A Seven-Day Journal

Engineering Centre, Glasgow: New Developments

THE new conference and coffee room which has just been opened at the Engineering Centre, Sauchiehall Street, Glasgow, marks a further addition to the many amenities of this Centre for visitors to the Clyde industrial area. The room has been provided by Wylie and Lochhead, Ltd., of Glasgow, a well-known firm of ship furnishers, as a demonstration of the firm's craftmanship and artistic work. The room is pannelled in walnut with a zebrano banding. There are three tiers of panels extending around the room, which is furnished with chairs and small tables. An interesting feature of the new installation is the use of low-temperature electrically-heated panels for space heating. The heating installation has been carried out by Wylie and Lochhead, in conjunction with Richard Crittall and Co., Ltd., a firm which supplied the "Medrae" elements, these being generally similar to "Dulrae" elements except that they can be operated at a somewhat higher temperature. The heating elements are placed in the lower tier of panels and comprise 36in by 24in heating panels installed in wall recesses 42in by 27in. Heat loss to the walls is controlled by an insulating material placed between the panel and the face of the wall. For covering the heating panel a special type of wallboard has been used, which is polished and is more durable than the usual type of fibrous wallboard. To this board the walnut veneer was glued under pressure and the completed panel, with the heating element behind the front veneer panel, is mounted flush with the other decorative panels. The cables supplying power to the heating units are led up through the floor and are completely hidden. The room measures about 35ft by 15ft and the total heating load is 7kW. The amount of heat is controlled by thermostats on three separate circuits. The new exhibits at the Centre include two engines demonstrating starting by I.C.I. power cartridges, and a stand for the National Physical Laboratory, which will be opened soon by the Department of Scientific and Industrial Research.

Britain's Second Atomic Pile

IT is announced by the Ministry of Supply that on Saturday, July 3rd, Britain's second atomic pile, the new large Harwell pile, began operation at low power. It will be recalled that in August last the first pile, the "Gleep," was put into operation. The Harwell pile has a rated output of 6000kW and although experimental in character, it has been designed to produce by the transmutation of inactive elements all of the artificial radioactive isotopes required in this country by medical and other research workers. It is a graphite-moderated, air-cooled pile, the cooling air being drawn in through channels by electrically driven exhausters. The whole pile is surrounded by a concrete shield several feet in thickness to protect the workers from radiations, and the cooling air is discharged from a 200ft high chimney stack. The protective shield is pierced by holes, which can be plugged when not needed. Through these holes the inactive elements are placed within the pile for transmutation into radioactive isotopes. Surrounding the pile are the control rooms and the laboratories used by the scientific and operating staff. The operation of the pile is controlled by two sets of neutron-absorbing rods, which can be pushed in and out of the pile. The first set of rods is used to keep the pile operating at a constant power level, while the second set is available for shutting down the pile should any emergency occur. The basic calculations for the Harwell pile were begun in 1945, and work on the design was started in April, 1946. In June, 1946, the first ground was broken by the contractors, W. E. Chivers and Sons, Ltd. The pile is built in an ex-R.A.F. hangar at Harwell, and it was necessary to raise part of the roof by means of a Bailey bridge erected over the hangar during the work of excavation. The Royal Ordnance Factories and the Royal Dockyard at Devonport manufactured components and fabricated and erected the main steelwork. Special workshops were set up at Harwell for machining the graphite blocks, and the uranium metal was furnished by the Imperial Chemical Industries Rocksavage factory, and the Ministry of Supply factory at Springfields. By the co-operation of scientific and technical workers, both Government and private, it has been possible to start in operation this highly complex pile only two years after work was first begun.

The Stringfellow Centenary

AT Chard, in Somerset, there was celebrated at the week-end, July 2nd and 3rd, the hundredth anniversary of the first free flight of a power-driven model monoplane. It had been designed by John Stringfellow, the successful flights taking place in a disused lace factory at Chard during June, 1848. At the celebration dinner on Friday, July 2nd, over which the Mayor of Chard, Alderman Dr. A. E. Glanvill, presided, there were present Dr. Roxbee Cox, the President of the Royal Aeronautical Society, and Sir Frederick Handley Page, its Past-President, along with a granddaughter and great-granddaughter of the inventor. On the Saturday morning an official pilgrimage of remembrance, headed by the Mayor, was made to Chard Churchyard, where wreaths, one of which was from the Royal Aeronautical Society, were laid on Stringfellow's tomb. The pilgrimage was continued to the house in High Street, where Stringfellow lived and worked. A plaque was placed on the wall of this house some forty years ago. The celebration closed with a centenary dance on Saturday evening at the Town Hall. During the week-end there was staged in the Town Hall a small exhibition of model aeroplanes, including a replica of Stringfellow's successful model, and copies of a life-sized reproduction of the inventor's portrait were displayed in prominent parts of the town. A souvenir brochure has been issued by the Stringfellow Centenary Committee, of which Mr. F. W. Searle, the Town Clerk, has acted as hon. secretary. It may be recalled that some account of the work of Henson and Stringfellow was given in our columns on August 17, 1945. On Monday, July 5th, an exhibition of experimental apparatus and literature bearing on the work of Henson and Stringfellow was opened at the Science Museum, South Kensington, and will remain open for one week.

Completion of the Manchester-Sheffield Electrification Scheme

SIR CYRIL HURCOMB, the Chairman of the British Transport Commission, during his tour of the Eastern Region of British Railways, made an announcement at Sheffield, on Tuesday, July 6th, on the progress being made with the electrification of the Manchester-Sheffield-Wath lines. The project was (he said) decided upon before the war, and it covered 75 route miles, representing some 330 single-track miles, and when it was completed, in December, 1952, all classes of passenger, goods and mineral trains would be worked by electric traction, the use of steam locomotives being confined to shunting in marshalling yards and concentration sidings. The overhead system of power transmission using 1500-V d.c. will be employed. The completion of the electrification will be carried out in four stages. It is expected to introduce electric traction between Wath and Dunford in March, 1951, and in March of the following year to bring it into operation from Dunford to Manchester (London Road), including the new repair depot and car sheds at Reddish. The third and fourth stages, which include Sheffield to Barnsley Junction and Levenshulme to Manchester (Central), will, it is expected, both be completed in December, 1952. The scheme will cost over £6,000,000 and will save, it is hoped, 100,000 tons of coal per annum.

International Commercial Motor Transport Exhibition

IT is announced by the Society of Motor Manufacturers and Traders that the notable series of exhibitions held in London will be revived by the first holding of the International Commercial Motor Transport Exhibition at Earl's Court, from October 1 to 9, 1948. The exhibition, which will be the fourteenth biennial event of this kind, started in 1907, will be larger than all its predecessors, both in regard to the number of exhibitors and the range and variety of its exhibits. In all, the products of some 420 manufacturers are to be displayed, which will include motor chassis builders, body builders and trailer manufacturers. In the accessory and component section 200 manufacturers will be represented along with tyre makers and makers of transport service equipment. Many of the exhibits will represent designs specially produced for export trade, and every form of prime mover, including petrol and diesel engines, electric trolley and battery-operated vehicles. The transport vehicles will include models designed to carry a range of loads between 11 cwt and 22 tons, and for passengers from four to fifty-six persons. Special-duty types for municipal and public utility services will be on view, with trailers having capacity ranges from 5 cwt to 60 tons. In the auxiliary sections of the exhibition a complete range of constructional, maintenance and repair materials, accessories, components and equipment for workshops and garages will be shown. The organisers of the exhibition are willing to provide special facilities for visitors from overseas, and such visitors are asked to apply to the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1.

Ministry of Fuel and Power Scientific Advisory Council

IN a Journal note of June 25th we recorded the appointment of Sir Alfred Egerton, F.R.S., Professor of Chemical Technology at the Imperial College of Science, and Secretary of the Royal Society, as Chairman of the Scientific Advisory Council which has been set up to advise the Minister of Fuel and Power on the scientific aspect of his duties. The names of the members of the Committee appointed by the Minister are as follows:—Engineer Vice-Admiral Sir Harold Brown, Engineer-in-Chief of the Fleet at the Admiralty from 1932 to 1936, and Chairman of the Fuel Research Board; Dr. H. Roxbee Cox, M.I. Mech. E., F.R.Ae.S., Chief Scientist of the Ministry of Fuel and Power; Sir Charles D. Ellis, F.R.S., Scientific Director of the National Coal Board; Professor F. H. Garner, Ph.D., M.I. Mech. E., Professor of Chemical Engineering, Birmingham University; Sir Charles Goodeve, F.R.S., Director of the British Iron and Steel Federation; Dr. E. S. Grumell, M.I. Mech. E., Chairman of the Fuel Efficiency Committee of the Ministry of Fuel and Power; Mr. J. Hacking, M.I.E.E., Deputy Chairman of the British Electricity Authority; Dr. H. Hollings, Chairman of the Gas Research Board; Professor D. M. Newitt, of the Imperial College of Science and Industry; Sir Harry Ricardo, F.R.S., M.I. Mech. E., consulting engineer; and Professor S. Zuckeman, F.R.S., Professor of Anatomy in the University of Birmingham. The work of the Council will include the advising of the Minister with regard to the development of the coal, petrol and other fuel sources in Great Britain, and in promoting economy and efficiency in fuel supply, distribution and consumption.

Water Supply of Greater London

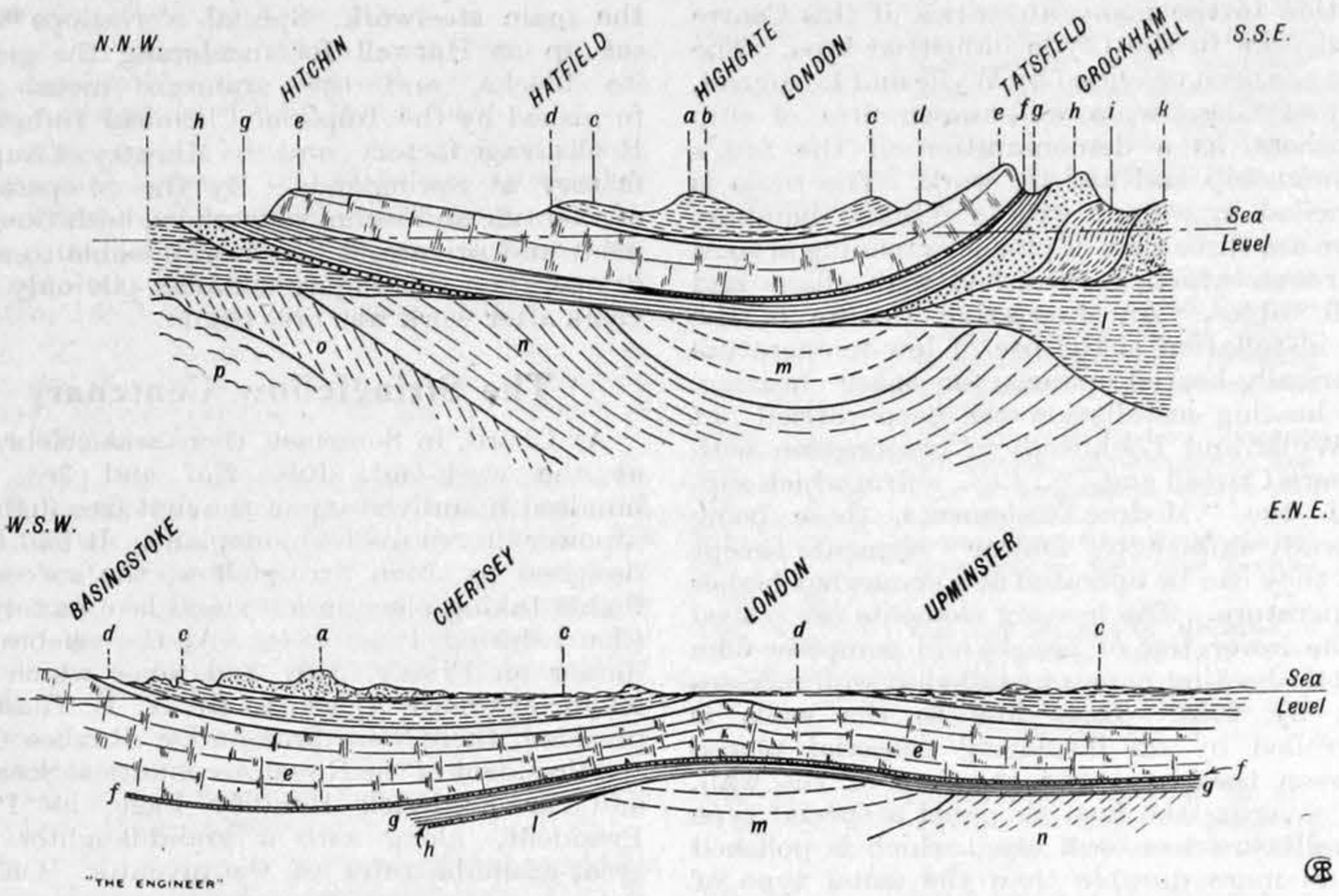
No. I

IT is safe to say that the site on which the original settlement of London was made was chosen or at least decided upon largely because of its water supply. As in the case in other parts of the world, a site sufficiently far up a river estuary to ensure safe harbourage and anchorage for shipping was requisite ; in the case of the Thames no site nearer the sea afforded sufficiently high ground above the neighbouring marshes coupled with that desideratum, a supply of clear water. Another important factor in its location was that this was the nearest convenient point to the sea where the river was fordable, whence it became in neolithic times the ganglion of a number of trackways. We know little of London before the Roman occupation 55 B.C., but we can envisage it as a fishing hamlet on the high ground where the Tower now stands and supplied with clear water from the Walbrook. Early in the Roman period it was realised that Londinium, because of the ford and converging trackways, was a strategic point ; consequently, it was fortified and became a walled city. Clearly the natural water supply proved adequate for the inhabitants, otherwise the Romans, as was their normal practice, would have added to it by an aqueduct as in others of their cities in Britain, e.g., Uriconium. No trace, however, of one in London has been found and historical records are silent on the matter.

To recapitulate, the site pitched upon for what is now the City of London is on the banks of a broad tidal estuary. This fact needs to be emphasised because tidal power was the main resource for actuating pumps in quite a number of installations during a period lasting for 250 years. The estuary is within 50 miles of the sea, in a valley into which descended from the north and from the south many a stream now forgotten or remembered only in place names, on a healthy gravel soil above surrounding marshes, and in a basin interspersed with beds of clay resting on a substratum of chalk. The supply of water was obtained from the River Thames supplemented by that from its tributary streams, from shallow wells sunk in the gravel near the river, and from springs at a further short distance away. Thus, every need was supplied from the time of the earliest settlement, during the Roman period of occupation until their withdrawal round about 400 A.D., during the reoccupation of the site from 200 years later, and onwards by the Saxons (for they were not an urban-minded folk), till the Norman invasion, when London finally replaced Winchester as the capital of England. In all this long period nothing further in the way of water supply was called for.

The situation of London, advantageous as, indeed, it is, based upon topographical considerations, has other advantages, however, than those already enumerated, and these arise from its geological situation, not that this affected supply in the earliest days, but in recent centuries it has served to amplify the supply materially. This is not the place to go deeply in any detail into its geological aspects, but the main outlines may be recapitulated in general terms. Fig. 1 shows[1] the surface geology—the extent and distribution of the alluvial or drift deposits of mud, sand and gravel over the area, but more especially the natural drainage and watercourses. Fig. 2 gives a section to scale across the London basin of the stratified geology. roughly N.N.W. to S.S.E., about 70 miles, while Fig. 3 gives a similar section across the basin from W.S.W. to E.N.E., rather greater in distance, i.e., 96 miles. In both cases the vertical scale is exaggerated about 1 : 35. The run-off is what fed the tributary streams already mentioned. The rainfall percolates through the drift deposits and meets the London clay ; this being impermeable, the top stratum acts as a reservoir, and as no evaporation can take place the water issues as springs at the junction of the gravel and the clay, thereby adding to the tributary streams. Where the drift deposits extend to a depth below the river level, water is everywhere to be found and was tapped by sinking wells. By constant drawing of water from these a reverse flow from the river through the gravel can and does occur with the benefit of intermediate filtration. Indeed, this method of obtaining clear water has been taken advantage of on a large scale higher in the Thames Valley, for example, at Hampton and at other localities still further up.

