although buyers would be prepared to place fresh contracts. Generally speaking, the present production is sufficient to satisfy current contracts, but there is little to spare to meet any new demand. The makers claim that they have given their regular customers an opportunity of covering to the end of the first quarter of next year, and that many of them have done so. There is, of course, little iron available for export, although a substantial tonnage was recently sent to Australia. Most of the export merchants complain that the works are still in arrears with deliveries against contracts on overseas account. In the Midlands the demand seems to be gradually broadening, and whilst most of the big consumers have covered their requirements so far as they can estimate until the end of next March, others have bought only until the end of this year. In some cases producers have rationed their customers to the quantities taken during the previous six months. There has been an active demand for special irons lately, the prices of which are uncontrolled, and trading in forge iron has also improved. In Scotland business shows no signs of relaxing and the requirements of the light castings industry are on a good scale. Although some consumers have bought Scottish foundry iron for far forward delivery, the producers are not keen to accept this business. The market for hematite has become quieter rather on account of the limited quantities which the makers will have for disposal for some time to come than as a result of any slackening in consumers' requirements. Considering the difficulties which threaten the supply of ore, production has been maintained, but there seems little chance of any consumer being able to add to his stocks if he should be fortunate enough to hold any. The tightness which it was feared might develop in the market for basic iron appears to have been avoided. Arrangements were made to import about 60,000 tons of Russian basic iron with the option of increasing the quantity; but it has not been found necessary to call for the latter supplies.

The Midlands and South Wales.

The market for steel has broadened during the past week or two, but the actual volume of business has not increased in proportion simply because the steel manufacturers are not in a position to accept all the business offering for the dates on which it is required. Practically every department of the steel works is operating at capacity and order books are somewhat congested. On the other hand, consumers are pressing for deliveries against contracts and the weights of individual specifications show a tendency to rise. For some weeks the tightness in the structural steel department has caused uneasiness, and lately this has become accentuated as a result of the increase in the demand. Constructional engineers are pressing new orders upon the steel works, and at the same time trying to accelerate deliveries against old contracts. A certain amount of irritation has been caused by cases in which work in hand is reported to have been held up through the difficulty of obtaining material. It is not easy, however, to see how the situation can be remedied and it is pointed out that additional imports of Continental steel would not fully meet the case as British steel is specified for most of the work now being undertaken by the constructional trades. The position in the semi-finished steel department is also creating apprehension, since it is doubted if the increase which has taken place in the home production this year will enable the British makers to satisfy the requirements of the consuming industry. It is assumed that the British Federation will again import supplies of semis in excess of the quota; but this will only be done if it becomes absolutely necessary. In this case, also, it is pointed out that the demand is principally for British semis as the contracts users are working upon specify this to a greater extent than formerly. The plate makers are much better off for orders than at this time last year, and there is a considerable amount of fresh business which will probably come upon the market shortly. Most of the steel sheet mills are well employed, but except for some of the thicker gauges the position is not so tight as in other sections of the trade. The motor car manufacturers are taking heavy tonnages of special sheets, and there is a strong demand for strip. The re-rollers in the Midlands are without exception busily employed, and their anxiety is chiefly to secure supplies of semis. In South Wales there has been no sign of any relaxation in the activity that last month resulted in this district becoming the leading steel-producing area in the country. The tin-plate mills are working at over 60 per cent. of capacity, and their steel requirements are keeping the producers of sheet and tin-plate bars busy.

Scotland and the North.

All the Scottish steel works are assured of active employment until the end of the year, and it is anticipated that the steel production in Scotland for 1936 will constitute a record. The shipyards are taking considerable quantities of plates and sections, and it is expected that this demand will continue for some months. Of late there has been a halt in the placing of contracts for new ships, but the work the yards have in hand will necessitate the use of large tonnages of steel, and it is understood that orders for new vessels will be placed later in the autumn. The marine engineering establishments and the boilermakers are also busily employed and considerable quantities of plates are being taken up. The constructional engineering concerns in Scotland have work in hand to keep them busy for months to come, and they are exerting considerable pressure upon the steel makers to obtain delivery of joists and sections. Export business does not develop, but few of the makers are anxious to take fresh business for overseas in the present congested state of their order books. The production of sheets is on a good scale and the manufacturers have enough work in hand to keep them busy until the end of the year. Business has been principally in the thicker gauges and by far the greatest proportion of the output has passed into home consumption. Most makers would like to secure more export orders, but in spite of arrangements with the Continental Cartel overseas trade is slow in developing and reports from several markets indicate an increase in competition from American and Japanese makers, who are outside the arrangement. In the home market the tonnage of special sheets which is being taken by the motor car industry is a feature of the position, whilst a strong and growing demand comes from the manufacturers of tanks and drums. In Lancashire the constructional engineers are pressing specifications for joists and sections upon the works. A fair amount of new business has been placed, but few of the makers are able to quote for anything like near delivery. The re-rollers are experiencing a heavy request for their products, and the quantities of bars of all kinds which are passing into consumption has aroused comment. With the development of the autumn trade the request for special steels has broadened.

Current Business.

The British Chilled Roll and Engineering Company, Ltd., Empire Works, Haverton Hill, Middlesbrough, has been acquired by Davy Bros., Ltd., Sheffield. The Birmingham Corporation has placed an order for twelve trolly omnibuses with the General Electric Company, Ltd., Witton, Birmingham, and for sixty-five motor omnibus chassis with the Daimler Company, Ltd., Coventry. Hayward-Tyler and Co., Ltd., pump makers and brassfounders, Luton, have closed the waterworks fittings department of their works and the branch has been taken over by Edward Barber and Co., Ltd., engineers and brassfounders, Paxton-road, London, N.17. Five hundred acres of land at Avonmouth have been acquired by the National Smelting Company, Ltd., as a result of recent developments. An order has been placed by the Air Ministry with the Furness Shipbuilding Company, Ltd., Haverton Hill-on-Tees, for four large hangars to be erected at Royston Aerodrome, Herts. It is estimated that 2250 tons of steel work will be required. A new seam has been struck by the West Houghton Coal and Cannell Company, Ltd., which will considerably prolong the life of the pit. The London and Thames Haven Oil Wharves, Ltd., are taking 70 acres of land for the establishment of an oil refinery at Dublin Harbour. The Dublin Harbour Board will reclaim 17 acres. The Department of Overseas Trade announces that the following contracts are open for tender:—South Africa, Johannesburg City Council: two portable self-contained asphalt and bituminous macadam mixers (Johannesburg, October 10th); Union of South Africa, Public Works Department: two vertical cross-tube boilers with a working pressure of 100 lb. per square inch, and two Weir feed pumps; high and low-tension switchgear and transformers, (Johannesburg, October 9th); two locomotive type boilers, two feed pumps and calorifier, &c. (Pretoria, October 16th); South African Railways and Harbours: two pressed steel tanks and accessories (Johannesburg, October 19th); Argentine State Oilfields: four synchronous motors for three-phase A.C. and accessories (Buenos Aires, October 9th); seamless steel and galvanised iron pipes, galvanised curves, couplings, bends, flanges, &c. (Buenos Aires, October 6th); 16,000 m. of seamless black steel piping, nominal diameter 6in.; four two-stage air compressors, each of approximate capacity of 15 cm. per minute at a pressure of 8 atmospheres; electric motors, 440 volts D.C. (Buenos Aires, October 8th); Indian Stores Department: 4500-kW, 6600 volts turbo-alternator set, condensing plant, and auxiliaries to specification (New Delhi, October 27th); Egypt Ministry of Communications: bridge over the Nile at Samannoud (Cairo, November 3rd).