In this way began what may be termed an intermediate stage of supply by wells and by conduits from springs within the populated areas. With the extension of population involving the covering of more and more of



FIGS. 2 AND 3—SECTIONS ACROSS LONDON BASIN

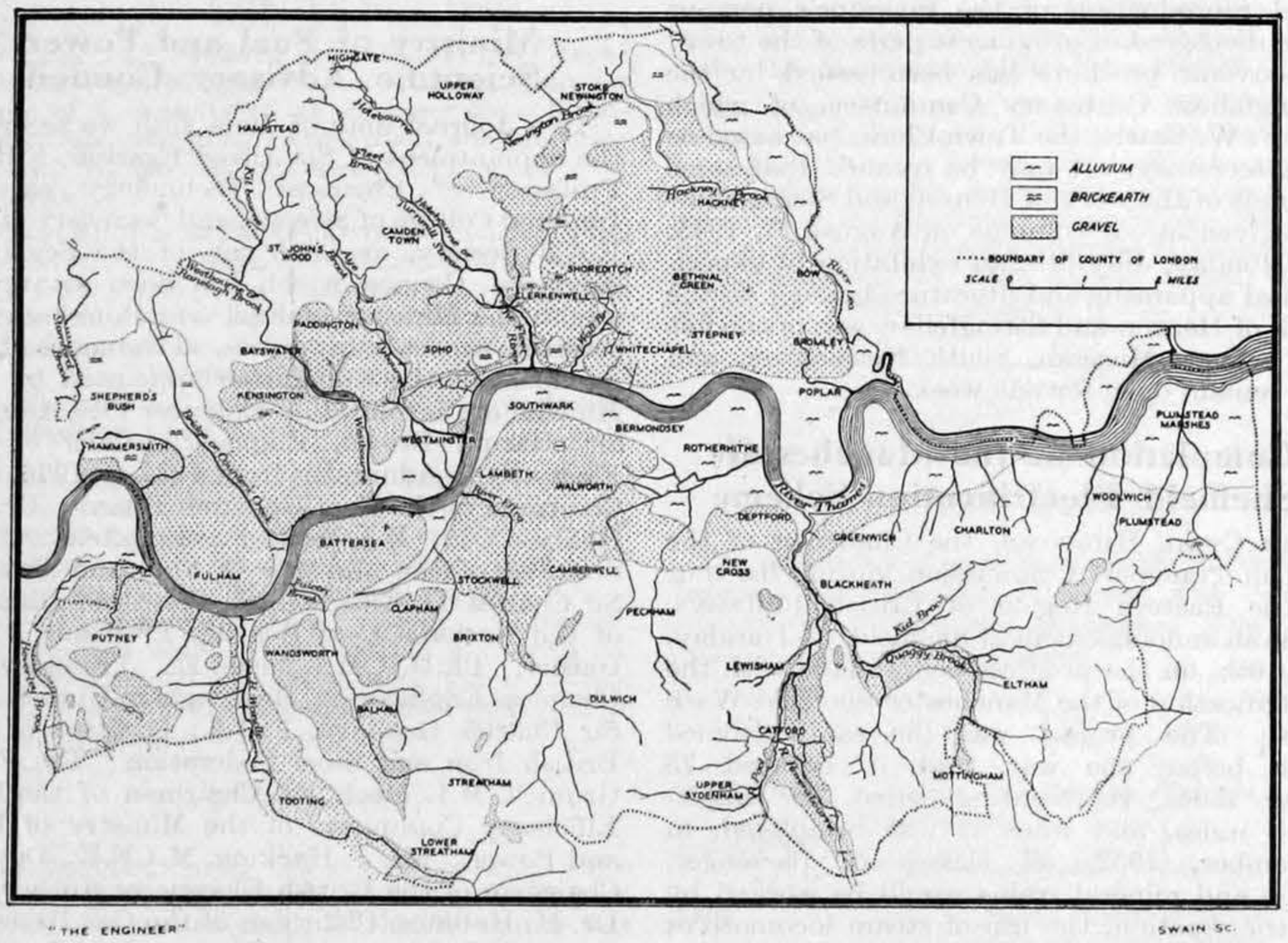


FIG. 1—DISTRIBUTION OF DRIFT AND NATURAL DRAINAGE

[1] *Cf.* " Water Supply of the County of London," H.M. Geological Survey, 1937.

the catchment area with dwellings and involving pollution of the water by cesspits and cemeteries in the gravel, most of these sources had to be abandoned. By the thirteenth century supplies had to be drawn from springs and wells outside the populated area, e.g., from Tyburn, 1237 ; from Paddington, 1440 ; from Hackney, 1559 ; and from Hampstead, 1589. This interesting period will be treated in detail later. Such supplies suffered in dry weather and were irregular ; eventually, in any case, they became insufficient for the population that had been increasing slowly during the Middle Ages. During all this time water was being obtained from the Thames by water bearers, but this was a laborious, inefficient and unsatisfactory method, so that a limit might well have been placed upon further extension of population in the area.

However, during the fifteenth and sixteenth centuries great advances were made in the mechanic arts, providing among many other steps in progress the means to pump water from ground level to a high head, first by the aid of animal and by water power, and later, from great depths as well as to great heights, by energy derived from coal.

Pumping from deep wells in the tertiary beds was a stage that has now almost passed and was succeeded early in the nineteenth century by sinking wells into the chalk formation. This, as will be gathered from Figs. 4 and 5, showing the standing water levels in the chalk in 1878 and 1936 respectively, is a bed from 550ft to 750ft in thickness and constitutes by far the most important water-bearing bed below London. We may even call it a reservoir, but not in the ordinary sense of the word, because chalk is like blotting paper and will not yield up its water, unless by pressure and heat, till the stage of saturation is reached. Even then passage of water through chalk except along cracks and fissures is extremely slow. Hence, if a well does not strike a fissure, four or more adits or levels have to be driven radially from the bottom of the well to tap the water ; this is now the established technique. The catchment areas as shown by the diagrams are on the perimeter of the basin, specially the escarpments of the North and South Downs. The rainfall takes a long time to reach the central area, so that continuous pumping from wells bored into the chalk has resulted in a steady lowering of the water table not necessarily uniformly over the area. This is clearly shown by the maps, Figs. 4 and 5. The level is sinking at the rate of 1ft to 2ft per annum ; hence, wells have to be deepened at intervals or fall out of service. It is calculated that it would take half a century to restore the water table to the *status quo ante*.

The position now is that supplies can be obtained from a widely extended area above and below ground and distributed to any district, however elevated and at any distance. Such are the factors that govern the vast extension of London's water supply. How all this has been compassed, what have been the methods employed, and who were the actors in these notable undertakings, which, beginning with an area occupied by Londinium, a matter of a little more than one square mile with an estimated population in the Norman period of possibly 20,000 persons, has been extended to cover the "Greater London" of the Metropolitan Water Board with an area of 576 square miles and a population of nearly eight million persons, will occupy our attention. Some idea of what this figure means will be realised when we recall that the population of Scotland is 4,842,000, that of the Commonwealth of Australia 6,620,000, and that of the Netherlands 8,560,000 persons.

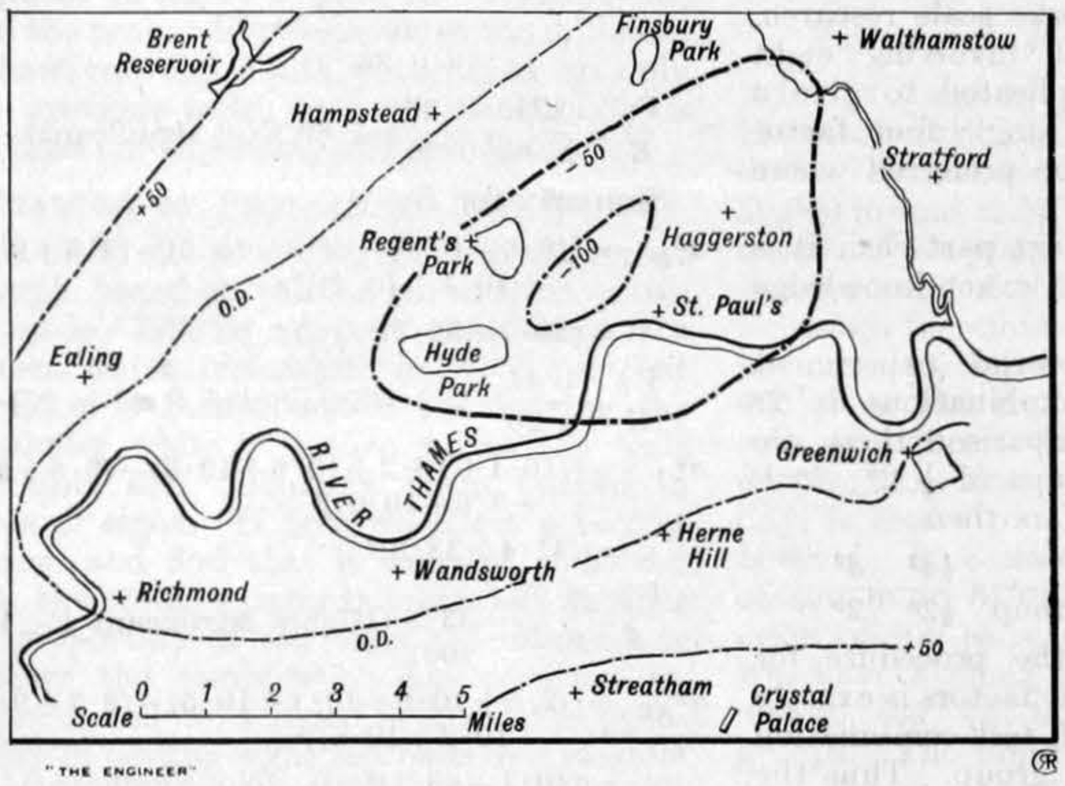
It must be emphasised that throughout the whole period under review, the abiding and main source of the water has been the river Thames itself ; other sources have helped, but extension of population, from the City to the City of Westminster, to the Borough of Southwark on the south side, and then to the boroughs that have grown up around these, could not have taken place had it not been for the advantageous topographical position of the river.

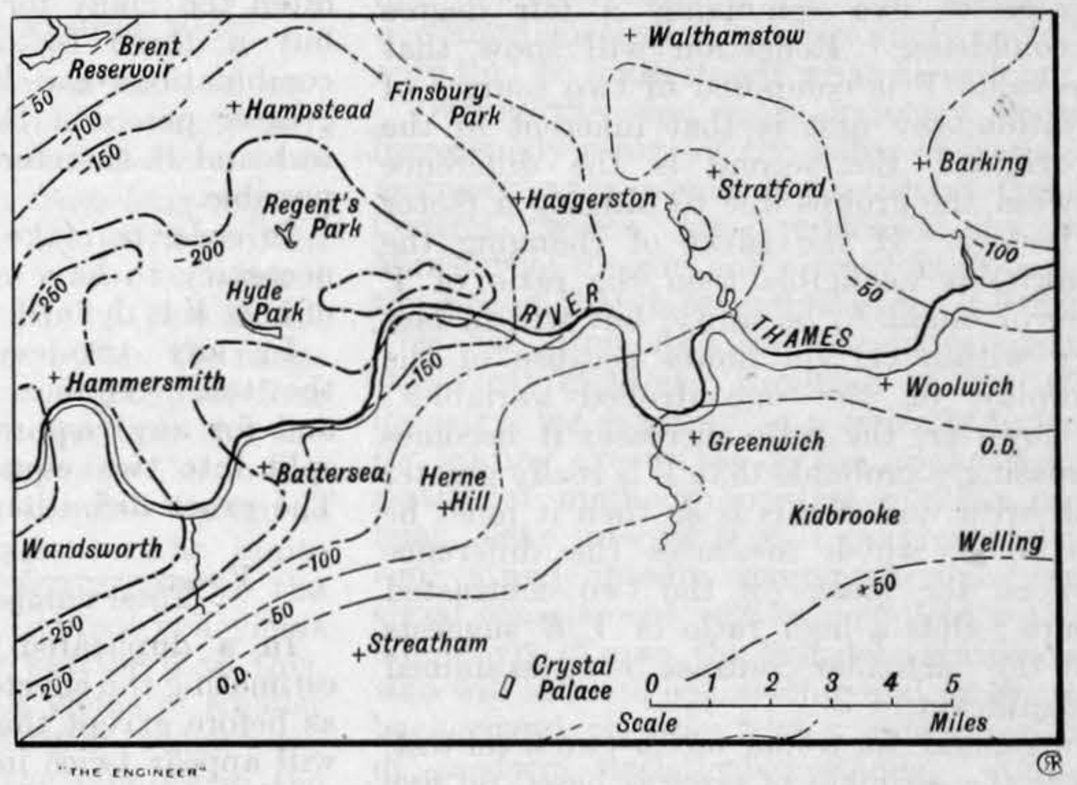
It will be found as we proceed that this water supply has been mainly a matter of engineering. As time has gone on it has resolved itself largely into a question of pumping appliances, for it is true to say that there is not a drop of water available to-day in the Metropolitan area that at some stage or another has not had to be pumped, and twice or thrice at that. Hence, we shall find that the history of the supply is likewise that of advances in the art of harnessing the forces of nature to actuate water-raising appliances, and the share in this that London has taken has been no mean one. Along with this there have arisen problems first of distribution, then of the provision of settling and storage reservoirs, and lastly of filtration and of purification plant according as higher and higher standards of quality have been demanded and attained.

Nor can the human side of the story be neglected ; the inventors of new plant, the numerous promoters of schemes, the engineers, the workmen and other persons must be mentioned and awarded the credit due to them. Furthermore, it will be necessary to touch upon economic, social and even political events during the centuries of supply, in order to understand what were the motives that initiated or stimulated progress. Inextricably bound up with these events are the activities of the Corporation, of local authorities, of the water companies and, lastly in particular, of the Metropolitan Water Board that serves the area at present. These latter aspects, however, will not need very detailed presentation, since they have been so frequently treated, books even having been written on the subject.[2] The whole story will be the subject of this series of articles. The chief source of our information has been the Metropolitan Water Board, to the wholehearted help of the officials of which we return our sincere thanks.

It will be convenient to treat the subject of London's water supply more or less chronologically. Emphasis will be laid upon the means adopted as technique advanced to get and supply the water. This advance falls roughly into periods, albeit ill-defined : supplies from streams and wells, lasting till the thirteenth century ; supplies by gravitation in conduits, lasting till the end of the seventeenth century ; and in aqueducts, still continuing. These afforded low service only in areas limited by their topographical situation. The great advance permitted by pumping appliances, animal power, water wheels and tide mills started in the sixteenth century. The supersession of these by steam power beginning in the latter part of the eighteenth century permitted an enormous increase in the scope of supplies and eventually introduced high service. The nineteenth and twentieth centuries have seen, besides the harnessing of extended powers, the collection and purification of supplies brought to fruition.

(To be continued)





FIGS. 4 AND 5—STANDING WATER LEVELS IN CHALK, LONDON BASIN, 1878 AND 1936

[2] W. Matthews, "Hydraulia . . . The Water Works of London, 1835" ; Sir Francis Bolton, "London Water Supply, 1884" ; H. C. Richards, W. H. C. Payne and J. P. H. Soper, "London Water Supply," second edition, 1899 ; R. Sisley, "The London Water Supply, a Retrospect and a Survey," 1899 ; A. Shadwell, "The London Water Supply," 1899 ; H. Berry, "London's Water Supply, Three Lectures," 1943.

Process Research

By A. H. ASTON, F.S.S., A.M.I.P.E., A.M.I.I.A.

No. II—(*Continued from page 3, July 2nd*)

Error in Factorial Design

IN general the estimation of inherent error is a task which only a statistician can undertake, but for the four factor test described above there is a fairly simple method.

In any comparison let d be the difference between the sums of the two contrasted groups of eight. Calculate $\frac{d^2}{16}=V$ and repeat for each of the fifteen comparisons, then pool and average the five values of V, representing triple and quadruple interaction. Now, because the incidence of triple and quadruple interactions is uncommon each of these five values of V is likely to be an estimate of the inherent error and while each, taken separately, may be of low precision, the estimate based on the average of five commands a fair degree of confidence. Reflection will show that any value V is composed of two sources of variation, the first is that inherent in the experiment, the second is the difference between the groups due to altering a factor or factors. If the effect of changing the factor(s) is negligible then the ratio of V to error ought to be unity, but will in fact vary within certain limits because of the interplay of the uncontrolled variables; as, however, the ratio increases it becomes increasingly probable that V is really greater than error and if this is so then it must be due to d, which measures the difference between the means of the two contrasted groups; thus a high ratio of V/E suggests that the particular contrast being examined is significant.

In general, for a four factor two level test, where the estimate of error is based on five values, it is likely that a ratio greater than 70 shows a real significance while a ratio greater than 16·0 makes it highly probable.

These values will appear high and they are dependent upon the size of the experiment. If, for example, the estimate of error had been based on ten values then the significance levels would have been five and ten; if the estimate had been based on twenty values then the levels would have been 4·5 and 8·0. This merely illustrates the obvious, though often neglected, fact, that the precision of an experiment is dependent upon the amount of data available.

There are several comments which must be made upon the use of this method of evaluation. The first is that the estimate of error depends upon the absence of triple or quadruple interaction. If these are present then the apparent error will be increased, the ratio V/E will be reduced and significance will not be obtained. The second is that a high ratio is not necessarily a proof of significance; the basis of the test is that we assume there is no difference between the groups and then assess the frequency with which the observed difference would occur if both groups were values or samples drawn at random from a much larger group of values or parent population. By convention a difference which would occur with a frequency of less than one in twenty in repeated sampling is considered significant and a frequency of less than one in one hundred highly significant. Thus for our four factor test a ratio of V to E greater than 7·0 indicates that the probability is less than one in twenty, that the two groups are drawn from the same population, and a ratio greater than 16·0 indicates a probability of less than one in one hundred. It is obvious that these long odds will occur with their expected frequencies and occasionally therefore in repeated experiments a false conclusion may be drawn.

Increasing the Precision of Error Estimate

The precision of an experiment may be considerably increased by duplicating each test, because the comparison of each identical pair gives an estimate of the inherent error of the experiment and, as pointed out previously, improved precision in estimating E reduces the ratio required for significance. Duplicating a four factor experiment would mean making thirty-two tests and this is often too many for a works scale research, but a three factor test involving eight combinations can be duplicated to give a greater precision than a single four factor test and is therefore to be preferred where possible.

In order to make the next part clear it is necessary to have a more exact knowledge of how V is defined.

In any two-level factorial experiment the total number of combinations is 2^n and for any required comparison these are split into two equal groups of $\frac{1}{2}\ 2^n=2^{n-1}$. The exact definition of V is then :—

$$V=\frac{\frac{1}{2}d^2}{\text{Total number in group}}=\frac{\frac{1}{2}d^2}{\frac{1}{2}2^n}=\frac{d^2}{2^n}$$

In a duplicated test the procedure for estimating the effects of the factors is exactly as before except that each test combination will appear twice in each group. Thus the total number of tests is $2\times2^n=2^{n+1}$, and each group for a required contrast will contain 2^n test results, consequently :—

$$V=\frac{\frac{1}{2}d^2}{\frac{1}{2}\ 2^{n+1}}=\frac{d^2}{2^{n+1}}$$

Thus, for both a single four factor test and a duplicated three factor test $V=\frac{d^2}{16}$.

The estimation of error in a duplicated test is simple. Take each pair of tests with the same combination of factors, call the difference D, calculate $\frac{1}{2}D^2$, repeat for all combinations, then sum and average the results. Algebraically this may be shown as :—

$$E=\frac{1}{2^n}\sum\frac{1}{2}D^2=\frac{1}{2^{n+1}}\sum D^2$$

The required ratio of V/E can then be reduced to :—

$$\frac{V}{E}=\frac{d^2}{\Sigma D^2}$$

For judging significance the following table, which has been extracted from those published by Snedecor and Fisher, can be used. It gives the one in twenty and one in one hundred levels for the ratio V/E for single and duplicated tests, as indicated in the third column. For the single tests the estimates of error are based on the pooled and averaged values of V for triple and higher interactions.

N	2^n	No. of Exps.	Significance Levels (P) 1 in 20	1 in 100
2	4	2	7·71	21·20
3	8	2	5·32	11·26
4	16	1	6·61	16·26
		2	4·49	8·53
5	32	1	4·49	8·53
		2	4·15	7·50

Simple Three Factor Example at Two Levels

To illustrate the foregoing sections, here is an example of a duplicated three factor test :—

		Test 1	Test 2	Sum	Diff.	D^2
ABC	*I*	4·7	4·8	9·5	0·1	0·01
aBC	*a*	4·7	5·0	9·7	0·3	0·09
AbC	*b*	4·9	4·7	9·6	0·2	0·04
abC	*ab*	5·0	5·0	10·0	0·0	0·00
ABc	*c*	5·1	5·0	10·1	0·1	0·01
aBc	*ac*	5·0	5·2	10·2	0·2	0·04
Abc	*bc*	5·3	5·3	10·6	0·0	0·00
abc	*abc*	5·2	5·3	10·5	0·1	0·01
		39·9	40·3	80·2	0·20 = ΣD^2	

To assess the effect of altering A to a :—

$$d^2{}_A=2^{n+1}V_A=[(9\cdot7+10\cdot0\ \ 10\cdot2+10\cdot5)-(9\cdot5+9\cdot6+10\cdot1+10\cdot6)]^2$$
$$=(40\cdot4-39\cdot8)^2$$
$$=0\cdot36$$

$$\frac{V_A}{E}=\frac{d^2}{\Sigma D^2}=\frac{0\cdot36}{0\cdot20}=1\cdot80 \text{ (Not significant)}$$

Similarly for B :—

$$d^2{}_B=[(9\cdot6+10\cdot0+10\cdot6+10\cdot5)-(9\cdot5+9\cdot7+10\cdot1+10\cdot2)]^2$$
$$=(40\cdot7-39\cdot5)^2$$

$$\frac{V_B}{E}=\frac{1\cdot44}{0\cdot20}=7\cdot2 \quad \text{(Significant } P<1 \text{ in 20)}$$

$$d^2{}_C=[(10\cdot1+10\cdot2+10\cdot6+10\cdot5)-(9\cdot5+9\cdot7+9\cdot6+10\cdot0)]^2$$
$$=(41\cdot4-38\cdot8)^2$$

$$\frac{V_C}{E}=\frac{6\cdot76}{0\cdot20}=33\cdot8 \text{ (Highly significant } P<1 \text{ in 100)}$$

$$d^2{}_{AB}=[(9\cdot5+10\cdot0+10\cdot1+10\cdot5)-(9\cdot7+9\cdot6+10\cdot2+10\cdot6)]^2$$
$$=(40\cdot1-40\cdot1)^2=0 \quad \text{(Not significant)}$$

$$d^2{}_{AC}=[(9\cdot5+9\cdot6+10\cdot2+10\cdot5)-(9\cdot7+10\cdot0+10\cdot1+10\cdot6)]^2$$
$$=(39\cdot8-40\cdot4)^2$$

$$\frac{V_{AC}}{E}=\frac{0\cdot36}{0\cdot20}=1\cdot80 \text{ (Not significant)}$$

$$d^2{}_{BC}=[(9\cdot5+9\cdot7+10\cdot6+10\cdot5)-(9\cdot6+10\cdot0+10\cdot1+10\cdot2)]^2$$
$$=(40\cdot3-39\cdot9)^2$$

$$\frac{V_{AC}}{E}=\frac{0\cdot16}{0\cdot20}=0\cdot80 \quad \text{(Not significant)}$$

$$d^2{}_{ABC}=[(9\cdot7+9\cdot6+10\cdot1+10\cdot5)-(9\cdot5+10\cdot0+10\cdot2+10\cdot6)]^2$$
$$=(39\cdot9-40\cdot3)^2$$

$$\frac{V_{ABC}}{E}=\frac{0\cdot16}{0\cdot20}=0\cdot80 \quad \text{(Not significant).}$$

The following gives a check on the arrangements and arithmetic :—

$$d^2 \quad =2^{n+1}\,V, \text{ therefore } \Sigma V=\frac{\Sigma d^2}{2^{n+1}}=0\cdot5775.$$

But ΣV may also be estimated directly from the data thus :—

$$\Sigma V=9\cdot5^2+9\cdot7^2+9\cdot6^2+10\cdot0^2+10\cdot1^2+10\cdot2^2+10\cdot6^2+10\cdot5^2-80\cdot2^2/16$$
$$=0\cdot5775$$

If, now, reference is made to the assessment of laboratory data discussed earlier in this article, it may be observed that the argument was parallel to that just discussed, but that a definite assessment of significance was made on the basis of the range of the results of repeated tests. It may now be asked whether the conclusion was valid and whether the observed difference of 5 per cent would

be more accurately expressed as a probability; but if it should, then how can a probability be applied to a result which falls outside given finite limits? The answer is that the probability method is correct, and the reason is that the limits on the range are not finite.

The Misuse of Range

The misleading character of range is that as the quantity of data increases the range limits get wider. A few moments' reflection will show why; for if the range is the variation about a true value caused by the interplay of uncontrolled variables, then the frequency with which each variable takes up its extreme values will be small and the frequency with which several or all will be simultaneously at their extreme values and weighting the results in the same direction will be very small indeed. Consequently the more frequently samples are taken the more likely it is that wider limits will occur. The missing data from the laboratory assessment was therefore that no reference was made to the number of tests on which the limits of ± 1 per cent were based. If the limts were derived from years of testing so that the numbers of tests ran into many thousands, then the probability would be one in millions; if, however, the limits were based on only two previous tests, then the probability is less than one in twenty and not significant.

Example of Probability and Limits

To make the preceding sections clearer an example based on the binomial theorem can be used. Let us suppose that there is a process which makes golf balls, 50 per cent of which it should colour red leaving the remainder white; it then mixes the balls throughly and discharges them packed in boxes of eight. If now we select a box at random and find that it contains eight red balls, the problem immediately arises whether the proportion of red balls has changed or whether the combination has occurred by chance; and we require to know the probability of getting eight red balls in a random sample. This problem can be solved with mathematical exactness. It is obviously possible to obtain eight red balls under the stated conditions, but it is most unlikely that it would happen and the probability can be calculated accurately by expanding the binomial $(R+W)^8$. If 256 boxes of eight were taken then the expected occurrence of each combination of red and white balls would be :—

Red	White	Frequency	
8	0	1	
7	1	8	(Binomial
6	2	28	coefficients
5	3	56	from
4	4	70	Pascal's
3	5	56	Triangle)
2	6	28	
1	7	8	
0	8	1	
		256	

The probability of getting eight red balls is therefore 1 in 256, and as this is far beyond the significance level it would be considered extremely unlikely that the process was producing equal quantities of each colour. It would not, however, be a proof, because in fact it is always possible that the 256 to 1 chance has occurred. Now pose the question differently. No knowledge is available concerning the proportion of red balls, but 127 boxes have given the following distribution :

Red	White	Frequency
7	1	4
6	2	14
5	3	28
4	4	35
3	5	28
2	6	14
1	7	4
		127

If, now, a box containing eight red balls is obtained, does this show a change in proportion, as it is outside the previous range? Quite obviously it does not, because the limits of the range are not finite; but what a temptation it would be if the theoretical distribution had been unknown, as is nearly always the case in process control.

Range therefore is dependent upon the number of tests on which it is based, and its use is not advocated. For small numbers range is a very inaccurate assessment of variation, but it may in certain circumstances and with proper safeguards be as efficient as other methods of estimation, as is explained in British Standards Publication B.S. 600R.

It should be clear by now that in any experimental work the results can only be assessed by knowing the inherent error in the process, and the precision with which the error is known depends upon the number of tests from which it is estimated; moreover, comparison between groups can be made only when the number of tests in each group is similar or when correction factors have been used to eliminate the differences. This last point is one of such interest that it deserves one more example to illustrate it.

Example Involving Sample Sizes

In the aluminium industry a series of, say, 100 electrolytic cells are simultaneously producing aluminium. The total daily yield is 50,000 lb and it is known from long experience that the yield of any day will be within ± 2 per cent of this figure; the daily yield limits are therefore 49,000 lb to 51,000 lb and the mean yield per cell lies within the range 490 lb to 510 lb. If now a group of four cells of different design is put into the circuit and the first yields average 530 lb per day, is this a proof that the new design is better? It certainly is not! The limits of 490 lb to 510 lb/day apply only to the *mean* of 100 cells, the individual cell yields will have a much greater scatter than this, and so, too, will the mean yields of smaller groups. The limits for a mean value vary with the square root of the number in the group, thus, with a given range R based on N observations, the value of r of a group of n observations will be :—

$$r = R\sqrt{\frac{N}{n}}$$

If both n and N are very large this relation is fairly accurate, but for a small value of n or N the range will be subject to the limitations discussed above. In this instance we are not concerned with accurate values but only to illustrate the principle; thus, for the example given above the range for r would be

$$r = 20\sqrt{\frac{100}{4}}$$

Hence $r=100$ and for groups of four the limits on the mean are 450 lb to 550 lb and the mean yield of 530 lb does not prove the new design to be better.

The faulty comparison of means drawn from different sized groups is so common that the importance of this section cannot be overstressed.

The Statistical Background

Much of this article has been concerned with the inherent error and it has been shown that the range is an inefficient method of estimating it. A much better method is to calculate the "variance" or second moment about the mean of the data*, which is a simple, statistical estimate giving the maximum efficiency. This estimate, together with its square root, called the "standard deviation," constitute the basis on which most of statistical science is built. They have provided the background for this article, which has been essentially statistical in its methods and arguments, but the presentation has been made in non-statistical language, for the purpose of showing that the application of simple statistical methods to industry does not require mathematical scholarship but only elementary algebra, commonsense and an understanding of the fundamentals of statistical reasoning.

Factorial design is a powerful research tool, but it is only one of many such statistical techniques which are available for use in industry and all of them can be readily applied by anybody with slight mathematical ability who is prepared to devote some time to the study of statistical reasoning. The misconception that high mathematical skill is required arises because statistical science may be split into two parts; the first deals with the theoretical mathematics of statistics and certainly calls for mathematical ability of a high order, but the results of the mathematical theory are translated into relatively simple formulae which the non-mathematical can safely apply provided only that he understands what he is doing.

During the war years industry became increasingly aware of the value of statistical methods, as a result of Statistical Quality Control, which was publicised by the Ministry of Supply and simply explained in the British Standards publication, B.S.600R. This has stimulated an interest in general statistical methods, resulting in the steel industry, for example, in a series of lectures for leading executives on the application of statistical methods to steel making problems. The interest is still growing and the time is undoubtedly coming when no managerial complement will be complete without a new type of man, the industrial statistician, who will have an engineering and production background, together with a wide knowledge of modern statistical methods. Already some employers are looking for such men, but there are very few and the employer is handicapped in trying to estimate an applicant's statistical knowledge, as there is no academic qualification other than a university degree in mathematics, which usually precludes the production and engineering experience and qualifications which are also essential.

The Royal Statistical Society is aware of the need for both industrial statisticians and a new academic standard and is therefore setting itself vigorously to solve both problems. It has started an Industrial Application Section, which is solely concerned with the application of statistical methods to industry, and now holds internal examinations among its own members, so that in future a Fellow of the Society will be able to demonstrate his statistical ability together with his engineering and production qualifications.

The Council of the Society should be congratulated on their foresight in anticipating the coming demand and it is hoped that employers will increasingly avail themselves of the experience of the Industrial Application Section and the knowledge of its members, both of which can contribute greatly to the efficient reorganisation of our industrial economy.

The subject of factorial design is treated at length in "The Design of Experiments" R. A. Fisher, published by Oliver and Boyd, Edinburgh, and also in "Industrial Experimentations," K. A. Brownlee, published by His Majesty's Stationery Office.

*See B.S.600R or any text book on elementary statistics.

The Royal Show at York

No. I

THE Royal Agricultural Society's annual show opened in York on Tuesday last, July 6th, and closes to-day, July 9th. This is the fourth occasion on which the "Royal" has been held in the immediate neighbourhood of York, former shows there having taken place in 1848, 1883, and in 1900. The site of the present show is at Knavesmire, on the Tadcaster Road, and covers an area of approximately 100 acres. At the time of going to press, it is not easy to estimate the total attendance at the show, although there are indications that last year's record figure of 250,000 will be equalled if not surpassed.

The machinery section comprises 535 stands and is therefore even more extensive than that of last year's show at Lincoln, where 425 stands were occupied. The exhibits again cover a very wide range of implements and certainly present an up-to-day impression of the progress of mechanised agriculture. Equipment designed to assist arable farming, dairy farming, and horticulture may be seen, and all of it demonstrates the careful attention which engineers are constantly giving to the needs of cultivation, not only in this country but in overseas countries as well. As usual, a prominent feature of the show is the Royal Agricultural Society's Silver Medal competition for new implements. Thirty-seven new implements were entered for the competition, which number included a few machines upon which the judges deferred their decision last year. Another feature of special interest is the demonstrations representative of rural craftsmen, such as blacksmiths, wheelwrights, saddlers and hurdle-makers, all of whom still take an important part in the business of British farming.

In what follows, we begin a description of some of the implements shown at York. For the most part, the present article is concerned with implements entered for the Silver Medal competition.

H. Leverton and Co., Ltd.

A potato harvesting machine in the Silver Medal competition is the potato and root-shaker-digger built by H. Leverton and Co., Ltd., Spalding, Lincs. It is a tractor-driven machine mounted on wheels which are adjustable on an extending axle. The land wheel can be offset by a screw adjustment to give more or less land as may be required for varying row widths. Two divided shares lift the potatoes, which are passed on to a conveyor consisting of reciprocating parallel rails. The soil is sifted from the potatoes which are then passed to the rear end of the machine by the action of shakers and are finally deflected from the next row. The power drive is transmitted through double universal joints to the main shaft, which passes through a substantially constructed gearbox encasing a ground bevel gear and pinion, running in a sealed oil bath. A safety clutch, incorporated in the power mechanism of the machine, can be operated from the tractor driver's seat by means of a cord.