Copper and Tin.

The market for electrolytic copper continues to gather strength and, in spite of the increases in production and rumours that a further rise of 5 per cent. will be announced shortly, prices have shown an advancing tendency. Occasionally some easiness has developed, but this has been shortlived, and for the time being market sentiment seems to be definitely in favour of the metal. It is generally considered that stocks in all countries are not more than normal, and that it will not be difficult for the consuming industries to absorb the increased production; but, of course, this will depend to a very great extent upon the quantities which will be required for rearmament purposes by the various countries engaged in schemes of this nature. The advance in the export price of electrolytic copper has brought it almost level with the American domestic quotation, and has given rise to expectations that the latter will be raised to at least 10c. within the next week or two. On the other hand, the producers generally appear to have set their faces against increasing the price and to be bent upon encouraging consumption. It is interesting to note that the world's stocks of refined copper at the end of August, according to American figures, totalled 405,580 tons, compared with 432,320 tons at the end of July. Of these, 205,740 tons were in the United States, compared with 218,700 tons at the end of the previous month. The world's production of refined copper in August was 128,630 tons, compared with 119,450 tons in July. Firm conditions have ruled in the standard market and there has been a certain amount of profit-taking on the advance in prices. The copper put on the market, however, was taken up by consumers, as the industrial demand was somewhat in excess of the supplies offered by the producers. . . . Although there have been some fluctuations in the tin market the general tendency has been for prices to advance. This has been largely due to persistent support from strong interests, but when this has ceased a weaker tone has developed. For the time being the market shows an inclination to follow any pronounced lead, which naturally accentuates both the strength and weakness in prices. The market has been overshadowed by the forthcoming meeting of the International Tin Committee. The question of the Siamese quota will be discussed and it is probable that the quota for the December quarter will be fixed. Sales in the East have been rather limited and at the same time little tin has been put into Liverpool warehouse or shipped to the United States. The market is somewhat puzzled by this position.

Lead and Spelter.

There has been no change in the situation in the lead market and the steady demand from consumers has maintained prices. In fact, the general impression seems to be that if industrial requirements continue at their present rate quotations must necessarily rise further. In this country most consumers have covered themselves forward and are taking heavy deliveries, and on the Continent also the situation has appreciably improved of late. To some extent business with foreign users has been held in check by the financial restrictions in force in many countries, but as much of the lead now in demand is required for rearmament purposes it frequently happens that these difficulties can be overcome. The manufacturers of lead pipes and sheets are well booked for weeks to come, but most of them appear to have arranged for their supplies. A number of fresh contracts have been entered into and no difficulty has been found in placing these, although the full prices have had to be paid. It is not easy, however, to obtain supplies of prompt metal if a consumer requires quantities to supplement contract deliveries, and the position in this respect is indicated by the fact that a backwardation of about 1s. 3d. rules upon the London Metal Exchange. A fair quantity of Mexican lead is expected to arrive at the end of September, and it seems likely that a good proportion of this will go into consumption, although probably some of it will be placed in warehouse. . . . Prices in the spelter market have fluctuated rather sharply at times, but for the most part the market has benefited from sympathetic influences arising from the stronger tone in other non-ferrous metal markets. Fundamentally the position in this market does not alter and for this reason sentiment of late has played a rather important part in the price movements. On the whole, the demand for the metal is good, but the production is much too large to promote healthy conditions. Lately there has been a certain amount of speculation and at times profit-taking has caused a reaction in prices.

Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. *For Markets other than Canada, India, Australia and New Zealand, 5s. per ton must be added. † South Africa 5s. and Foreign Markets 2s. 6d. higher.

PIG IRON.

	Home. (*D/d Teesside Area*) £ s. d.	Export. £ s. d.
N.E. COAST—		
Hematite Mixed Nos.*	4 5 0	3 14 6
No. 1	4 5 6	3 15 0
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 17 6	—
No. 3 G.M.B.	3 15 0	—
No. 4 Forge	3 5 0	—
Basic (*Less 5/- rebate*)	3 15 0	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	4 0 0	—
„ „ Forge	3 15 0	—
Basic (*Less 5/- rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 17 6	—
Forge	3 12 6	—
Derbyshire—		
No. 3 Foundry	4 0 0	—
Forge	3 15 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces*	4 5 6	—
No. 1 Foundry, ditto	4 1 6	—
No. 3 Foundry, ditto	3 19 0	—
Basic, d/d (*Less 5/- rebate*)	3 15 0	—
N.W. COAST— Hematite Mixed Nos.*	4 5 6 d/d Glasgow 4 11 0 „ Sheffield 4 17 0 „ Birmingham	

* *Less 5/- rebate.*

MANUFACTURED IRON.

	Home. £ s. d.	Export £ s. d.
LANCS. AND YORKS.—		
Crown Bars	10 10 0	10 0 0
Best Bars	11 0 0	10 12 6
MIDLANDS—		
Crown Bars	10 10 0	10 0 0
Marked Bars (Staffs.)	13 0 0	12 10 0
No. 3 quality	8 17 6	—
No. 4 „	9 7 6	—
SCOTLAND—		
Crown Bars	10 10 0	10 0 0
Best	11 0 0	10 12 6
N.E. COAST—		
Common Bars	10 10 0	10 0 0
Best Bars	11 0 0	10 12 6
Double Best Bars	11 10 0	11 10 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars f.o.q.	10 17 6	—

STEEL.

	Home. £ s. d.	Export. £ s. d.
LONDON AND THE SOUTH—		
Angles	9 2 6	*8 0 0
Tees	10 2 6	*9 0 0
Joists	9 10 0	*8 0 0
Channels	9 7 6	*8 5 0
Rounds, 3in. and up	10 2 6	*9 0 0
„ under 3in.	9 9 6	7 15 0
Flats, 5in. and under	9 9 6	7 15 0
Plates, ⅜in. (basis)	9 12 6	†8 5 0
„ 5/16in.	9 17 6	†8 10 0
„ ¼in.	10 2 6	†8 15 0
„ 3/16in.	10 7 6	†9 0 0
„ ⅛in.	10 0 0	9 0 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	9 0 0	*8 0 0
Tees	10 0 0	*9 0 0
Joists	9 7 6	*8 0 0
Channels	9 5 0	*8 5 0
Rounds, 3in. and up	10 0 0	*9 0 0
„ under 3in.	9 7 0	7 15 0
Plates, ⅜in. (basis)	9 7 6	†8 5 0
„ 5/16in.	9 12 6	†8 10 0
„ ¼in.	9 17 6	†8 15 0
„ 3/16in.	10 2 6	†9 0 0
„ ⅛in.	9 15 0	9 0 0
Boiler Plates, ⅜in.	9 17 6	—
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	9 0 0	*8 0 0
Tees	10 0 0	*9 0 0
Joists	9 7 6	*8 0 0
Channels	9 5 0	*8 5 0
Rounds, 3in. and up	10 0 0	*9 0 0
„ under 3in.	9 7 0	8 0 0
Flats, 5in. and under	9 7 0	7 15 0
Plates, ⅜in. (basis)	9 10 0	†8 5 0
„ 5/16in.	9 15 0	†8 10 0
„ ¼in.	10 0 0	†8 15 0
„ 3/16in.	10 5 0	†9 0 0
„ ⅛in.	9 15 0	9 0 0
Boiler Plates, ⅜in.	10 0 0	—

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
GLASGOW AND DISTRICT—		
Angles	9 0 0	*8 0 0
Tees	10 0 0	*9 0 0
Joists	9 7 6	*8 0 0
Channels	9 5 0	*8 5 0
Rounds, 3in. and up	10 0 0	*9 0 0
„ under 3in.	9 7 0	7 15 0
Flats, 5in. and under	9 7 0	7 15 0
Plates, ⅜in. (basis)	9 7 6	†8 5 0
„ 5/16in.	9 12 6	†8 10 0
„ ¼in.	9 17 6	†8 15 0
„ 3/16in.	10 2 6	†9 0 0
„ ⅛in.	9 15 0	9 0 0
Boiler Plates	9 17 6	—
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	9 0 0	*8 0 0
Tees	10 0 0	*9 0 0
Joists	9 7 6	*8 0 0
Channels	9 5 0	*8 5 0
Rounds, 3in. and up	10 0 0	*9 0 0
„ under 3in.	9 7 0	7 5 0
Flats, 5in. and under	9 7 0	7 10 0
Plates, ⅜in. (basis)	9 10 0	†8 5 0
„ 5/16in.	9 15 0	†8 10 0
„ ¼in.	10 0 0	†8 15 0
„ 3/16in.	10 5 0	†9 0 0
„ ⅛in.	10 0 0	9 0 0

IRELAND—F.O.Q.	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	9 5 0	9 7 6
Tees	10 5 0	10 7 6
Joists	9 12 6	9 15 0
Channels	9 10 0	9 12 6
Rounds, 3in. and up	10 5 0	10 7 6
„ under 3in.	8 5 0	8 5 0
Plates, ⅜in. (basis)	9 12 6	† 9 15 0
„ 5/16in.	9 17 6	†10 0 0
„ ¼in.	10 2 6	†10 5 0
„ 3/16in.	10 7 6	†10 10 0
„ ⅛in.	10 2 6	10 5 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	10 5 0	9 5 0
14-G. to 20-G., d/d	11 15 0	9 15 0
21-G. to 24-G., d/d	12 0 0	10 0 0
25-G. to 27-G., d/d	12 12 6	10 15 0

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24 G·—

Home.	£ s. d.
4-ton lots and up	14 0 0
2-ton to 4-ton lots	14 7 6
Under 2 tons	16 0 0

Export: £12 7s. 6d. to £13 2s. 6d., c.i.f. India.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 18s. 9d.

Tin-plate Bars, d/d Welsh Works, £5 15s. 0d. to £6 0s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	7 5 0
„ Medium (0·42% to 0·60% C.)	7 15 0
„ Hard (0·61% to 0·85% C.)	8 5 0
„ „ (0·86% to 0·99% C.)	8 15 0
„ „ (1% C. and up)	9 5 0
Soft (up to 0·25% C.), 500 tons and up	6 2 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/1½ per lb.	
Ferro Tungsten	3/- per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 10 0	7/-
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/-
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/-
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 10 0	11/-
„ „ „ 1 p.c. carbon	£36 5 0	11/-
„ „ „ 0·50 p.c. carbon	£37 5 0	12/-
„ „ „ carbon-free	9½d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£11 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/- p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	6/- to 6/1 per lb.	

NON-FERROUS METALS.

Official Prices, September 23rd.

		Export.
COPPER—		
Cash	£38 15 0 to £38 16 3	
Three months	£39 0 0 to £39 1 3	
Electrolytic	£43 2 6 to £43 12 6	
Best Selected Ingots, d/d Birmingham	£43 15 0	
Sheets, Hot Rolled	£72 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	11d.	11d.
„ Brazed (basis)	11d.	11d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£33 0 0 to £35 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	10d.	10d.
„ Brazed	12d.	12d.
TIN—		
Cash	£192 5 0 to £192 15 0	
Three months	£190 15 0 to £191 5 0	
LEAD:	£18 0 0 to £17 18 9	
SPELTER:	£13 17 6 to £14 2 6	
Aluminium Ingots (British)	£100 to £105	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—Navigation Unscreened	15/- to 15/6
Hamilton Ell	15/9 to 16/6
Splints	18/6 to 19/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	14/9 to 15/-
Unscreened Navigation	15/- to 15/3
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	14/6 to 14/9
Secondary Steam	14/-

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	19/6 to 23/-
Furnace Coke	19/- to 24/-
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	16/- to 16/6
„ Second	15/- to 15/6
„ Best Small	13/-
Unscreened	14/6 to 15/6
DURHAM—	
Best Gas	14/8 to 15/-
Foundry Coke	24/6 to 26/6

SHEFFIELD—	Inland.	
Best Hand-picked Branch	26/- to 29/-	—
South Yorkshire Best	23/- to 25/-	—
South Yorkshire Seconds	20/- to 21/-	—
Rough Slacks	11/- to 12/-	—
Nutty Slacks	10/- to 11/-	—

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/- to 19/4½
Best Dry Large	18/6
Ordinaries	18/3 to 18/6
Bunker Smalls	13/6 to 14/6
Cargo Smalls	12/6 to 13/-
Dry Nuts	24/- to 25/-
Foundry Coke	30/- to 47/6
Furnace Coke	24/6 to 25/-
Patent Fuel	21/-
SWANSEA—	
Anthracite Coals:	
Best Large	36/- to 40/-
Machine-made Cobbles	41/- to 48/6
Nuts	40/- to 48/6
Beans	25/- to 35/-
Peas	19/- to 23/6
Rubbly Culm	11/6 to 12/-
Steam Coals:	
Large Ordinary	18/- to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.

Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon
Furnace Oil (0·950 gravity)	3½d
Diesel Oil	4d.

French Engineering Notes.

(*From our own Correspondent in Paris.*)

A Crucial Test.