Other exhibits of this firm include a pea cutter, which, it is claimed, is particularly suitable for use under conditions where it is not possible to work a mower. The machine consists of three torpedo-shaped dividers placed in V formation, and mounted on an adjustable framework at the front of the tractor. These dividers can be set to suit the spacing of the crop and their purpose is to part the drill rows, thus making way for the tractor wheels and automatically positioning the vines for the cutting blades. The cutting blades are carried by heavy beams on a row crop toolbar fitted to the rear of the tractor. The blade units can, of course, be set to accommodate the depth and spacing of the crop and are easily detachable for sharpening. A front view of the pea cutter at work in a heavy crop is reproduced in Fig. 1.

A power lift rear steerage hoe, illustrated in Fig. 3, is another machine shown by H. Leverton and Co., Ltd. It can be used with most standard row crop tractors. The hoe blades are all independently sprung to ensure even hoeing depth and are attached to a bar on which they can be adjusted for spacing as required. The hoe is fitted to the toolbar frame, and as it is mounted on rollers it has independent lateral movement, which is controlled through a tiller lever by an operator seated at the rear of the machine. The requisite depth adjustment can be made by raising or lowering the wheels on the toolbar frame.

Modern Designs, Ltd.

The Packman potato harvester, illustrated in Fig. 2, is among the exhibits of Modern Designs, Ltd., Twyford, Berks, and is one of the implements entered for the Silver Medal competition. A feature of this machine is the main separating drum, which is a rotating circular sieve of welded steel, 90in in diameter. This sieve is connected by sixteen paddles to a centre wheel having an axis inclined in two directions to the line of travel. The narrow steel plough fitted to the machine coincides with the lower circumference of the separating drum and makes an angular cut below the ridge, thus allowing the soil and potatoes to flow in a tangential direction on to the sieve. As the sieve rotates, its surface tilts until the potatoes are discharged through spaces between the paddles on to a horizontal welded steel disc sieve.

Revolving brushes help to remove the soil, and the potatoes are carried round the disc sieve while spring fingers complete the cleaning process. The potatoes are then brush-swept on to a welded steel sorting disc and finally pass to an inclined elevator which discharges them into the collecting vehicle. The elevator has a treated canvas band 18in wide, to which light alloy buckets are riveted, and its upper portion is encased in a steel body which can be

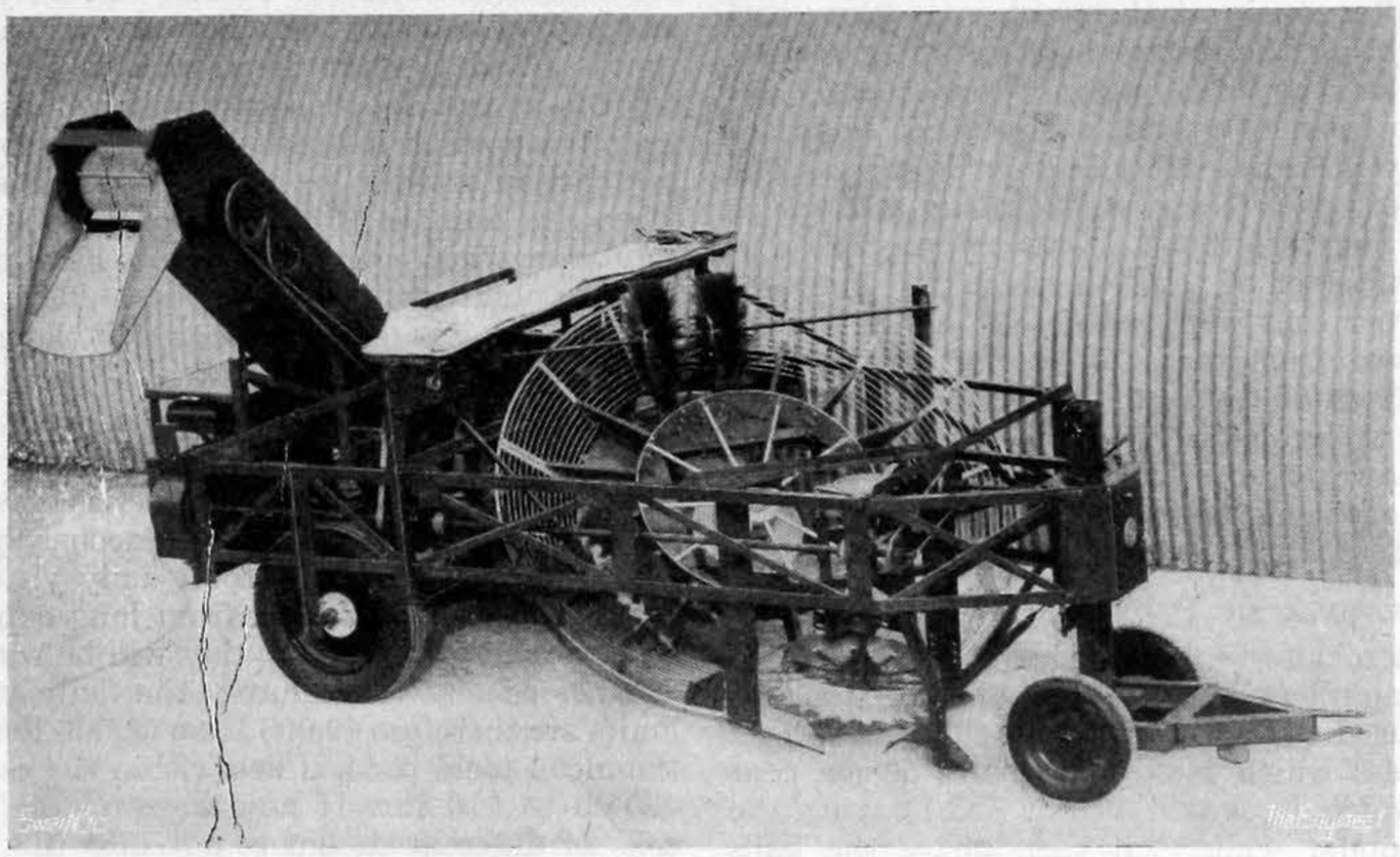


FIG. 2—PACKMAN POTATO HARVESTER—MODERN DESIGNS



FIG. 1—PEA CUTTER—LEVERTON

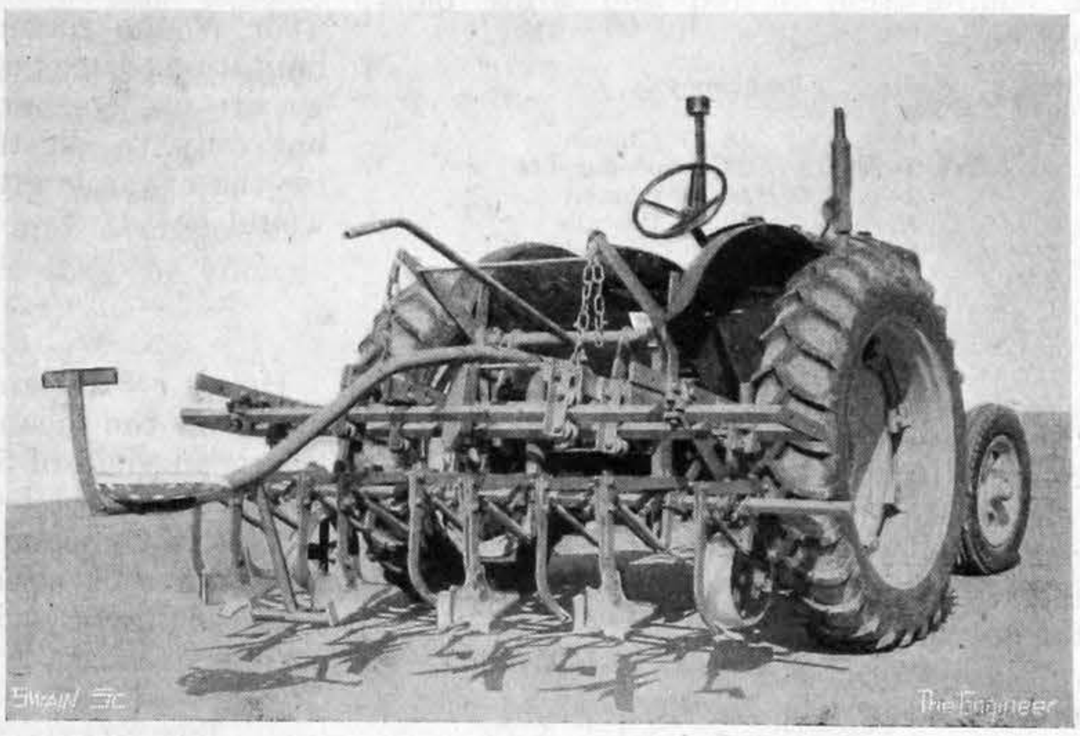


FIG. 3—STEERAGE HOE—LEVERTON

folded down to facilitate transport. The power unit of the Packman harvester is a Petter 5 h.p. air-cooled engine which drives through a clutch the main lineshaft, and from this shaft various V-rope drives are taken to dust-tight gearboxes which enclose shafts and gears running in oil baths.

The main frame of the machine is a welded tubular steel structure mounted on pneumatic-tyred wheels. The forward end of the frame slides up and down a steel column under the influence of a power-driven lift gear, by means of which the plough can be raised and lowered as required. The makers have also designed some accessories to the harvester, which include a haulm stripper, a haulm plucking machine, a bagging attachment, and a stone ejector.

JOHN SALMON ENGINEERING COMPANY, LTD.

In the last few years, agricultural engineers have given a good deal of attention to the mechanical harvesting of sugar beet, and one of the machines for this purpose which was entered as a new implement is that constructed by John Salmon Engineering Company, Ltd., Dunmow, Essex. This tractor-drawn machine, a view of which is reproduced in Fig. 4, is primarily intended to lift and load the beet directly into a trailer drawn alongside, but if necessary a hopper can be fitted so that the beet can be left in windrows in the field. The main frame is constructed of angle steel, and from it the topping unit is suspended by springs. The beet tops are actually cut off by a single inclined knife, controlled by a power-driven spider wheel, the spokes of which ride over the tops of the beet and force them on to the knife. The severed tops are turned to one side by a blade on the rear of the inclined knife and are left in windrows clear of the machine.

A twin-arm lifter takes the beets out of the ground and they pass to a cleaning elevator, the trough of which is constructed of undulating rods set at an angle to the base. The beets pass over the crests of these rods without damage, but as the earth picked up with them is of weaker structure, it breaks up and passes through the slats. Most of the earth is removed by the continuous shaking action of the cleaning elevator, but the rear elevator on the machine is designed to knock any remaining soil and trash from the crop. The Salmon harvester is equipped with a 4½ h.p. J.A.P. air-cooled engine which provides power through a centrifugal clutch, V-belt and chain drive, and adjustable slip-clutches fitted to the main drive, primary feeder and rear-elevator drive give protection against overloading to all working parts.

The makers claim that the arrangement of the steering unit ensures that the harvester is easily manœuvrable when at work, giving a fine adjustment while travelling along the rows and also permitting the tractor to turn at an acute angle to the harvester when the headlands are reached. This movement is obtained by a steering bar actuating in a rack attached to the tractor; it can be easily adjusted or disengaged by the operator, and enables the harvester to be turned on a 6-yard headland and to be set in squarely to the beginning of the row.

THE BIRTLEY COMPANY, LTD.

Another sugar beet harvester in this year's new implement competition was the Birtley Silk machine, which is shown on the stand of the Birtley Company, Ltd., Birtley, Durham, This machine, which is illustrated in Fig. 5. does not top the beet, but is intended to lift and clean the crop after the tops have been taken off by hand.

As the tractor draws the machine along the row the action of rotary ploughs is such that the beets are squeezed from the earth and passed to a conveyor which is, in effect, a series of transverse steel bars linked together. Much of the soil is shaken from the beets as they are passed along this conveyor to a cleaning elevator which delivers the crop to a second conveyor at the rear of the harvester. This latter conveyor is constructed from steel bars connected by links, and as it runs in opposition to the beets, any remaining soil is removed from them as they fall against the rising conveyor bars.

The two conveyors and the elevator are driven by an 8 h.p. twin-cylinder petrol engine with a built-in clutch. It may be mentioned that the engine is easily detachable from the machine and can thus be employed in other farming tasks during months when the beet harvester is not in use. The rotary ploughs are carried by a system of chains and links and are adjustable to the most convenient angle and height for removing the beets from the earth. A lever, placed so that it can be operated from the tractor driver's seat, provides the means for lifting the plough wheels clear of the ground. The complete harvester, as our illustration shows, is carried by two pneumatic-tyred rear wheels, their stub axles being so designed that the gauge of the wheels can be altered to suit the pitch of the rows of beet.



FIG. 5—BEET HARVESTER—BIRTLEY

E. ALLMAN AND CO., LTD.

Crop sprayers are among the principal exhibits of E. Allman and Co., Ltd., Chichester, one of them being the "KlingKloud" turbine-operated duster, which was a Silver Medal entry. This machine is provided with a dusting boom 24ft wide, to which extensions may be made to give a width of 40ft. It incorporates dusting fish tails made from moulded rubber, which can be spaced at intervals suitable for dealing with the various row widths of ground crops, and the boom is folded and lowered automatically by the hydraulic power lift, thus facilitating turning on headlands. Where it may be necessary to distribute a large cloud

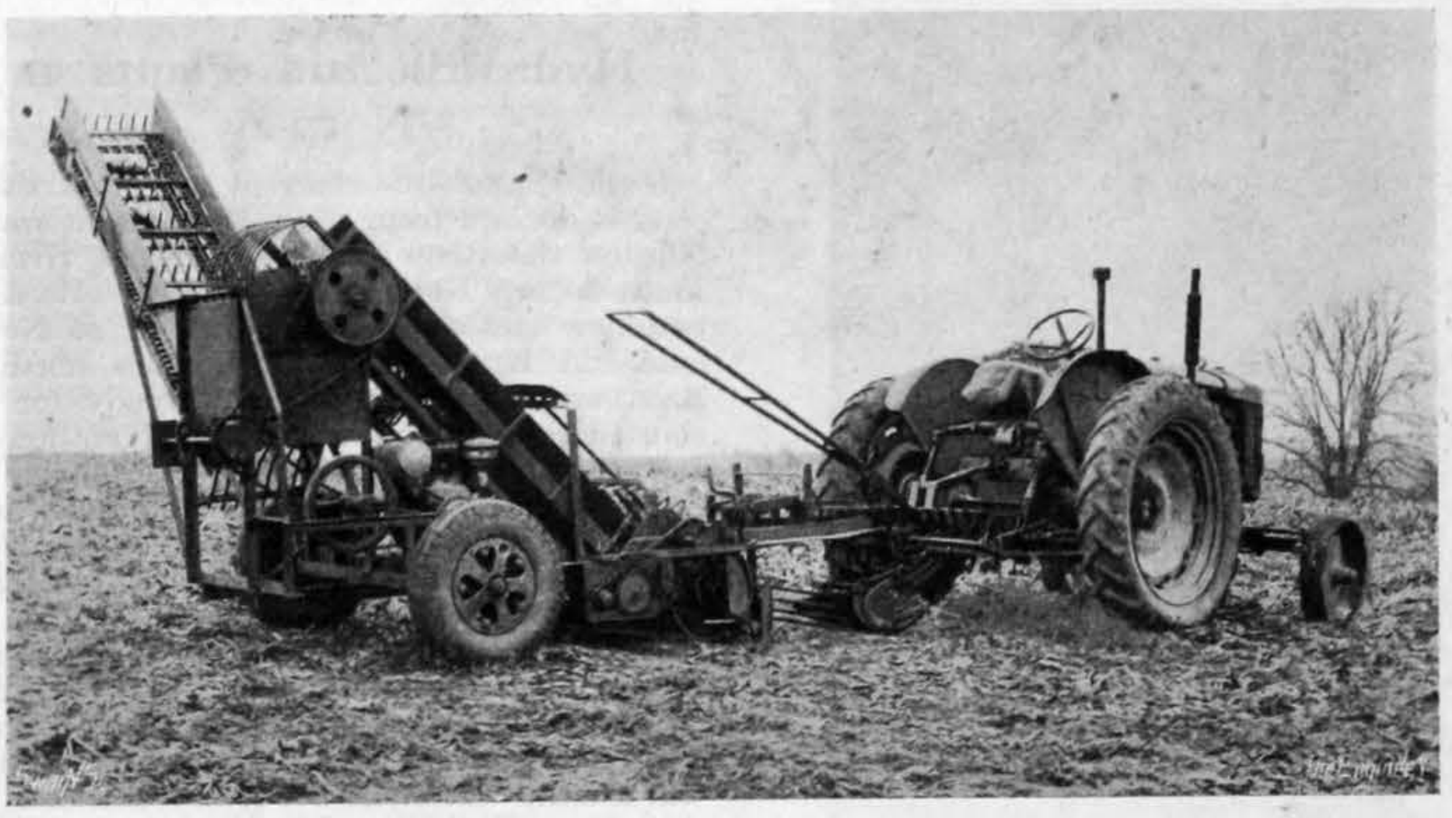


FIG. 4—BEET HARVESTER—SALMON



FIG. 6—CROP DUSTER—ALLMAN

of dusting powder over a wide area, such as in rubber plantation or forestry work, a single adjustable fish-tail unit can be employed. A petrol engine drives directly by triple-vee belts the turbine fan, which is provided with shutter-controlled air blast to suit all conditions.

The firm is also showing the "Pestmaster," which is a smaller fan-operated crop duster. It can be supplied to fit a tractor hydraulic lift, or, as the engraving Fig. 6, shows, there is a market garden model on adjustable track wheels. The conical powder hopper is fitted with a worm drive positive feed, and, in the market garden model, there is a steel tubular sectional boom, 100in wide, which is drilled with apertures designed to give complete dusting coverage over its entire width. A single flexible nozzle, adjustable in all directions for fruit and orchard dusting, can be fitted to both the tractor mounted or hand-propelled types of the machine. A J.A.P. air-cooled petrol engine drives the high-duty fan, which, as in case of the "KlingKloud," is provided with the shutter-controlled air blast to suit different dusting conditions.

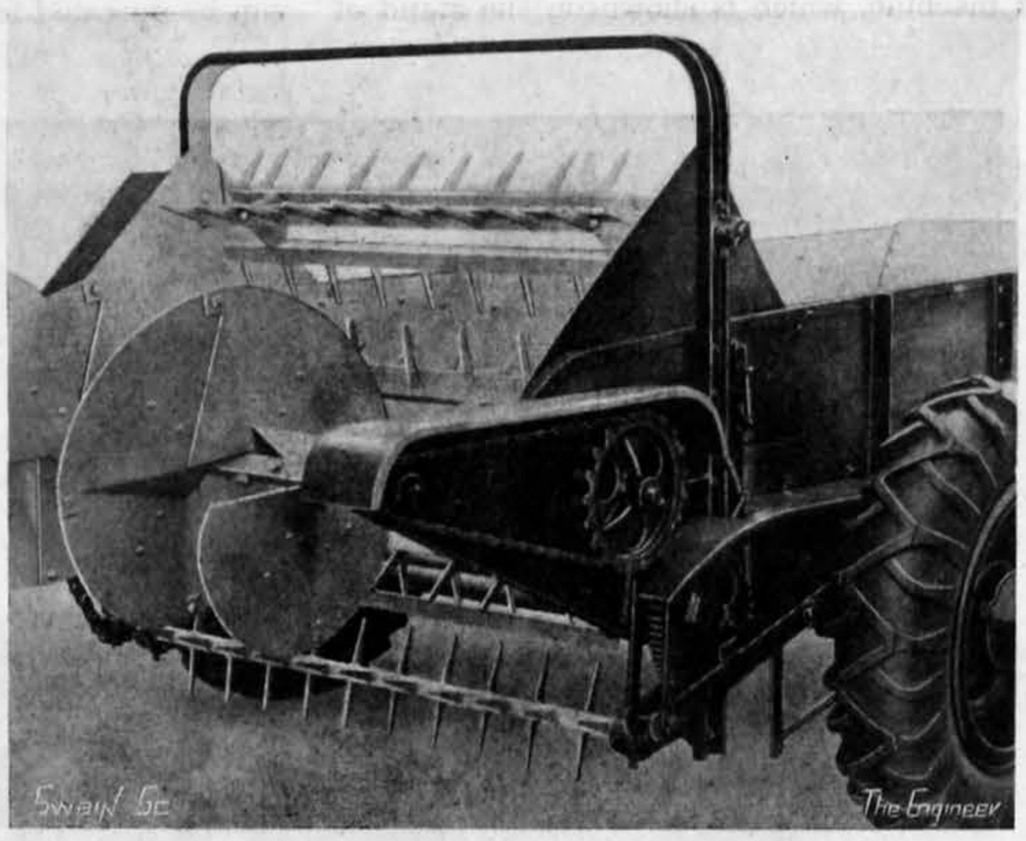


FIG. 8—FARMYARD MANURE SPREADER—BAMFORD

WARD BROTHERS

Among the many types of cultivator and hoe to be seen at York is the tractor-drawn four-row scuffler, shown by Ward Brothers, Sherburn, Near Malton, Yorks. This implement, which was a Silver Medal entry, is illustrated in Fig. 7. Its main frame is fitted with four independently sprung tool bars and the blades, which are made from high carbon content steel, are designed to resist bending. By compensating springs, the blades can be easily lifted or lowered, a feature which the makers claim eliminates pauses at the end of rows. The springing is adjustable from practically 0 to 50 lb pressure on each blade, and to enable them to penetrate exceptionally hard ground the blades can be adjusted for set. The scuffler is equipped with pneumatic-tyred wheels carried on a telescopic axle to provide for varying row widths.

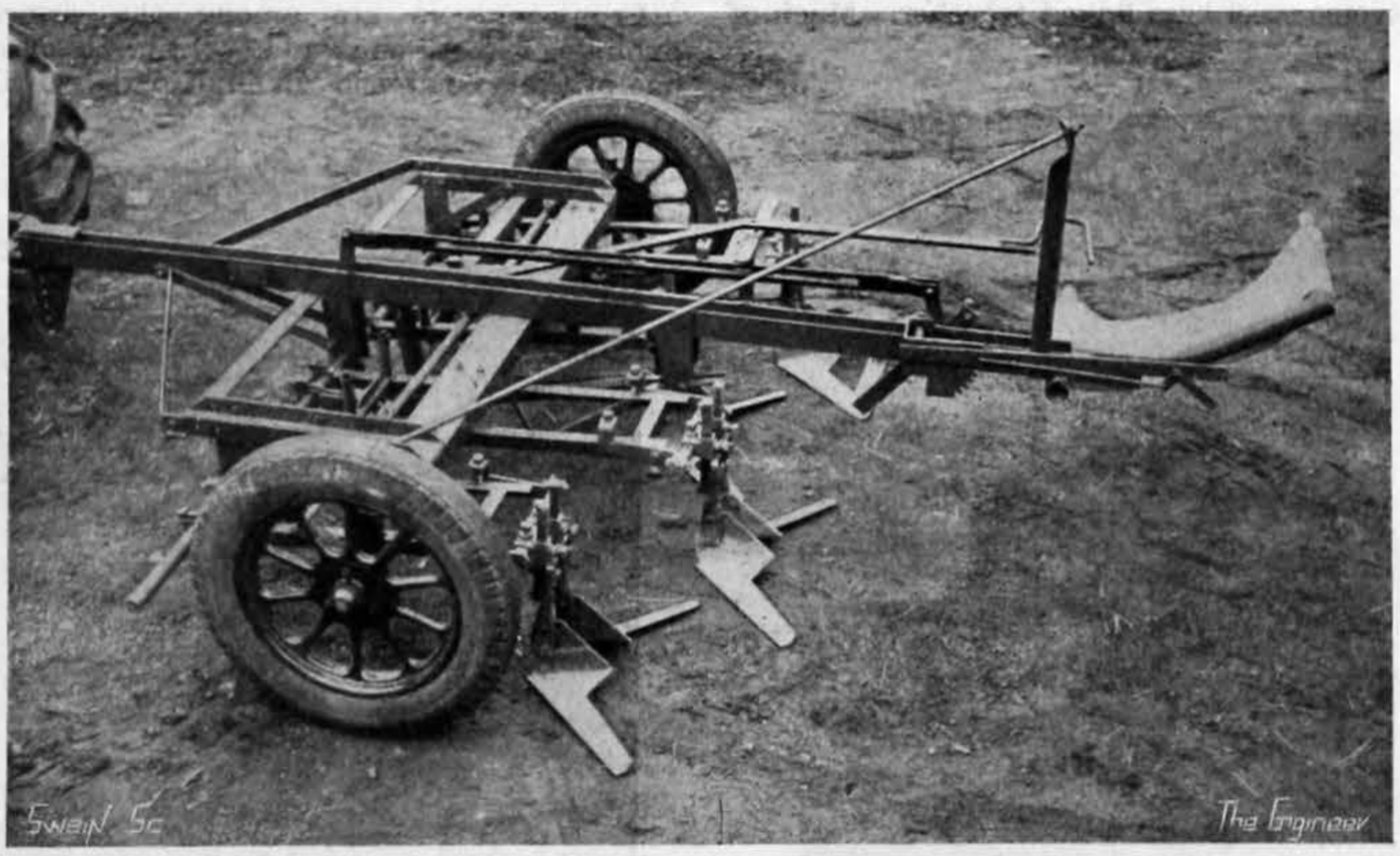


FIG. 7—FOUR-ROW SCUFFLER—WARD

BAMFORDS, LTD.

A variety of implements is to be seen on the stand of Bamfords, Ltd., Uttoxeter. It includes the "Major" grass mower, a machine designed specially for working with the Fordson "Major" tractor; a combined side-rake and swath turner, with adjustable bars; and the "Universal" crop loader, a machine working on the reciprocating crank principle, with a three-bar rotating pick-up element at the foot of the chute.

The firm is also showing a new hammer mill, the cast iron body of which has the top half hinged to allow adjustment or inspection of the working parts. The hammers, of which there are twenty-four, are arranged in eight rows on a rotor, and are of the swinging type, reversible, thus giving four stepped cutting edges, two at each end. The mill is provided with an adjustable hopper, and a screen of large area through which a fan draws the ground material and elevates it to the cyclone. The normal power required for driving the mill is 20 b.h.p.

A new machine recently produced by Bamfords, Ltd., is the farmyard manure spreader, illustrated in Fig. 8. It is a tractor-drawn implement, comprising a large-capacity container, evenly balanced on two pneumatic-tyred wheels, to which there is fitted an endless conveyor, which takes its drive from one of the road wheels through a star wheel operating a lever actuating ratchet mechanism assembled on the conveyor driving shaft. An operating lever at the front of the machine controls the rate of delivery of the manure to the spreading mechanism, which consists of three beaters. The rotary spreading device at the rear of the beaters is designed to break up the manure and assist its even distribution. The beaters and the rotary spreading device are driven by chain and sprockets from one of the road wheels, an "in and out" gear being operated by a lever from the front of the machine. The three beaters are disposed in triangular formation, with the main beater immediately to the rear of the conveyor and an auxiliary beater above it, whilst the second auxiliary beater is fitted below the main beater and therefore is able to deal with any manure which may fall from the back edge of the hopper. The drawbar at the front of the machine is provided with a new type of spring folding jack, which springs up automatically when the machine is drawn off by the tractor.

(To be continued)

Final Report: Railway (London Plan) Committee

As foreshadowed in its report of January 21, 1946, the Committee, under the chairmanship of Professor Sir Charles Inglis, considered the recommendations made in the County of London Plan as regards the railway terminals north of the Thames, except those of the Southern Railway, and also in respect of freight traffic and distribution, and the following suggestions are made: the reconstruction of Fenchurch Street Station "at a more convenient level" (with a view to the elimination of the approach viaduct) on a site adjacent to the "A" Ring Road; the setting back of Liverpool Street Station "partly to clear it of the confusion of narrow thoroughfares in the vicinity" by constructing a new main line passenger terminal on the site of Bishopsgate Goods Station, where it would be adjacent to the "A" Ring Road; the utilisation of the present site of Liverpool Street Station for an underground station for surburban lines; the construction of a low level loop to connect the new suburban passenger terminal at Liverpool Street with the new station replacing the existing one at Fenchurch Street; the improvement of King's Cross; the combination of Euston and St. Pancras, and the enlargement and bringing forward of Paddington. The plan makes no recommendation with regard to Marylebone, which it assumes will remain as at present, and there is no mention of Broad Street.

Hydro-Electric Plants in Norway

HYDRO-ELECTRIC current for Kristiansand is derived from several important waterfalls on the River Otra, the longest river in south-eastern Norway (155 miles). Recently two new stations were completed at Nomeland and Kringsja, about 15 miles north of Kristiansand. Plans are now ready for the construction of a third power station at Ivelandsfoss, also utilising a waterfall on the Otra. The new station will be equipped with three turbines with an overall capacity of 45,000 h.p. High tension current will be transmitted over a distance of 19 miles. When the Ivelandsfoss station is completed, the oldest station at Krinja will be put out of service. At the same time the construction of a new hydro-electric station will be started, which will use the waterfalls between Nomeland and the Venneslafjord. This station will be situated at Steinfoss, about 13 miles from Kristiansand and will be equipped with turbines having a total capacity of 50,000 h.p. The catchment area of the Otra River is estimated at 1300 square miles. The overall water head amounts to 350ft, with an average water discharge of 7500 cusecs. The whole scheme will retain about 500,000,000 cubic yards of water. After completion of all these works the total capacity of the Kristiansand power stations will be 125,000 h.p. It may be of interest to recall that Kristiansand possesses an important harbour free of ice.

The Works of the David Brown Organisation

No. II—(*Continued from page 6, July 2nd*)

Hardening and Welding Shops

THE hardening shop is a department of particular importance in these works, not only because a majority of the components has to be heat-treated, but also owing to the fact that in most cases they have already undergone expensive machining operations and any scrap caused in heat treatment would be particularly costly. This shop is claimed by the firm to be one of the most up to date in the country, and much of its equipment has been specially developed or adapted for the class of work. Electric furnaces are used throughout and all operations are carried out under very close temperature control to schedules laid down by the laboratory.

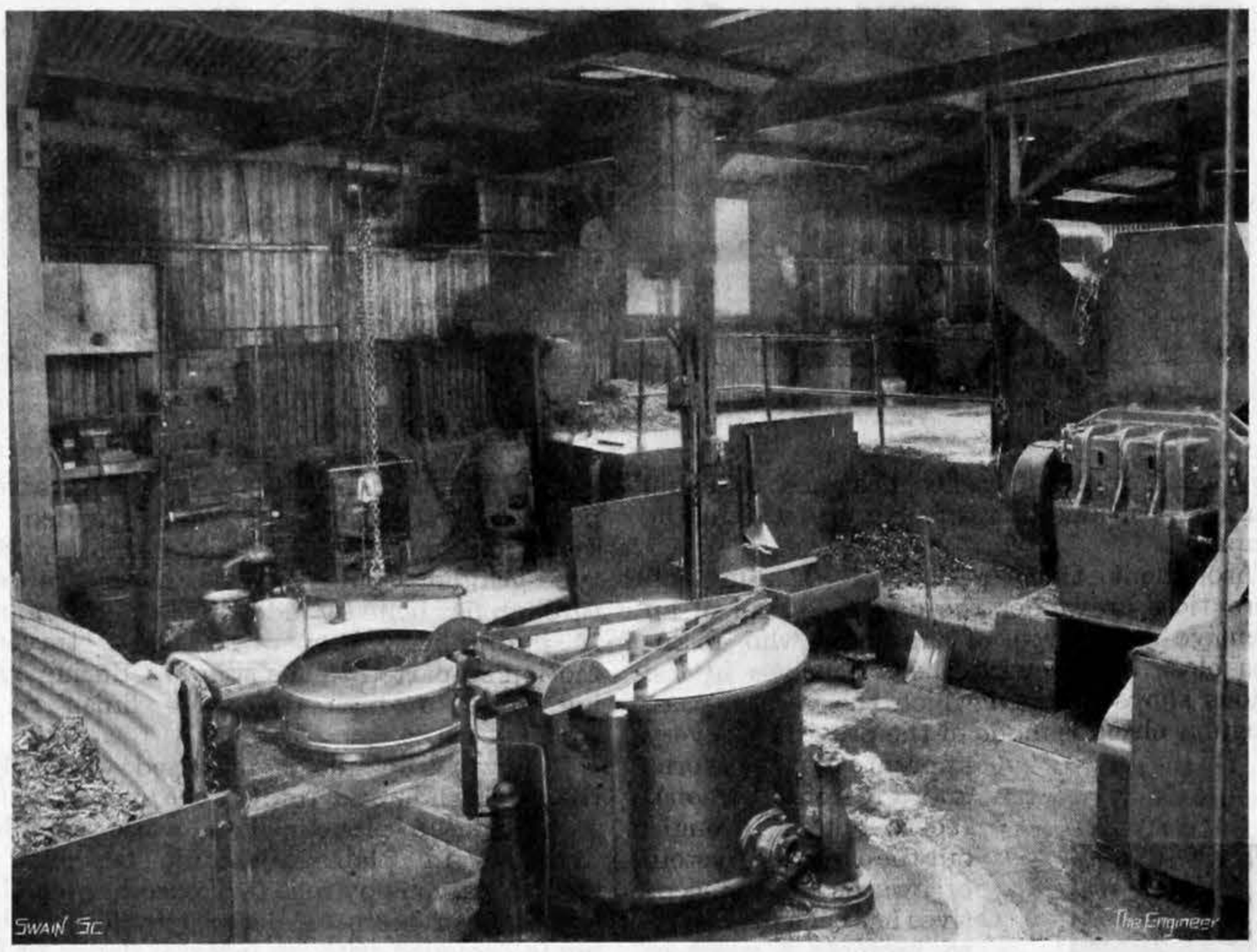
The equipment includes circulating oil baths for quenching purposes and vertical forced-air tempering furnaces working to a suitable time/temperature combination to ensure a consistent degree of specified hardness of components. A considerable amount of case-hardening is done and the six pack carburising furnaces used for this work are served by a charging machine running on rails between the two rows of three furnaces. A large plating section adjoining the heat treatment department is fully engaged on copper plating the areas in components which are required to be left soft after surface hardening.