THE settlement of the dispute in the Lille textile industry may prove to be a turning point in the relations between employers and their men. When employers found themselves wholly unprepared to meet the tactical strike methods adopted by the men at the outbreak of the labour revolt, and were helpless in face of the Popular Government's refusal to do anything to stem the strikes, they saw that their only alternative was to create a united front in opposition to that of labour. They have now taken the first determined and successful action. The occupation of factories in Lille in support of a claim for an advance in wages corresponding with the rise in living costs was met by a refusal to negotiate or to accept any arbitration until the factories were vacated. The claim for a wage advance was not rejected, but was to be subjected to an inquiry into the actual rise in living costs. Later, employers presented an ultimatum to the Government to the effect that they intended to exercise complete authority in their own factories. To that end, the illegality of " stay in " strikes had to be confirmed by the Government, which would take measures to prevent their recurrence in the future, and all Soviet organisations in workshops and factories must be entirely suppressed. This latter demand necessitates an amendment of the Matignan contract relating to the appointment of workshop delegates who are alone authorised by the labour unions to present workers' claims to the management. It was expected that this clause would have offered some safeguard to employers in consequence of precautions taken to ensure a free election by the men, but Communist unions have manipulated the clause in such a manner that they are often able to impose the choice of their own representatives. There has consequently been a rapid extension of Communist organisation in big works. The Lille employers demand that instead of one delegate representing all the workers in a factory, and thereby exercising an authority which is a powerful aid to extremist influence, there shall be delegates representing different categories of workers, or a delegate for each shop, who will be elected under conditions which will ensure that the men are not subjected to outside pressure in their choice. Having obtained satisfaction on these essential points, the Lille employers consented to an advance of 6 per cent. in wages, instead of the 10 per cent. demanded by the men, towards the higher living cost, the extent of which will be ascertained when the usual returns are published. The men accepted all the conditions imposed, and, after evacuation, work at all the factories was resumed.

The Labour Federation.

This success of the Lille textile firms has been obtained with the backing of the newly formed General Confederation of Employers, and the recovery of their authority has seriously perturbed the General Labour Confederation, which is holding a meeting this week to discuss the situation arising out of the amendment of the Matignan contract. The Government committed itself to this amendment in view of the gravity of the industrial situation, and a fear that the Lille conflict would create serious issues and danger in view of the general resistance of the employers. It is probable that the amendment will be slight, although sufficient for the employers to regain their liberty, but the Labour Confederation affects to regard any tampering with the contract as imperilling the men's interests. A stage has now been reached at which the Confédération Générale du Travail will have to make a sharp distinction between Socialist and Communist action, and it is difficult to see how this can be done without a violent split and more agitation before industry can settle down on the basis of the Matignan contract, amended in a way to enable employers to carry on business normally. Employers have the support of a large and growing section of men who are satisfied with what they have got and object to be deprived of work by futile strikes. They are sane enough to see that they have nothing to gain and everything to lose by agitation, and it is believed that there is some sanity in the Labour Confederation where the moderate element is drawing away from the extremists. The Confederation does not represent one-half of the total number of workers, although recognised as completely representative by the Government. Workers outside show increasing discontent at the manner in which industrial activity is disorganised. In the Paris area 3000 engineers, technicians, and foremen have sent a protest to the Government insisting upon the gravity of the situation, and now that employers are organised for the defence of their liberty, and have made it clear that their aim is to make conciliation as easy as possible, there is better prospect of matters righting themselves in the future.

Coal Organisation.

Amongst what may be called the Socialist " key " plans that drift towards a national control of certain industries is the organisation of the coal trade, which was included in the first batch of measures carried through the Chamber of Deputies some weeks ago. As many collieries in the Nord and the Pas de Calais are stated to be working at a loss, it was feared that the raising of wages would have necessitated the closing down of some of them, for which reason the Government elaborated a plan for making good those losses by an additional tax on coal import licences and by creating a comptoir under the direction of the Mines Department for the sale of coal on the home market, including coal imported at the discretion of the comptoir. This comprehensive arrangement for placing the colliery industry and the marketing and importation of coal under the complete control of the Mines Department was rejected by the Senate pending an exhaustive inquiry into the whole situation by the Mines Department and the Ministry of Finance, and the Bill was whittled down to the fixing of coal prices in different districts for a period of three months and the payment of a subsidy to coalowners who work at a loss. Financial inspectors and mining engineers have now been appointed to carry out the inquiry, so that the Senate will probably be able to resume the debate on the Government's proposal during November next.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

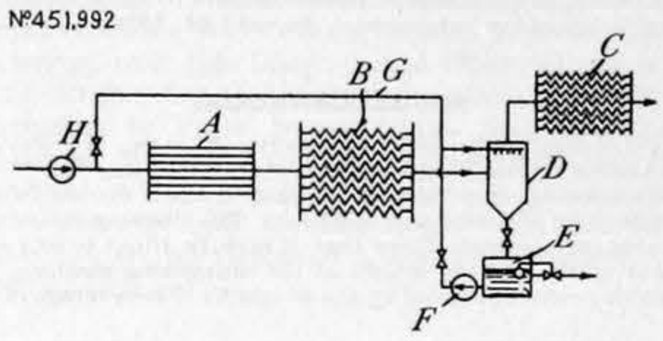
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C.2, 1s. each.

The date first given is the date of application ; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

451,992. August 30th, 1935.—TUBULOUS STEAM GENERATORS, Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt, Germany.

In this steam generator the steam is washed or scrubbed before it enters the superheater. The generator, shown diagrammatically, comprises a radiant heat section A, a convection heat section B, and a superheater C. The steam leaving the

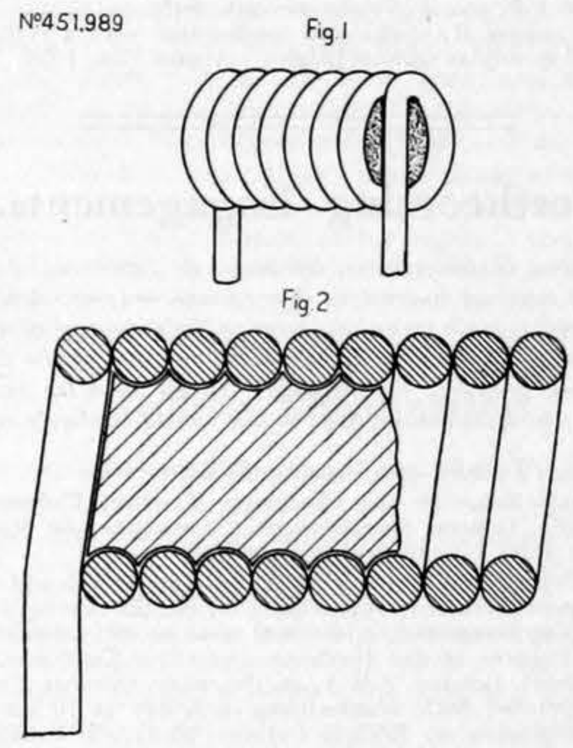


two first sections passes through the cleaning chamber D on its way to the superheater. In this chamber it is subjected to the cleaning action of a spray of water which washes down impurities into the tank E, from which they are occasionally sludged away. The cleaning water is circulated by the pump F and is replaced when necessary by the connection G. H is the feed pump.—*August* 14*th*, 1936.