During recent years a gas carburising process has been developed in this department. It involves the introduction of a powerful carburising gas into a temperature-controlled chamber containing the work. The process permits precise control of all carburising conditions to give consistently good results. Its use eliminates the dust and dirt involved in packing and unloading boxes in the normal way with the components and requisite carburising mixtures. This process has not yet been fully adopted, but its eventual introduction into general production will, it is anticipated, prove particularly acceptable. For the surface hardening of direct hardening steel components flame apparatus is being used, but we understand that experiments are in progress with induction heating apparatus for this class of work.

A certain amount of normalising and annealing of forged components is carried out in temperature-controlled electric furnaces. Normalising is done in a continuous roller hearth furnace, which can also be used as a continuous hardening or a continuous tempering furnace.

An important phenomenon particularly associated with direct hardening and case-hardening relates to changes which occur in the dimensions of components during hardening. Even though every precaution is taken to ensure that no internal stresses are present in the components before heating, and great attention given to even heating, it is inherent in the material that dimensions should change slightly. If the component is simple in shape and of uniform section, the changes in dimensions can often be tolerated, but for such complicated shapes as gears it is inevitable that dimensional changes must lead to severe distortion if the gears are allowed to quench freely. For this reason it is common practice to restrict the relative movement of gear sections by mechanical means during quenching. For bores which tend to close in, special plugs are available which are inserted in the component immediately before quenching. These plugs are pressed out after quenching, leaving the dimensions of the bore within specified limits. Considerable use is made of " Gleason " quenching machines which, in conjunction with specially devised jigs and fixtures, are used for preventing distortion. These machines are of particular value for such components as spiral bevel wheels, which are not usually finished by grinding.

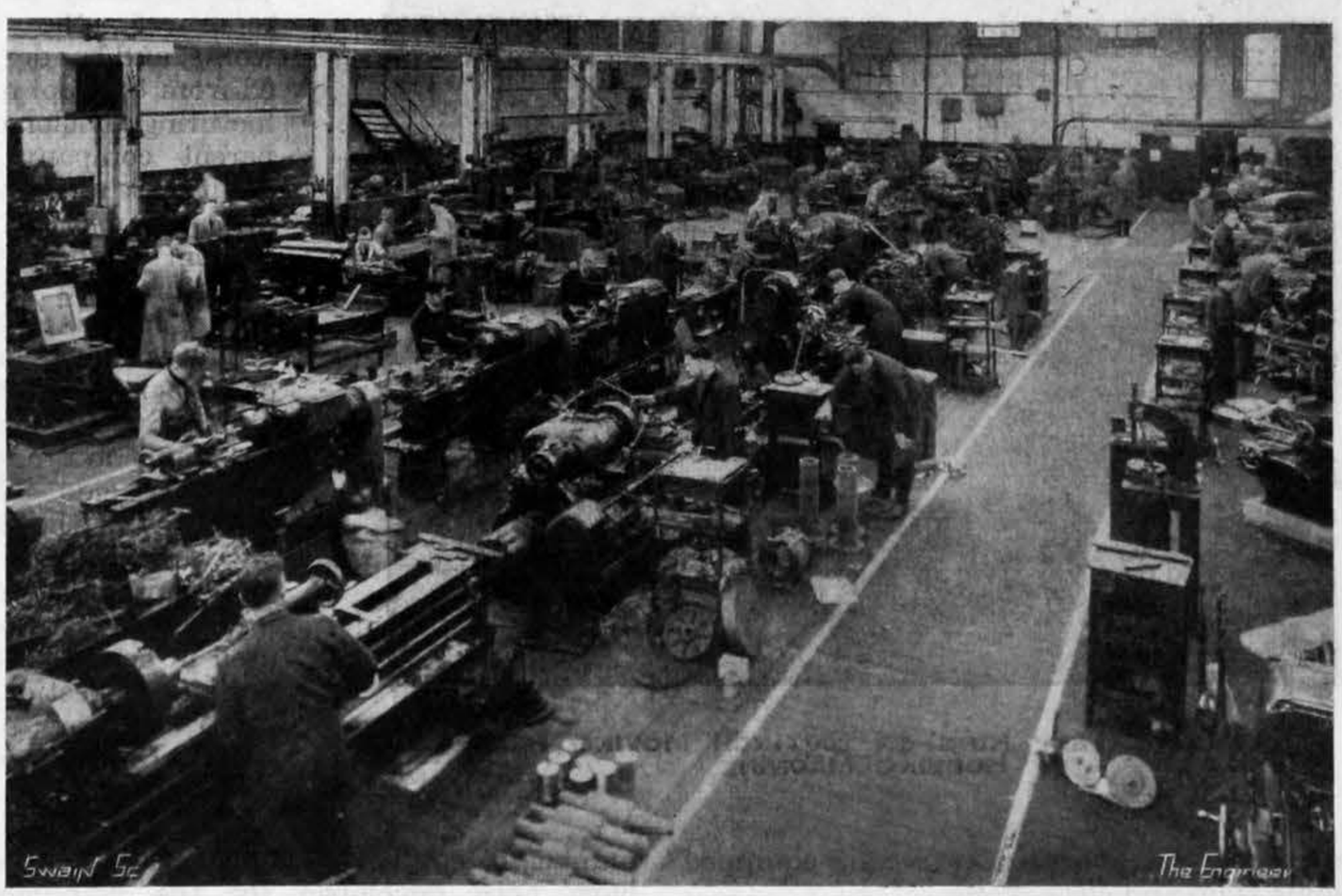
The Welding Department adjoining the hardening shop is particularly well laid out In keeping with the remainder of the works, it presents a clean, orderly appearance, with ample room for fabricating the very large gear cases and base plates required for heavy gear units. The whole of one side of the shop is fitted at intervals with hinged screens which normally lie against the wall. These screens can be swung out to form welding cubicles of any required size, according to the size of the work being fabricated. In addition to the gas and arc welding equipment a mobile flame-cutting machine and a " Shorter " flame-hardening machine are installed.



SWARF RECOVERY PLANT

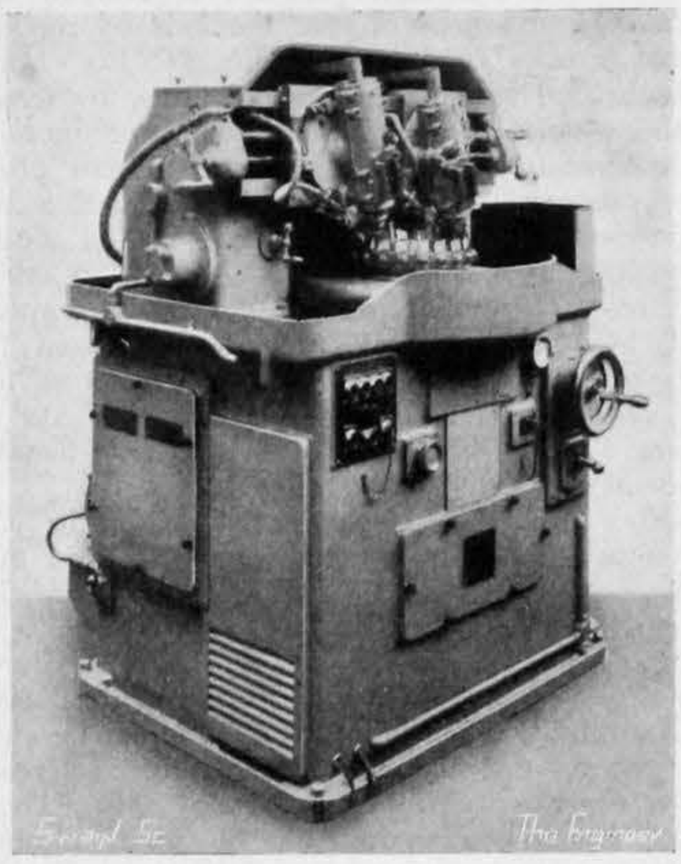
Swarf Recovery

As in most up-to-date works, a particular feature is made of swarf recovery, which is now regarded as one of the important factors in an economic organisation. The recovery plant at Park Works closely adjoins the machine shops. A special gang of labourers spends its entire time clearing the swarf and turnings from the machines. Each type of material is kept separate and transported in trucks to the recovery section, where it is dumped in the appropriate bin. These bins are situated on a floor about 3ft above the recovery plant floor and the swarf and turnings are shovelled from them into the hopper of a centrally disposed chip breaker. The ejection chute of the chip breaker is on the lower floor level and the chips falling from it are loaded into the bowl of a hydro-extractor. When a bowl is full of chips it is raised by a mono-rail block and deposited in the extractor, which is then sealed and started up. The oil removed in the extractor is cleaned in a centrifugal purifier and returned to stores for reissue.



TOOLROOM OF DAVID BROWN TOOL COMPANY

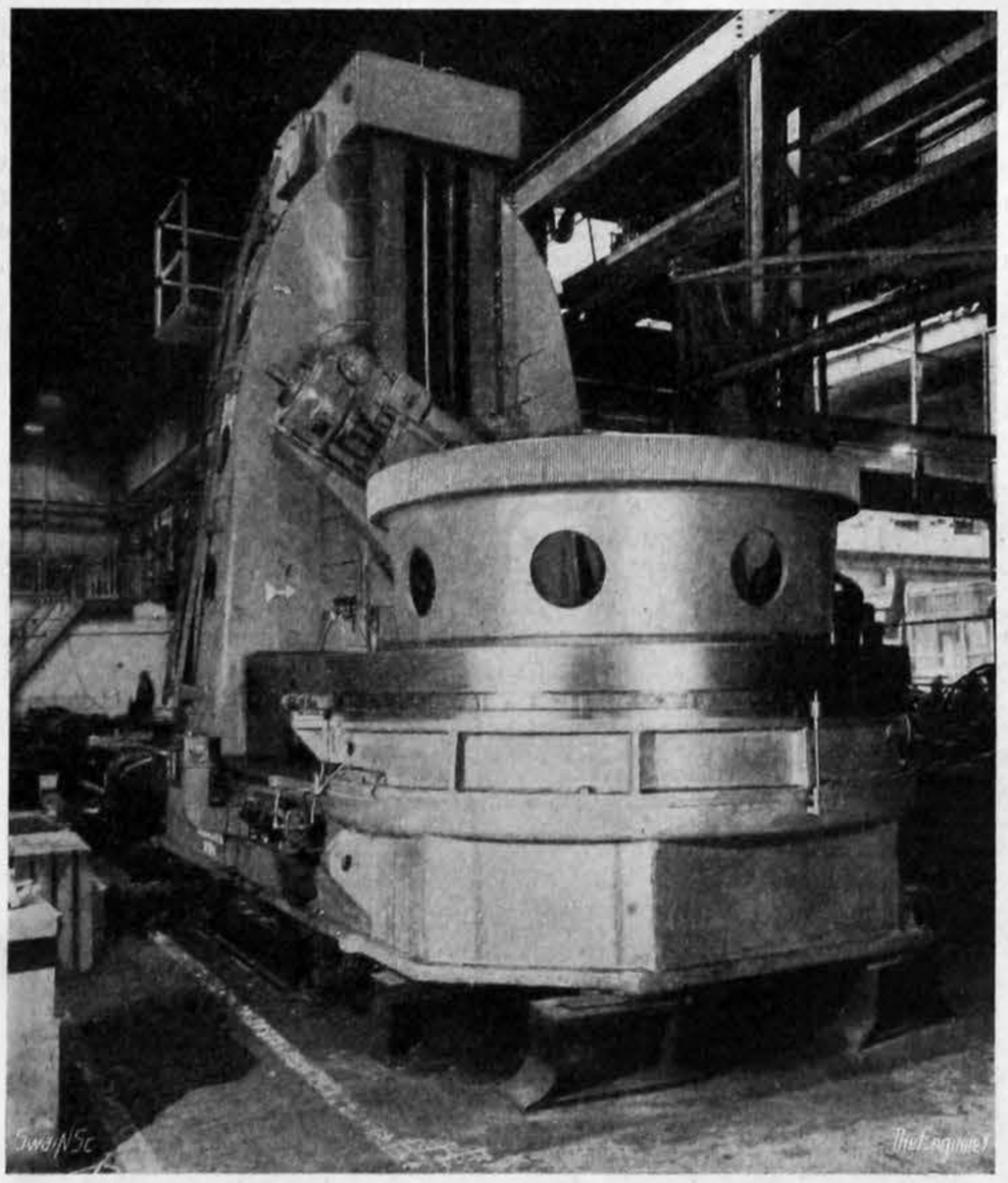
The cleaned chips are deposited in hoppers having grating floors from which chutes lead down to an outside roadway set at a lower level. Lorries can pull in onto the roadway below the chutes, where they are quickly and easily loaded with the chips without necessity for further manhandling.



SPIRAL BEVEL CUTTER GRINDING MACHINE

Apprentice Training

The training of apprentices is considered by the management to be essential in an efficient organisation and for training purposes a special section of the works with an independent staff has been allocated.



CUTTING TEST RING ON 200-INCH MOVING HEAD HOBBING MACHINE

The training section includes a fully-equipped machine shop and class rooms.

Three courses are laid down, a trade apprentice course, an engineering apprentice course, and a student apprentice course. For the first two courses the lads spend a probationary period of six months in the apprentice workshop, during which time they are given practical training on the various machine tools and attend special classes in the lecture room. On acceptance at the end of this period the apprentices are transferred to the main works for training in the various departments. At the end of the second training period the trade apprentices complete their training in a selected craft. Engineering apprentices continue to work at a trade until a suitable staff vacancy arises, or those who obtain a degree are transferred to the student apprenticeship course. The student apprentice course is of two years' duration and is designed to equip men for positions of responsibility within the company.

Throughout their period of training, all apprentices are under the direct control of an executive in charge of training, who maintains close liaison with the executives in the various shops through which the youths pass. A regular check is made of the progress of every apprentice in the works and a careful personal record is kept throughout the course. A system of awards and incentives has been instituted to promote a spirit of competition amongst the apprentices and encourage progress.



HEAVY MACHINE ASSEMBLY DEPARTMENT

The David Brown Tool Company

This company occupies premises which were originally the tool-room of the main works, and has developed from the tool manufacturing division of the parent company. In addition to manufacturing high precision hobs and cutters for all types of gear and worm-cutting machines, it also produces a wide range of jigs and fixtures for other establishments. An important and interesting side of its activities is the design and development of a variety of special machines and instruments used in gear manufacture and inspection.

In addition to the usual precision machine tools there are also used in this works a large number of specially designed machines, which have been developed for the manufacture, and, in particular, the relief grinding, of hobs. Special plant is also installed for the production of finishing hobs.

An interesting machine which was in production at the time of our visit was a relief grinding machine for spiral bevel cutters. Originally developed to grind the tooth profiles of spiral bevel cutters in the company's own shops, the machine is now produced for sale and several have been supplied recently to France.

This machine is semi-automatic in operation and has three independently controlled grinding heads. The three heads make it possible to grind the inside and the outside and the tops of the tooth profiles simultaneously. The two heads for grinding the sides of the cutter teeth are mounted on a rigid box-section bed, arranged vertically at the rear of the machine. These heads are adjustable for position and angle and are provided with scales and verniers for setting purposes. Shell-type grinding spindles in the heads are driven through flat belts by independent ½ h.p. motors. A hydraulically operated short traversing motion imparted to the spindles during grinding gives a high degree of finish to the cutter teeth.

The work spindle is mounted vertically in the work slide and rotates the cutter body in a horizontal plane. The work spindle is mounted in plain adjustable bearings and its final drive is by means of case-hardened and ground spur gears. A large spindle nose bearing is provided with an integral flange of large diameter for the reception of the cutter bodies or jigs. In operation, as the work spindle rotates it is raised by a cam to elevate each cutter tooth in turn as it passes across the grinding wheels. This movement imparts the necessary relief angle to each tooth.