ELECTRICAL APPLIANCES.

451,989. July 22nd, 1935.—THERMIONIC ELECTRODES, *The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.*

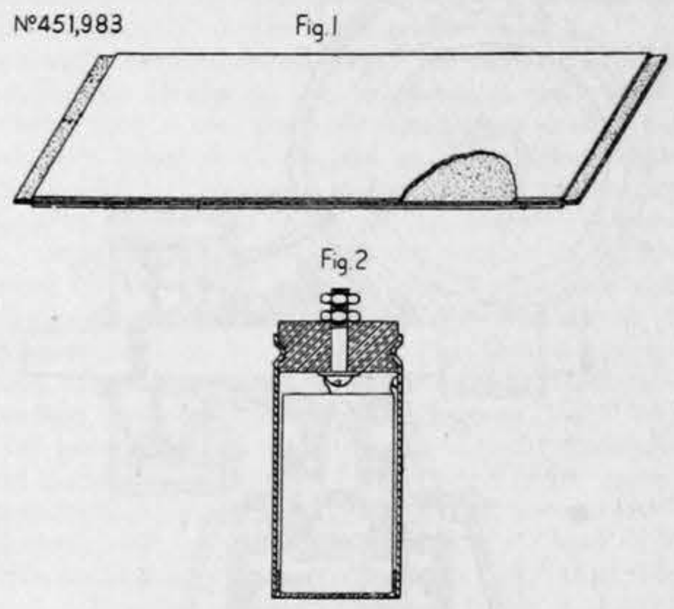
This invention relates to thermionic cathodes, more particularly for electric gas-filled discharge devices carrying current exceeding 1 ampere. According to the invention the manufacture of a thermionic cathode comprises the steps of filling the interior of a helix of a refractory metal with a paste of material of high thermionic emissivity and then heating the resulting body so as to convert the paste into a hard coherent mass. The material of high thermionic emissivity may be a mixture of alkaline earth oxides, or compounds reducible to



oxides, with tungsten powder. If so, it is preferably prepared by sintering the usual mixture of oxides or carbonates with tungsten powder to such a temperature and for such a length of time that a constant volume is obtained, and then grinding the resulting mass. By this means shrinkage during the second step characteristic of the invention is reduced or abolished. The paste may be made with alcohol as the liquid constituent. The helix is preferably of tungsten and is close wound, so that there are no intentional gaps between the turns. The heating and sintering step is preferably conducted in an oven filled with a neutral or reducing atmosphere at a temperature of at least 1700 deg. Cent. Fig. 1 is a perspective view, and Fig. 2 is longitudinal section on a larger scale.—*August* 14*th*, 1936.

451,983. June 13th, 1935.—ELECTRICAL CONDENSERS, *The Plessey Company, Ltd., Vicarage-lane, Ilford, Essex.*

This invention relates to electrical condensers of the electrostatic type. The general object is to provide such a condenser in a compact form, suitable for operation at high voltage and having a high capacitance in units of the same volume. The invention consists in a dielectric spacer for electrostatic condensers comprising a non-fibrous cellulose sheet having incorporated therein a water-free ester of a polyhydric alcohol of the class comprising glycols and glycerols, for example, triacetin. Referring to the drawings, Fig. 1 is a perspective view, partly broken away, showing a flat-plate condenser, and Fig. 2 is a vertical sectional view of an arrangement showing a rolled condenser within a protective housing. The cellulose is preferably impregnated or plasticised by washing the sheet in a pure alcohol or amyl acetate mixture of one of the dielectric materials above mentioned. When thus treated, a definite change in physical structure is noted. The sheet becomes soft and stretchable, and also maintains a tacky condition. Where " cellophane " is used, care must be exercised to prevent moisture absorption. After the cellulose spacer is impregnated, preferably by passing a thin sheet, about 0·4 mm. thick, through a bath of one of the mixtures, it goes through a pair of drying rollers which takes off the excess material. The length of time of immersion is dependent upon the concentration, temperature, and solvent action of the materials used. With certain materials the use of the amyl acetate or alcohol may be dispensed with. The condenser may be made by rolling a conductor, such as 0·0025in. aluminium foil, on each side of the plactisised cellulose material and then winding up into a tight roll, an extra sheet of dielectric material being interposed to prevent short circuiting of electrodes when wound. Plain or oxidised aluminium may be used. After being wound into shape, the condenser is placed

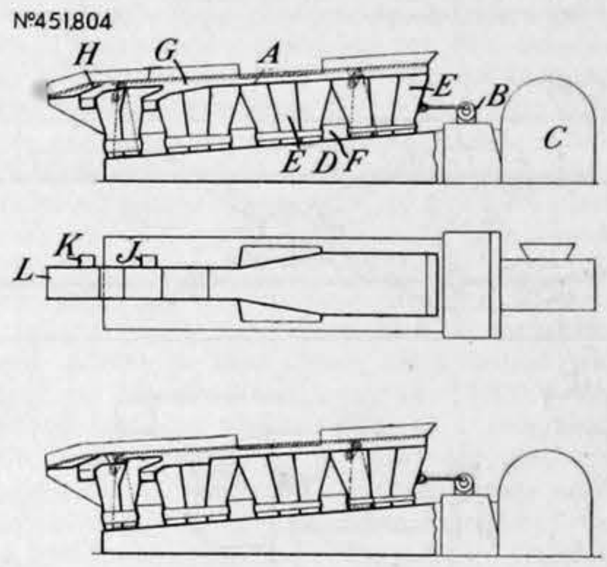


in a low-pressure heated chamber to release any volatile matter, and the entire unit is covered with a waterproof compound. Because of its non-fibrous uniform dielectric spacer, the condenser will withstand a higher voltage than condensers of the fibrous spacer type.—*August* 14*th*, 1936.

MINING MACHINERY.

451,804. February 29th, 1936.—COAL SEPARATORS, W. Barker, Shooters Hills, near Longton, Stoke-on-Trent.

This is a machine for separating coal from dirt and shale, operated on the pneumatic principle. The rough coal is supplied to the sloping deck A, which is jigged by the mechanism B, at its upper end. Through this bed there is blown a current of air by the fan C, the duct D, and the uptakes E E. Flexible con-

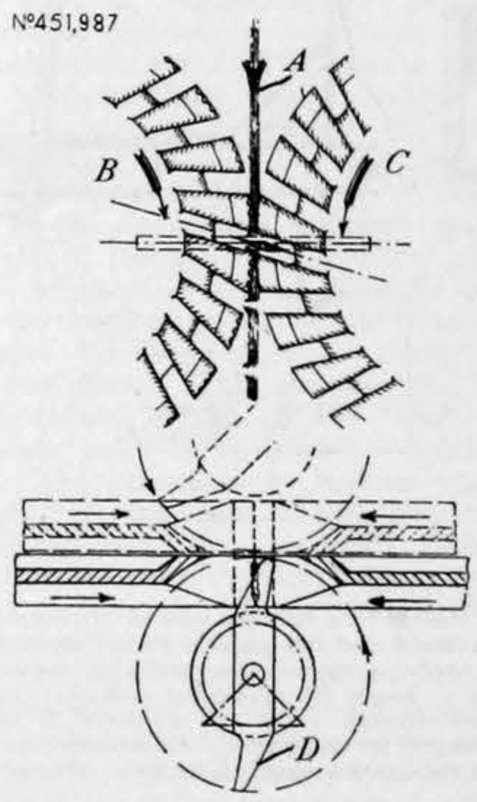


nections are provided at F. The deck is constricted towards the middle, as shown in the plan view. The action of the air blast and the jigging stratifies the coal and the dirt and the former falls over the sides at the restricted part of the deck. The dirty stuff goes on and meets the two slicing plates G and H, which divert the shale in two grades into the side shoots J and K, while the fines go over the end at L.—*August* 12*th*, 1936.

MACHINE TOOLS AND SHOP APPLIANCES.

541,987. July 10th, 1935.—CUTTING THREAD-LIKE BODIES INTO STAPLES, K. Grunert, 4 Lutherplatz, Zittau in Saxony, Germany.

This is a machine for cutting fibres into standard lengths, or staples, at a high speed. The fibres are delivered into the vertical guide A from a conveyor, and are gripped by the feed



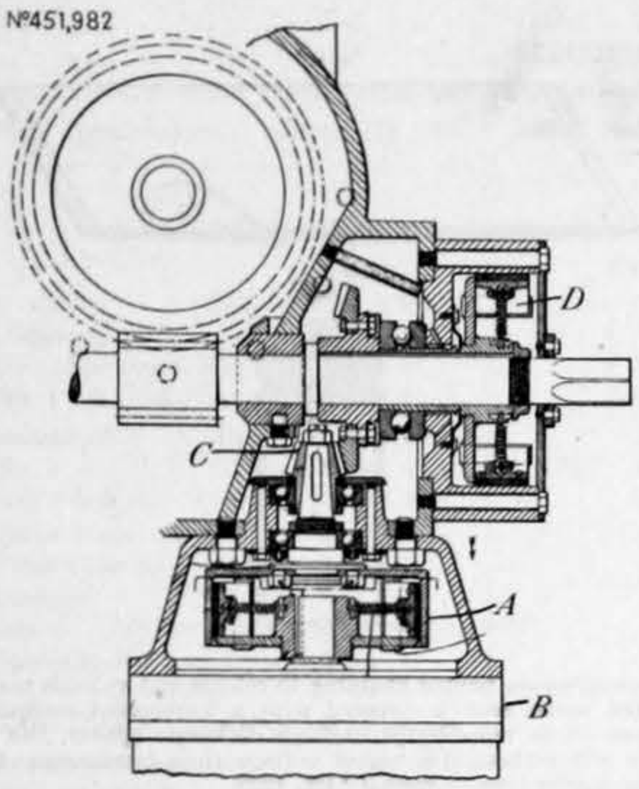
rolls B and C. Both these rolls have inserted teeth, those on B being serrated and those on C rubber covered, so that they grip the fibres firmly. In a plane at right angles to the feed rolls there rotates a two-bladed knife D, which is so geared that it passes between the gaps between the feed roll teeth and severs the fibre.—*August* 14*th*, 1936.

SHIPS AND BOATS.

451,982. May 25th, 1935.—PAYING OUT GEAR FOR SHIPS' DAVITS, H. G. Taylor, Ridgway, Lower Penn, near Wolverhampton.

The inventor explains that a ships' boat is usually lowered away at a much greater speed than that at which it is hoisted aboard again. As a consequence, there is a liability for the motor driving the winch to be damaged by overspeeding during

lowering. So he introduces a centrifugal friction clutch A between the motor B and the gearing C of the winch. This clutch only comes into operation when the motor attains a

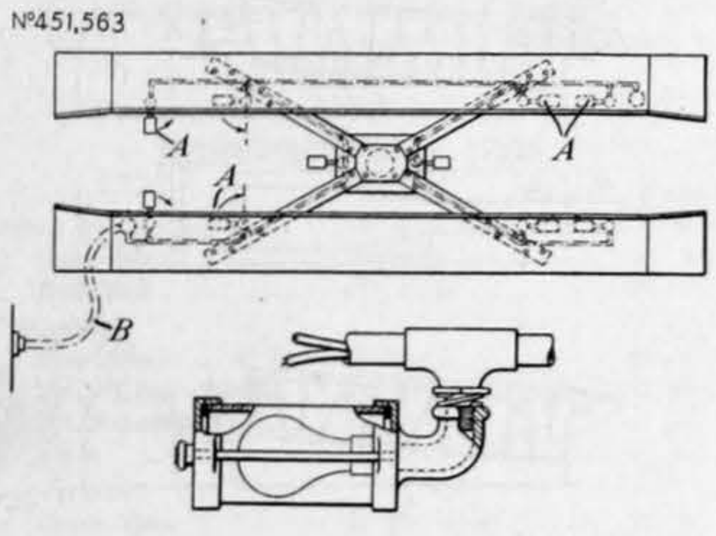


predetermined speed; when the current is cut off, so that the motor stops, it is entirely free. The boat is then lowered under the control of the centrifugal brake D.—*August 14th*, 1936.

MOTOR CARS AND ROAD TRAFFIC.

451,563. December 11th, 1935.—MOTOR VEHICLE HOISTS, J. D. Handley, Hilbre-street, Liverpool, 3.

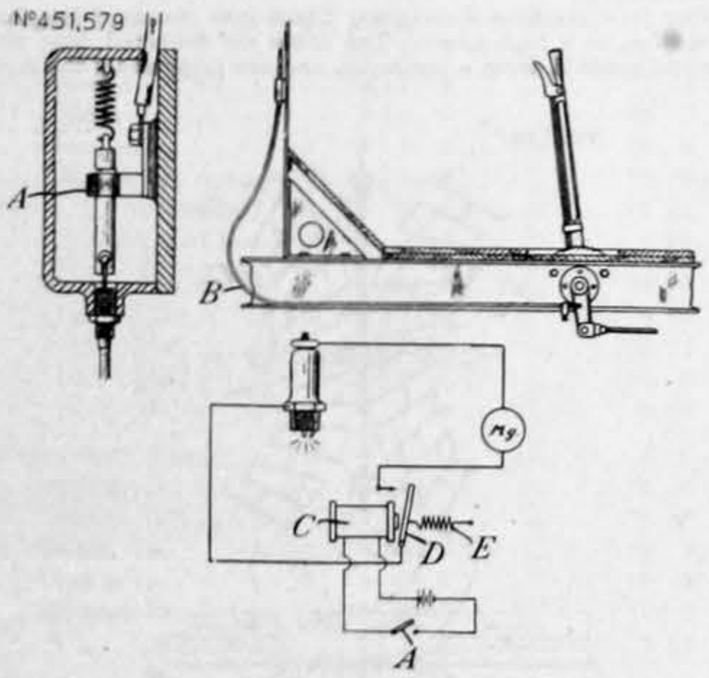
The idea is properly to illuminate the underside of a motor car raised on a lift so that it can be thoroughly inspected. The lift is of any normal design and is equipped with electric lamps



at such points as A A A. The lamps are held in brackets as shown in the detail sketch, so that they can be swung round and are wired in parallel. The supply lead is shown at B.—*August 7th*, 1936.