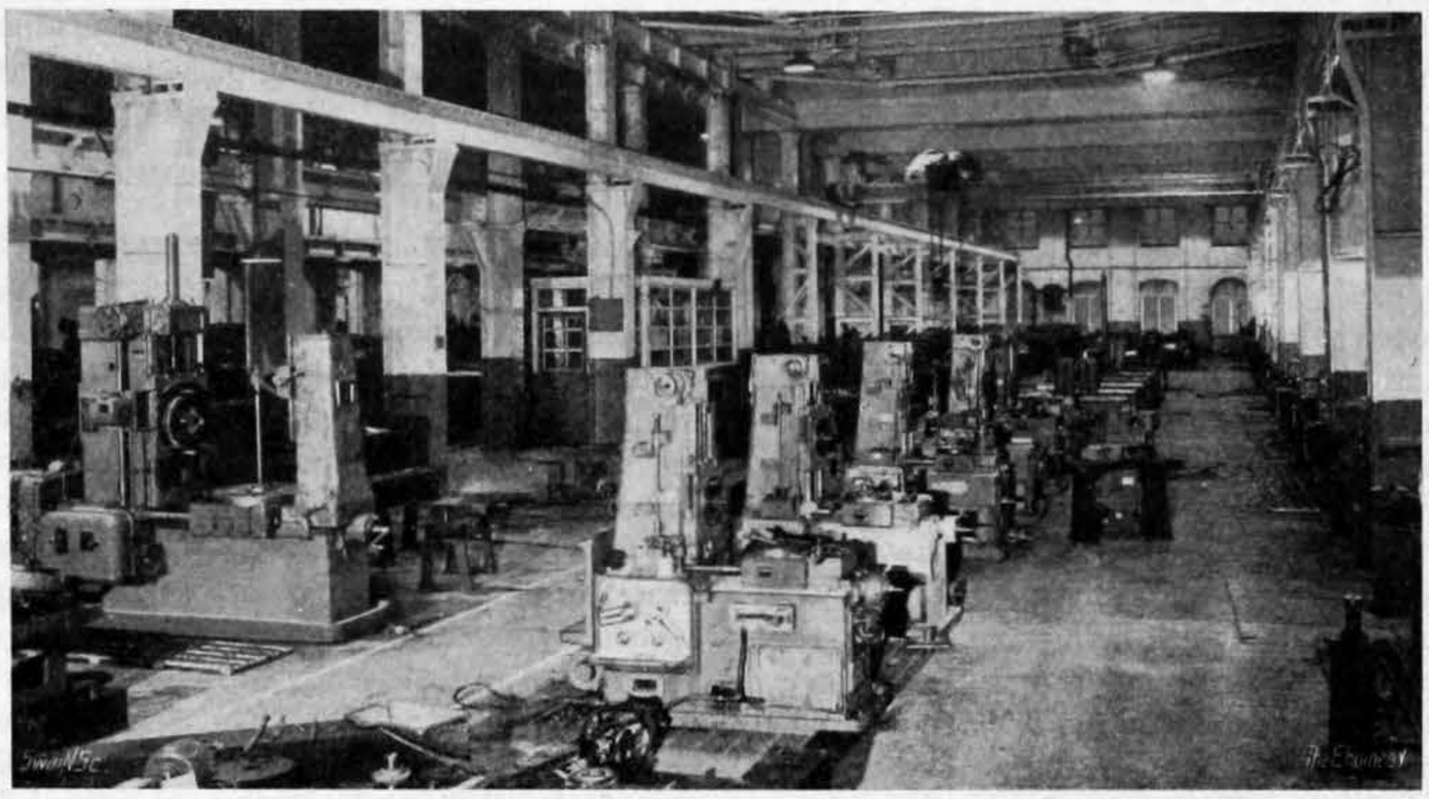
A separate department of the tool-room is engaged in the manufacture of the firm's improved type of adjustable reamer. This reamer has a permanent positive float and being self centring can be used with equal facility horizontally or vertically. No gears or spring mechanisms are used in its construction, movement of the blades being effected by a cam working in helical grooves on opposite hands.

David Brown Machine Tools, Ltd.

The premises occupied by David Brown Machine Tools, Ltd., of Manchester, are an excellent example of a carefully planned and executed modernisation of an old works. When the business of Muir Machine Tools, Ltd., was acquired some three years ago, the works premises were typical of more than half a century ago, and the plant layout was far from satisfactory from the viewpoint of modern production requirements. Despite the many difficulties encountered and the fact that urgent production was not to be interrupted, a complete reorganisation scheme was planned to take effect in a number of individual stages, and was put in hand at the beginning of 1945. The premises were altered, strengthened and rebuilt where necessary, and the whole of the plant and services rearranged to promote an easy production flow with full accessibility to all machines. The shops are now light, clean and well laid out, and the standard colour scheme described in our first article has been applied to good effect.

The works chiefly concentrates upon a range of hobbing machines, and has recently embarked upon the production of a range of gear-shaving machines.

Moving table hobbing machines are made in three sizes for producing gears of up to 15in, 30in and 60in, having face widths up to 8in, 12in, and 20in, respectively. The larger moving head hobbing machines are made in four sizes for maximum diameters of 75in, 100in, 150in, and 200in, with gear-face widths of 70in, 70in, 80in, and 90in, respectively. Two types of pinion hobbing machines made by the firm cut blanks up to 24in and 36in



ASSEMBLY OF MOVING TABLE HOBBING MACHINES

with face-widths up to 70in and 90in, respectively. Two pinion shaving machines are designed to handle work of a similar size. A range of six gear-wheel shaving machines covers diameters from 5in to 200in and face-widths from 2½in to 90in.

In addition to these products, the works are responsible for the production of special machine tools designed for the sole use of the parent company, including worm gear plant and hob production machines. As will be seen from the particulars given above, the smallest machines are of the moving table type. Each machine in this range is designed for the manufacture of spur and helical gears, or worm-wheels by incorporation of a tangential feed to the hob slide.

The moving head machines are built for two classes of production, high-speed turbine reduction gearing, and in similar capacities for general gear production up to 3in circular pitch. The design of these large machines, one of which can be seen undergoing tests in the photograph which we reproduce, is of some interest. They have a massive flat bed carrying a solid table at one end and an upright at the other. This upright is kept in alignment by square guides machined in the bed along which it is movable. In order to avoid extreme overhang of the hob slide when cutting small gears, the bed and base of the upright are widened so that the latter partially encloses the table when set over to machine small diameters.

The table is driven by a master worm-wheel and driving worm, the former having a large number of teeth of comparatively fine pitch to reduce to a minimum the pitch of the undulations caused by wave error. If required, a " creep " table may be supplied. This table is carried in a cradle bolted to the bed, which totally encloses the master wheel, the " creep " ring, and driving worm. The master wheel is a large diameter internal gear, driven by the " creep " ring, which comprises the spur wheel gearing with the master wheel and a worm wheel, with its driving worm. The driving worm is profile ground and is mounted on a separate bracket attached to the cradle. Large flat seatings are provided for the table, and the bearing of the centre spigot is a large-diameter casting, accurately ground to fine limits.

The upright is a heavy casting suitably ribbed to withstand heavy loads and to give the necessary rigidity. The hob slide, which is of ample width to ensure smooth movement on the upright guides, carries a swivel slide, which can be rotated by hand or power through 180 deg. In a main gearbox attached to the rear of the bed of the machine is all the gearing for the table, hob drive and feed screw. All the gearing is totally enclosed and removable covers give easy access to pick-off and change gears for the hob speed, spiralling, dividing, prime and feed. In addition to pick-off gears, three changes for the hob feed are incorporated. Feed may be stopped, started, or changed whilst the machine is running without affecting the helix angle of the gear being cut, and wheels of different numbers of teeth, but having the same helix angle, may be cut without changing the spiralling gear. Where necessary the makers fit a counterbalancing mechanism of the weighbridge type on the largest of these machines to relieve part of the weight on the table bearing surfaces. Alternatively, the practice is to incorporate oil pressure relief means in the table mechanism. The machines are particularly intended for the production of high-speed turbine gears, and are built to the latest B.S.I. standards, which are believed to be the highest ever set for machine tools of this nature.



ASSEMBLY OF HEAVY HOBBING MACHINE ON A SPECIAL FOUNDATION

PLANT LAYOUT

The production plant is arranged in a series of parallel bays, across the lower end of which is a heavy assembly bay for the erection of the larger machines. The main parts and materials issue stores are conveniently situated in close proximity to the first operation and final machine inspection.

The lighter machines are built in batches and one of our illustrations shows a group of moving table hobbing machines in course of erection. The method of production adopted for these machines is one of " flow production," whereby careful attention is given to dividing the machines into convenient sub-assemblies, so that they can be finally assembled to the main casting. Each component operation is carefully inspected to ensure high limits of accuracy. After final assembly, each machine is carefully checked by a series of alignment checks, and particular attention is paid to the lubricating system and general standard of finish, &c. During final inspection test cuts of the capacity of each machine are taken.

In all gear-generating machines the accuracy is mainly dependent upon the worm and wheel drive to the table and for generating these gears a master hobbing machine, installed in a temperature-controlled room, is used. This master machine is many years old and its accuracy has been developed by the successive manufacture of its own gear wheels during the generation of each one of which a degree of the error in the previous wheel was eliminated. For the production of lead screws a specially designed master lathe has been built and laid down in a separate room incorporating means of automatic temperature control within very close limits.

For the assembly of the big hobbing machines a special vibration free heavy machine foundation has been constructed. The necessity for a perfect foundation for these machines will be appreciated from the fact that each weighs in the region of 100 tons, and is designed to support work weighing up to 80 tons on its table. When in operation the accuracy is such that a deviation of 0·0005in only in 120in, both vertically and horizontally, is the maximum permissible amount. The need for a new machine foundation arose when the plant was being rearranged and the bearing quality of the new site was found to be too poor to permit the close accuracy which is essential when erecting the larger machines.

The new machine foundation consists of a mass concrete bed 36ft 4in long by 12ft 10in wide by 7ft deep below the floor level over parts of its length and 5ft 6in deep for the remainder. It is covered with 9in thick steel bedplates. The foundation has been cast within a pit constructed of reinforced concrete with 6in thick walls and with a 9in thick base slab, lined internally with asphalt and compressed cork slab.

(To be continued)

L.M.R. DIESEL-ELECTRIC EXPERIMENT.—By a modification of the fuel injector equipment, the engine output of diesel-electric shunting locomotive " No. 12045," which has recently been built at Derby Works, London Midland Region, has been raised from 350 h.p. to 400 h.p. at 680 r.p.m. The object of this experiment is to ascertain whether the additional power can be used effectively in shunting operations.

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

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COMPLEXES AND COMPLEXITY

DR. WILLIAM BROWN is an eminent psychologist. He knows all that Freud, Adler and Jung have ever written. The strange jargon of the science is "household words" to him. He writes books about it, lectures on it, practises it. We may take what he says for gospel; and what he does say in "Oxford Essays," recently published, is that when ordinary people talk about the inferiority complex they are trifling with a serious matter. What they mean is usually no more than the innocent fact that they themselves, or so-and-so, are conscious of their limitations. That is a straightforward feeling with no ulterior malign consequences. There is no complex about it, for the complex is the dreadful things that occur when a simple sense of inferiority runs away with one. In fact, to put it neatly, in Dr. Brown's own words, the inferiority complex is "a distorted conscious reaction in the mind of the individual to a repressed or rejected feeling of inferiority."

It would not matter a brass farthing whether we, as engineers, understood or did not understand what that meant, were it not for the fact that the scientific interpretation of human reactions is working its way into the new management. Our fathers and our forefathers prided themselves on knowing human nature, they believed firmly in selfwill; they were convinced that men could control their own actions and were responsible for all their acts. Biology and psychology have shaken that simple faith. We are informed that the ductless glands play ducks and drakes with our moral standards and that many of our mental reactions are conditioned by causes—complexes—over which we have, without specialised help, very little control. When, for example, we offer inducements to workpeople to produce more we often presuppose that nothing more is required, that the employees' reaction will be just what we expect and that production will rise and contentment will reign. Often nothing of the kind happens. The employee indeed takes the inducement but his attitude to his employer remains what it was. In working-class circles more than in clerical, the real "inferiority complex" has been nurtured by a long sequence of agitators and social reformers. Few, if any of them, were conscious of the scientific nature of the methods they employed. Nevertheless, they followed a plan that might have been prescribed by a psychologist. They began by making the workers conscious of inferiority; they told them that they were being exploited; that their faces were being ground; that they were ill-treated helots. They encouraged them to hate those who made them feel thus inferior. That is the basis of the detestation of "power." People hate the sense of inferiority to any one else. They have been taught to regard those in authority over them as their enemies. Appeals to them to remember that the interests of employers and employed are one and the same leave them cold. They mistrust the best intentions. Co-partnership is a device for destroying trade unions; welfare, tending the horse to get more work out of him. The new management seeks to overcome these old reactions to make the appeals effective by bringing representatives of the workers into management so that they may see for themselves that the unity of interest is a real thing. Will it break down the fifty-year-old inferiority complex; the hatred directed against everything and everybody, quite impersonally, that gives them a feeling of inferiority?

The inferiority complex is an invention, or, rather, discovery of the psychologists. They claim their ability to overcome it in individuals. They are now entering industry. Mr. J. J. Gillespie says, in "Free Expression in Industry," "on the whole, the type of person practising industrial psychology has been critical of management scientifics and on the side of the humanities." Management has had to take the world as it found it: its methods were conditioned by the era in which they were practised. Absolute authority and obedience were fixed levels up to less than fifty years ago. They are gone or going. Reasonableness is to replace them; reasonableness directed by industrial psychology. Good employers and good managers have always practised psychology, only they called it knowledge and sympathy with human nature. There were lots and lots of contented work people in happy works under the old name. No one had told them they were inferior. They were actually proud to have a successful and well-to-do employer. The virus of the inferiority complex had not entered their systems. Progress and changing conditions have almost submerged that old spirit. It is hard to maintain in vast works with mass production methods. Moreover it is discouraged by the leaders of labour; it is held to have the odour of feudalism. But it had its high qualities. There was something very human and very humane about it. The devotion to a chief, the pride in a firm, brought out the best in the workers and gave them contentment. Fifty years hence we shall know if the scientific methods of the new management and industrial psychology have been able to substitute for it something better still.

EXPERIENCED ENGINE ERECTORS

THERE was a time when the success of the business of Boulton and Watt depended, in a really vital degree, on a single craftsman, William Murdock. This man was no scientist in the accepted sense of that word. He was a mechanic by intuition and an extremely clever engine fitter. He had learned his art by practising it and Watt was quick to recognise this point. He once wrote to Murdock agreeing that "it is a great thing to find out what will not do, it leads to finding out what will do." That is why, when they were in trouble with an engine, Boulton and Watt sent for "William." But to-day there is a growing dearth of "Williams."

No one is likely to question the need to build up a reservoir of men competent to erect and overhaul (at sites remote from the factory of origin) the products of our heavy engineering industry. Engine erection is an art which can only be learned by doing, and it is a trite observation that erection and first adjustments are 80 per cent of the success of an installation. The skilled erector is, moreover, the finest of trade ambassadors, since on his work depends the reputation of the manufacturer. But no engine erector can be produced from a machine minder. The erector must not only possess an original flair for the job. He has also to be specifically trained for it and it should surely be part of the business of manufacturers to select and train these men, realising that they are among the assets of their business and as such worthy of full consideration and adequate remuneration. For there is all the difference in the world between a collection of packing cases containing an engine and the establishment, from the contents of these cases, of a satisfactory installation on a remote site. No schedule of instructions, exact as it may be, can take the place of the hands and brain of the man who supervises the completion of the foundation, puts the equipment together, makes the first adjustments, cares for the installation auxiliaries and starts the job up. It is practical men that are particularly needed and the idea that a university student with some months of practical training can become fitted for the job of setting up heavy machinery is just nonsense. An erector must, we repeat, be a man definitely trained for the work and with some gift for it. There is no other way of training such men than by long and arduous practical work, and in this connection we should always remember that while a science is something we learn by knowing, an art—such as engine erection—is something we learn by doing. In our concentration on technical training are we not in danger of forgetting the wise axiom which tells us how "The years teach much that the

days never knew" ? There is no synthetic substitute for experience and one of the major aims in all branches of human effort is the application, to the utmost extent, of its lessons.

In the early days of the steam engine, Watt (a good geometrician) was sorely troubled by lack of skilled erectors. A letter is extant in which, complaining of difficulties with an engine in Cornwall, Watt mentions that he attributed the sluggishness of the working to "perhaps a board, a bunch of oakum, somebody's hat or coat ... left in ye cylinder and come into ye nozzle (i.e., the steam valve)." Such things—and much worse—happen even now and they will always happen when there is no skilled supervision of the essential task of erecting and putting to work. There are, it is true, many manufacturing firms who, with an enlightenment which deserves all honour and encouragement, pay detailed attention to the thorough training of trade apprentices. Their number, we believe, to judge by several reports of new schemes recently put into operation that we have received, is growing. There are, however, still too few of them. It would be easier to build up a reservoir of well-trained erectors if there were a more general and conspicuous recognition of the fact that such men are valuable, indeed indispensable, and ought to be respected as such—to be respected, indeed, as Boulton and Watt respected Murdock.

Obituary

DOUGLAS RUDOLF POBJOY

AERONAUTICAL engineers will learn with regret of the death of Mr. D. R. Pobjoy, at the age of fifty-four, which occurred on Sunday, July 4th, when in low cloud an R.A.F. Transport Command "York" and a Swedish "Cloudmaster" collided over Northolt, Middlesex. We regret to have to record that there were no survivors among the thirty-nine persons aboard the two aircraft.