451,579. December 7th, 1934.—CONTROL GEAR FOR CAR ENGINES, S. S. Guy, Sauchieleigh, Albrighton, Wolverhampton.

This is an arrangement for automatically stopping the engine of a car which has been left with the engine running after a predetermined time. A plunger switch A is connected with the



brake lever of the car by a Bowden wire B. In normal running this switch is closed and the ignition circuit is complete. If, however, the brake is applied the switch is opened and the electro-magnet C looses its energising current. Its residual magnetism, nevertheless, holds the armature D against the pull of the spring E for some time. Eventually, the armature is released and the ignition circuit is broken.—*August 7th*, 1936.

METALLURGY.

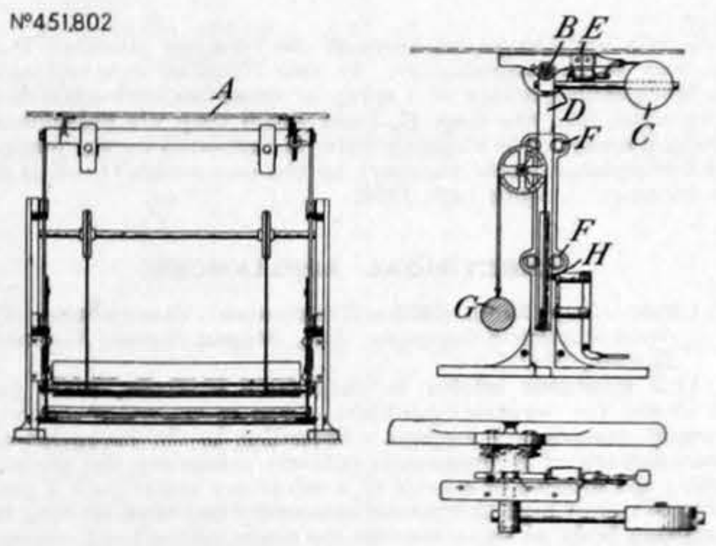
451,981. May 21st, 1935.—A PROCESS FOR RECOVERING VANADIUM FROM SUBSTANCES OF POOR VANADIUM CONTENT, O. Jochem, Greiz-Dölau, Germany.

It has been found that it is possible to recover vanadium as alkali vanadate, both from the lye produced by smelting or roasting the substances containing a very small percentage of vanadium, with sodium carbonate (soda ash) and subsequent lixivation or leaching, and also from the lye obtained by decomposition with sodium carbonate or caustic hydrate of soda (NaOH) under pressure in an autoclave, at a certain degree of concentration of alkali aluminate (to render possible the precipitation on cooling), and in the presence of an excess of alkali by cooling to a certain temperature in the presence of alkali phosphate and arsenate. The precipitate is enriched to such a degree that it pays to work it up further. Since Al_2O_3 is present, sodium aluminate is formed with sodium carbonate or NaOH. The surplus alkali is suitable for keeping the alumina in solution and to prevent the alumina from precipitating. The process itself, according to the present invention, is the following, viz.:—The ore or the slag or other suitable crude substance, such as, for instance, bauxite, which contains vanadium, is smelted or melted with an alkali carbonate or decomposed in a pressure vessel or autoclave with an alkali-hydroxide or an alkali carbonate or a mixture of these two substances. The alkaline extract thus obtained contains the vanadium as sodium vanadate. At the same time if phosphorus and arsenic were present in the raw material, these substances are found now in the solution obtained, as sodium phosphate and sodium arsenate. From the alkaline solution there are then precipitated at a concentration of 20–40 deg. Beaumé and a cooling down of the lye to approximately 10–15 deg. Cent., sodium vanadate, sodium phosphate, and sodium arsenate, which now only contain a very small amount of alkali aluminate and some sodium carbonate or common soda as impurities. The salt thus precipitated has a concentrated content of vanadium of 4 to 8 per cent. The presence of phosphates and arsenates is essential to precipitate the double salt on cooling. It is thus, for instance, possible in this manner to leach from a bauxite (crude alumina), having a content of only 0·02 to 0·03 per cent. of vanadium, the vanadium up to 80 per cent. of the total amount present, and then to precipitate it. In case the raw material used contains no phosphorus or arsenic at all, it will be found necessary to add suitable quantities of these elements to it, to favour the precipitation of the vanadium.—*August 14th*, 1936.

MISCELLANEOUS.

451,802. May 14th, 1935.—DRAWING TABLES, W. Mavitta, Anchor Works, Park-road, Aston, Birmingham.

This drawing-office table is specially devised for use in conjunction with a draughting machine. The drawing board A is mounted on a spindle B, so that it may be tilted to any convenient angle, and the weight of the draughting machine (not shown) is counterbalanced by the weight C. The leverage of this



weight can be adjusted. The angular position of the board is held by the toothed quadrant D and spring-controlled pawl E. The standards for the board can slide vertically between the guide rolls F F, and its weight is counterbalanced by G. A foot-operated trigger H, working in conjunction with a rack, holds the board steady as regards height.—*August 12th*, 1936.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY AND SATURDAY, SEPT. 26TH.

FARADAY SOC.—In the Chemistry Theatre, University of Edinburgh. General discussion on "Structure and Molecular Forces in Pure Liquids and in Solutions."

IRON AND STEEL INST.—Autumn meeting in Düsseldorf. In order to provide further opportunity for the discussion of papers presented at Düsseldorf, additional sessions will be held in the Lecture Theatre of the Institution of Civil Engineers, Great George-street, London, S.W.1, on Thursday, October 29th, and Friday, October 30th, commencing each day at 10 a.m. The afternoon session on Friday, October 30th, will constitute a joint meeting with the Institute of British Foundrymen. For programme, see page 84.

"MODEL ENGINEER" EXHIBITION.—Royal Horticultural Hall, Westminster, S.W.1. 11 a.m. daily.

THURSDAY, OCT. 1ST.

INST. OF METALS.—James Watt Memorial Institute, Birmingham. Birmingham Local Section joint meeting with the Iron and Steel Institute. "Strip Sheet Production," G. A. V. Russell. 7 p.m.

TUESDAY, OCT. 6TH.

INST. OF MARINE ENGINEERS.—85, The Minories, London, E.C.3. Presidential address. 6 p.m.

WEDNESDAY, OCT. 7TH.

LIVERPOOL ENGINEERING SOC. (INC.).—9, The Temple, Liverpool. Presidential address. 6.30 p.m.

THURSDAY, OCT. 8TH.

RAILWAY CLUB.—Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Some British Railway Accidents," Mr. H. W. Bardsley. 7.30 p.m.

ROYAL AERONAUTICAL SOC.—Royal Soc. of Arts, 18, John-street, Adelphi, W.C.2. "Aerodynamics and Structural Features of Tapered Wings," Dr. G. V. Lachmann. 6.30 p.m.

FRIDAY, OCT. 9TH.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, S.W.1. "Aircraft Accidents: Their Causes and Prevention," an informal meeting introduced by M. L. Bramson. 7 p.m.

INST. OF METALS: SHEFFIELD LOCAL SECTION.—Non-Ferrous Section of the Applied Science Department of the University, St. George's-square, Sheffield. "The Trend of Research in Non-ferrous Metallurgy," Chairman's address by Professor J. H. Andrew. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, London S.W.1. "The Microscope in Engineering and Industry," Mr. A. E. Bingham. 7.30 p.m.

MONDAY, OCT. 12TH.

INST. OF METALS: SWANSEA LOCAL SECTION.—Y.M.C.A., Swansea. "Some Objectives of Corrosion Research," G. D. Bengough. 6.30 p.m.

INST. OF TRANSPORT.—At the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Presidential address by Sir Alfred Read. 5.30 p.m.

TUESDAY, OCT. 13TH.

INST. OF METALS: NORTH-EAST COAST LOCAL SECTION.—Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne. "Solders," Chairman's address by H. Dunford Smith. 7.30 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—Works visit to Babcock and Wilcox, Ltd., Dumbarton. 7.30 p.m.

WEDNESDAY, OCT. 14TH.

INST. OF SANITARY ENGINEERS.—Caxton Hall, Westminster, S.W.1. "Recent Workings of Sludge Digestion Plant at Sittingbourne," Mr. M. W. Lashmar. 6 p.m.

THURSDAY, OCT. 15TH.

INST. OF FUEL.—Inst. of Mechanical Engineers, Storey's-gate, S.W.1. Presidential address by Sir John Cadman. 2.30 p.m. Melchett Lecture by Prof. Dr. Franz Fischer. 3.30 p.m. Annual dinner and dance at the Connaught Rooms, Great Queen-street, W.C.2, at 6.45 p.m.

INST. OF METALS.—National Physical Laboratory, Teddington. "The Common Field of the Engineer and Metallurgist," H. J. Gough. 7.30 p.m.

FRIDAY, OCT. 16TH.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, London, S.W.1. "Monolithic Furnace Construction," Mr. J. Duguid. 7.30 p.m.

TUESDAY, OCT. 20TH.

INST. OF MARINE ENGINEERS.—85, The Minories, London, E.C.3. "The Burmeister and Wain Two-stroke Cycle Engine," Dr. H. H. Blache. 6 p.m.

INST. OF TRANSPORT.—At the Institution of Electrical Engineers, Victoria Embankment, W.C.2. "Road Transport Statistics," Mr. A. E. Kirkus. 6 p.m.

WEDNESDAY, OCT. 21ST.

LIVERPOOL ENGINEERING SOC. (INC.).—9, The Temple, Liverpool. "The Oswestry Booster Plant on the Vyrnwy Aqueduct," Mr. F. H. Auger. 6.30 p.m.

LAUNCHES AND TRIAL TRIPS.

QUEEN VICTORIA, motor ship; built by Barclay Curle and Co., Ltd., to the order of Thos. Dunlop and Sons; dimensions, length 431ft. 6in., breadth 55ft., depth 37ft. 6in., 9200 tons deadweight. Engines, three-cylinder opposed-piston oil; launch, September 15th.

BRISBANE STAR, motor ship; built by Cammell Laird and Co., Ltd., to the order of Blue Star Line, Ltd.; Dimensions, length 522ft. 5in., breadth 70ft., depth 43ft. 4in. Engines, two Sulzer single-acting, two-stroke, ten-cylinder oil; launch, September 16th.

BRITISH POWER, motor ship; built by Harland and Wolff, Ltd., to the order of British Tanker Company, Ltd.; dimensions, 463ft. by 61ft. 6in. by 34ft. Engines, six-cylinder four-stroke oil. Launch, September 16th.

ESSEX, motor ship; built by John Brown and Co., Ltd., to the order of New Zealand Shipping Company, Ltd.; dimensions, length 530ft., breadth 70ft., depth 47½ft., gross tonnage about 11,000. Engines, two Brown-Doxford opposed-piston oil, each 6500 H.P. at 120 r.p.m.; launch, September 17th.

WALMER CASTLE, motor ship; built by Harland and Wolff, Ltd., to the order of Union Castle Mail Steamship Company, Ltd.; dimensions, 246ft. by 39ft. by 22ft. Engines, two-stroke airless injection oil. Launch, September 17th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE PHOSPHOR BRONZE COMPANY, Ltd., has removed to larger offices at 54, St. Thomas's-street, Borough, London, S.E.1.

TIME SWITCHES AND INSTRUMENTS, Ltd., 120, Victoria-street, Westminster, London, S.W.1, inform us that, as from September 21st, the sale of time switches previously conducted by the Stonebridge Electrical Company, Ltd., has been transferred to it.

THE JOHN THOMPSON ENGINEERING COMPANY, Ltd., Wolverhampton, has taken over Triumph Stoker, Ltd., of Leeds, manufacturers of all types of mechanical stokers, elevators, and conveyors. The company will still operate as Triumph Stoker, Ltd., at its present address at Kirkstall-road, Leeds, and the existing staff and employees will be maintained.

STELCON (INDUSTRIAL FLOORS), Ltd., is the name of a company which has been formed for the sale in Great Britain and overseas of Stelcon anchor steel plates and Stelcon steel-clad flags, which for the past ten years have been handled by Langley London, Ltd., of 161, Borough High-street, London, S.E.1. The address of the new company is Cliffords Inn, London, E.C.4. Mr. F. A. Langley and Mr. T. Kilburn are directors of the company.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

INTERNATIONAL COMBUSTION, Ltd., has received an order for sixteen "L" stokers, sixteen air heaters, and Ash-handling plant for the Greenwich power station of the London Passenger Transport Board from Yarrow and Co., Ltd. "L" stokers are already in operation at this station, and this order brings the total to twenty-six. Each stoker will be 10ft. 6in. wide by 19ft. long, giving a grate area of 199 square feet, making the "L" stoker grate area 5262 square feet at this station. The ash-handling plant will be an extension to the existing ash conveyor.

CROMPTON PARKINSON, Ltd., has secured the contract for the electrical equipment of the new mill at Warrington for Thames Board Mills, Ltd. This contract covers high and low-tension switchgear and transformers for the power station, with motors for driving auxiliary plants. The mill equipment will consist of specially designed high and low-tension truck type cubicles, power transformers, and lighting transformers. In all there will be about sixty high-tension motors of 100 B.H.P. and upwards, the majority of these machines being of the Crompton patented auto-synchronous type. Other machines will comprise slip-ring motors, direct-current variable-speed motors, and the whole of the motors for about twenty-seven cranes.