Mr. Pobjoy was a Bristol man, and he was trained as an engineer and gained his B.Sc. degree at Bristol University. He worked with Basil Straker and served in the Royal Field Artillery in the 1914–18 war. When the design of the "Jupiter" aero-engine was taken over from Mr. Straker by the Bristol Aeroplane Company, Ltd., Mr. Pobjoy joined that firm. He specialised in aero-engine design and from 1919 for four years worked on the development of the Bristol aero-engine. In 1924 he joined the Armstrong Siddeley Company, Ltd., and did similar work in connection with the aircraft engines of that firm. In 1926 he produced his own design of engine for smaller aircraft, a small geared radial engine, which in 1928 was successfully type-tested.

About 1930 Mr. Pobjoy founded the firm of Pobjoy Airmotors, Ltd., and under his personal direction some 600 aero-engines were produced and put into service, most of them being of the 80 h.p. to 100 h.p. type. Later that business was taken over by Short Brothers, Ltd.

In 1940 Mr. Pobjoy joined the Gloucester firm of Rotol, Ltd., with which he was responsible for the design and construction of a range of aircraft auxiliary engine gearboxes, which were fitted to many aircraft. He also produced the "Rotol" auxiliary aircraft generating plant, which consisted of a compact six-cylinder sleeve-valve engine, coupled to a generator. Later he designed a range of cabin superchargers for air conditioning services, which were fitted in transport aircraft. In 1945 he was appointed chief engineer of the Auxiliary Division of Rotol, Ltd. When, however, after the war, Mr. R. H. Coverley, the Controller of Rotol, Ltd., retired and interested himself in industrial developments in Grantham, Mr. Pobjoy also went to Grantham and was, we understand, engaged in engineering work connected with those developments.

Early this year he returned to the Bristol Aeroplane Company, Ltd., for a few months and about three months ago Mr. Pobjoy was appointed development engineer with Newman Industries, Ltd., of Grantham, in connection with that firm's programme of agricultural tractor and implement production. In 1945 Mr. Pobjoy was made a Fellow of the Royal Aeronautical Society. Although he was of a retiring nature, Mr Pobjoy was a talented designer, who did much for the aircraft industry. His death at a comparatively early age in one of Britain's worst air disasters will be widely regretted alike by the firms he served and the many friends he made in the engineering industry.

Letters to the Editor

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

TRAIN SERVICE COMPARISONS: HIGH-SPEED STEAM LOCOMOTIVES

SIR,—Mr. Livesay's proposed 250-ton 4–6–2 : 2–6–4 "Beyer-Garratt" type express locomotive, designed to work 600-ton trains between London and Glasgow at an average speed of 60 m.p.h. overall, including six intermediate stops, is certainly noteworthy. But, if he will accept a friendly and objective criticism, a fair appraisal of his engine, based on the particulars he gives, raises serious doubts whether it would fulfil his own expectations. Why ? In essence, because its steaming capacity would be inadequate. The boiler, and more particularly the firebox and grate, are not large enough for the exceptional service in view. The following table compares his engine and train with the pre-war L.M.S. "Coronation Scot" train with its "Pacific" type locomotive, and the proposed lightweight train with the "Atlantic" type locomotive, suggested in my letter last week. These figures speak for themselves :

	Proposed "Garratt"	L.M.S. "Pacific"	Proposed "Atlantic"
Total weight (locomotive and train), tons	850	450	330
Tractive effort (at start), pounds ...	60,100	40,000	23,500*
Grate area, sq ft ...	65	50	48
Grate area, per 100 tons total weight	7·65	11·11	14·54
Grate area, per 1000 lb tractive effort	1·08	1·25	2·04

* 65 per cent maximum cut-off.

The "Garratt" has 45 per cent more weight to shift, per square foot of grate, than the "Pacific."

A necessarily very approximate assessment of the probable power and performance of Mr. Livesay's locomotive may be of some interest. It may be observed that although it has 30 per cent more grate area than the L.M.S. "Pacific," apparently it has less than 20 per cent more firebox volume ; with two siphons it may be less than 15 per cent more, and large firebox volume is essential, especially at high rates of firing, for high-power output dependent initially on efficient combustion (which, incidentally, never proceeds to any appreciable distance along the tubes). Allowing for the use of a mechanical stoker, and utilising the steam expansively, the maximum power output of Mr. Livesay's engine may be assessed, fairly optimistically, at 3500 i.h.p. This should be available between 50 and 60 m.p.h., with some diminution at higher speeds ; at 90 m.p.h., the maximum speed contemplated, it might be below 3000 i.h.p. The total resistance of the locomotive and train, on straight and level track in still air, probably would exceed 9000 lb at 50 m.p.h., and 16,000 lb at 90 m.p.h. When climbing adverse gradients, under otherwise favourable conditions, it should be able to maintain 50 m.p.h. up 1 in 110, 60 m.p.h. up 1 in 180, 70 m.p.h. up 1 in 360, and 80 m.p.h. up 1 in 1500, or thereabouts. At 90 m.p.h. the total resistance exceeds the tractive force available, so this contemplated maximum speed would be attainable only on falling gradients. To sum up the foregoing briefly, in terms of a regular service from London to Glasgow, it seems most likely that it would (1) seldom attain 90 m.p.h. ; (2) seldom attain 80 m.p.h. on the level ; (3) fall below 40 m.p.h. on Shap and Beattock ; (4) take nearer eight than seven hours, overall, averaging nearer 50 than 60 m.p.n. To satisfy the specified requirements something larger or more powerful would be necessary.

R. OPIE, B.Sc.,
M.I.C.E., M.I.Mech.E.

London, June 28th.

SIR,—The correspondence in your columns concerning train services between London and Glasgow must have come as a forcible reminder to many of the lethargy of present-day timings over this route. While I am not in a position to criticise, it does seem very strange that whereas the Eastern Region "Flying Scotsman" can make the London-Edinburgh run in 7 hours 50 minutes, the "Royal Scot" crack express of the West Coast route, takes exactly one hour longer ; even allowing for four extra stops and heavier gradients in the north, the difference seems excessive.

If it is not possible to improve on the present timings of the "Scot," the question arises, is it possible to improve upon 8 hours 50 minutes for the 400¼-miles at present ?

From my own experience as a recorder of locomotive performance, I should say that a "Duchess," with eight or nine cars, 270–300 tons, could quite easily make the run in 7½ hours, even nowadays. Assuming a departure from Euston at 1 p.m., this would mean an arrival in Glasgow at 8.30 p.m.—a vast improvement on the present leisurely midday caravan for the north.

On one run, in April, 1947, I timed such a train to run from Carlisle to Beattock summit in fifty-three minutes, whereby sixteen minutes of lost time were regained and more also. With such a reserve of power, a train of this description should overcome all but the worst slacks, and provide a service which, apart from being more in keeping with the "Scotsman," "Cornish Riviera Express," and "Bournemouth Belle," would be popular, and an answer to a long-felt need.

W. J. ALCOCK.

Royal Naval Engineering College, Plymouth,
July 4, 1948.

PRODUCTION PER MAN HOUR

SIR,—I suggest that Mr. Oliver Lyle's example is too particular to have general application, although I have no doubt there are many others like it.

I only gave a very brief outline of Ord's book, and I can only repeat my view that it

seems to contain a great deal of sound common sense, which we shall neglect at our peril. Automatic processes using a minimum of producers certainly have their uses, and so have costs ; but I fear they are not the whole story.

H. G. P. TAYLOR

Shoreham-by-Sea, July 5, 1948.

Literature

SHORT NOTICES

Sub-Station Practice. By T. H. Carr, A.M.I.C.E., M.I.Mech.E., M.I.E.E. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 32s. net.—A worthy companion to the author's "Electric Power Stations," the book at present under review gives a comprehensive account of the theory and practice of sub-station design, construction and operation. Although particular aspects of this subject are dealt with exhaustively in published literature on switchgear, transformers and converting plant, there is room for a book such as this which correlates, and adds to, existing knowledge in this important branch of power supply engineering. The early chapters of the book are concerned with general principles governing the choice of sites and the classes of sub-station commonly used to meet various requirements. Plant lay-out in the sub-station and the constructional work involved in buildings and supporting structures are discussed in separate chapters. The book continues with a more detailed consideration of the electrical equipment ; switchgear, transformers, reactors, regulators and converting plant are dealt with in turn, and a separate chapter is devoted to the important subject of electrical protective systems. The remainder of the text forms a detailed study of the technical and administrative aspects of sub-station control and organisation, including such matters as short circuit calculations, plant economics, parallel operation, system control, supervisory control equipment and safety regulations. A bibliographical list at the end of each chapter enhances the worth of this useful reference book.

Metal Spraying and Sprayed Metal. Third edition. By W. E. Bullard, F.R.I.C., F.I.M. London : Charles Griffin and Co., Ltd., 42, Drury Lane, W.C.2. Price 32s. net.—The third edition of this book brings to the notice of the many users of metal-spraying equipment the latest developments and improvements in connection with the practical application of the process. Not only has the author succeeded in retaining the interesting scientific background of the subject, so well presented in the earlier editions, but he has added considerably to the valuable practical information to bring the book fully up to date. In order to keep the book within reasonable compass a certain amount of the information in the now well-known historical development of metal spraying has been deleted. The various processes with the different types of pistols and equipment used are described in lucid detail in the early chapters of the book. Other sections deal with spraying plant installation, special processes, the nature of sprayed metal and the properties of metal-sprayed surfaces. Interesting and informative comparisons are given of metal spraying with other methods of protection and deposition. The book is well illustrated, and each chapter concludes with a list of references which will be useful to the reader requiring further detail on certain points.

BOOKS RECEIVED

Vertical Boiler Defects and Repairs. By Sydney D. Scorer. London : John D. Troup, Ltd., 90, High Holborn, W.C.1. Price 5s. 6d.

Form Tools. By William F. Walker. London : Hutchinson's Scientific and Technical Publications, 47, Princes Gate, S.W.7. Price 25s.

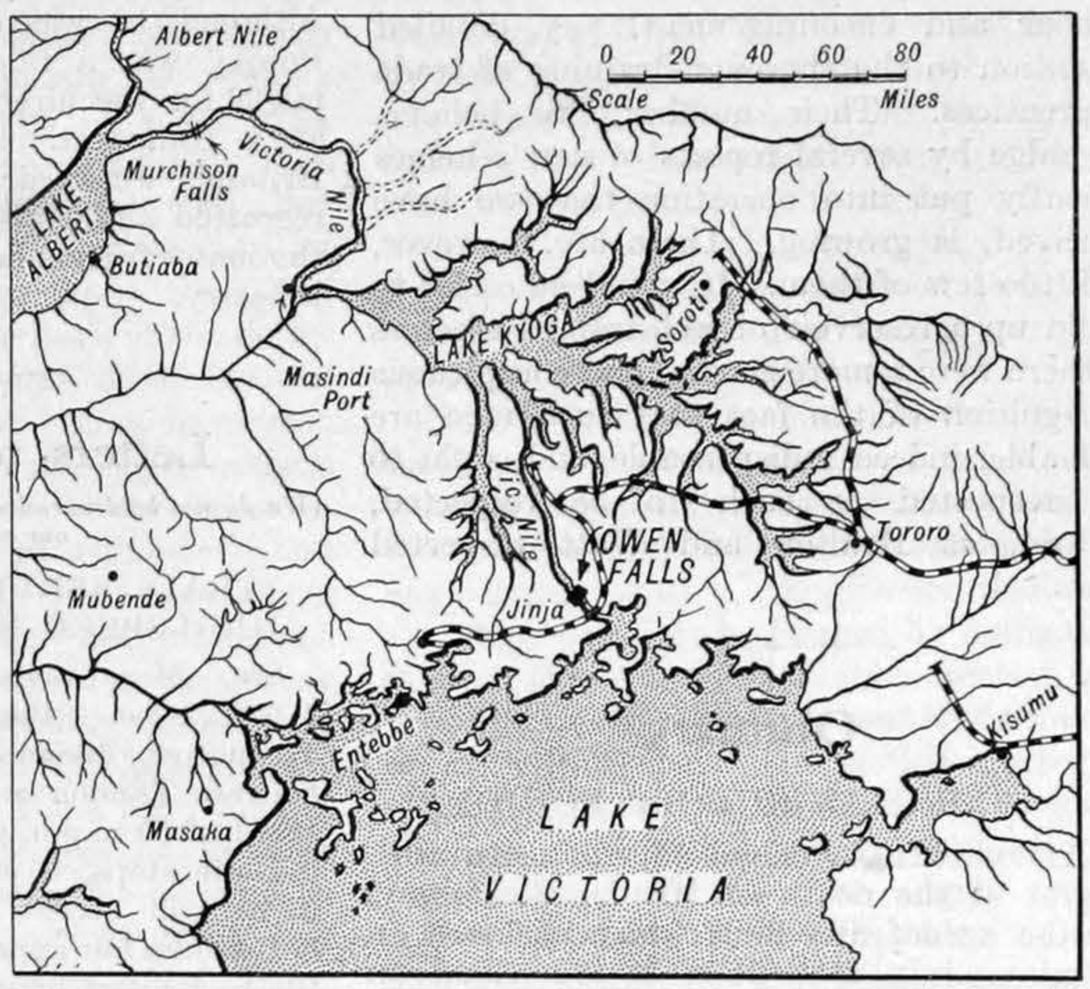
Steel Files. By Eric N. Simons. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 15s.

Gear Trains. By H. E. Merritt. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 30s.

Owen Falls Hydro-Electric Scheme

ON the instructions of the Under Secretary of State, Colonial Office, received in the middle of 1947, the two firms of consulting engineers, Sir Alexander Gibb and Partners and Messrs. Kennedy and Donkin, have jointly prepared a project report on the development of hydro-electric power at the Owen Falls site, near Jinja, on the Victoria Nile, East Africa. It envisages the construction of a dam and power station with hydro-electric plant of an installed capacity of 121,500kW.

Lake Victoria, around the shores of which are the three territories of Uganda, Kenya and Tanganyika, is a vast inland lake in East Africa, having an area of some 26,000 square miles (approximately the same size as Eire). Water discharged from the lake passes down the Victoria Nile through Lake Kyoga to Lake Albert, on the borders of Uganda and the Belgian Congo. Between the two lakes there is a difference of level of about 1700ft in the comparatively short distance of 260 miles. At Lake Albert the Victoria Nile joins with the water flowing from the catchment of that lake and flowing through the Sudan as the White Nile joins up with the Blue Nile at Khartoum, eventually reaching the Mediterranean Sea near Alexandria. It is of interest to note that the difference of level over the approximate 3000 miles stretch between Lake Albert and the Mediterranean is only a little more than that between Lakes Victoria and Albert. Lake Victoria therefore offers a quite exceptional opportunity for securing complete control of the headwaters of the Nile and provides a simple solution to the provision of adequate storage, which is often the greatest obstacle to the efficient use of the power resources of a river system.



LAKE VICTORIA AND SURROUNDING AREA

The report contains a very detailed study of all available statistical records relating to lake and river levels and rainfall, and the conclusion is drawn that over the considerable period during which records have been kept, the average long term discharge in the Victoria Nile amounts to 22,300 cubic feet per second, or about nine times the average discharge of the River Thames at Teddington. It may be of interest to note that if the whole of the difference of level between Lakes Victoria and Albert could be developed for hydro-electric purposes, the amount of power which could be made available annually would be about 22,000,000,000kWh, a quantity of electrical energy which would have been sufficient to meet the total electricity requirements of the United Kingdom in the year 1937.

River Flow through Egypt and Sudan

As is natural, the countries through which any river passes are interested in the quantity of water flowing in that river, and in the time of year at which it flows. This is particularly so in the case of Egypt and the Sudan because there is a great deficiency of rainfall in those countries and the agricultural economy is therefore largely based upon using the waters of the Nile for irrigation.

There are various possible sites on the Victoria Nile, in addition to that at Owen Falls, which are suitable for the construction of hydro-electric stations. In order to make it possible to install at each of these stations in the future the maximum capacity of generating plant, it would be necessary to smooth out the normal fluctuations in the discharge in the Victoria Nile. As this may not be convenient to the irrigation programmes of Egypt and the Sudan, the question is now being discussed between representatives of the Governments concerned in order to establish a basis of regulation which will not only permit the maximum use of the water flowing in the Victoria Nile for hydro-electric purposes, but will also provide additional storage in Lake Victoria for use when required by Egypt and the Sudan.

The capacity of plant to be installed in the station at Owen Falls will thus depend on the outcome of the discussions at present taking place in Egypt, and upon other factors on which no comment is necessary here. The report recommends that the station should be so designed as ultimately to be capable of housing not less than eight water turbine-driven alternators, rated at 15,000kW each, and it is proposed that three of these units should be installed as the initial development.

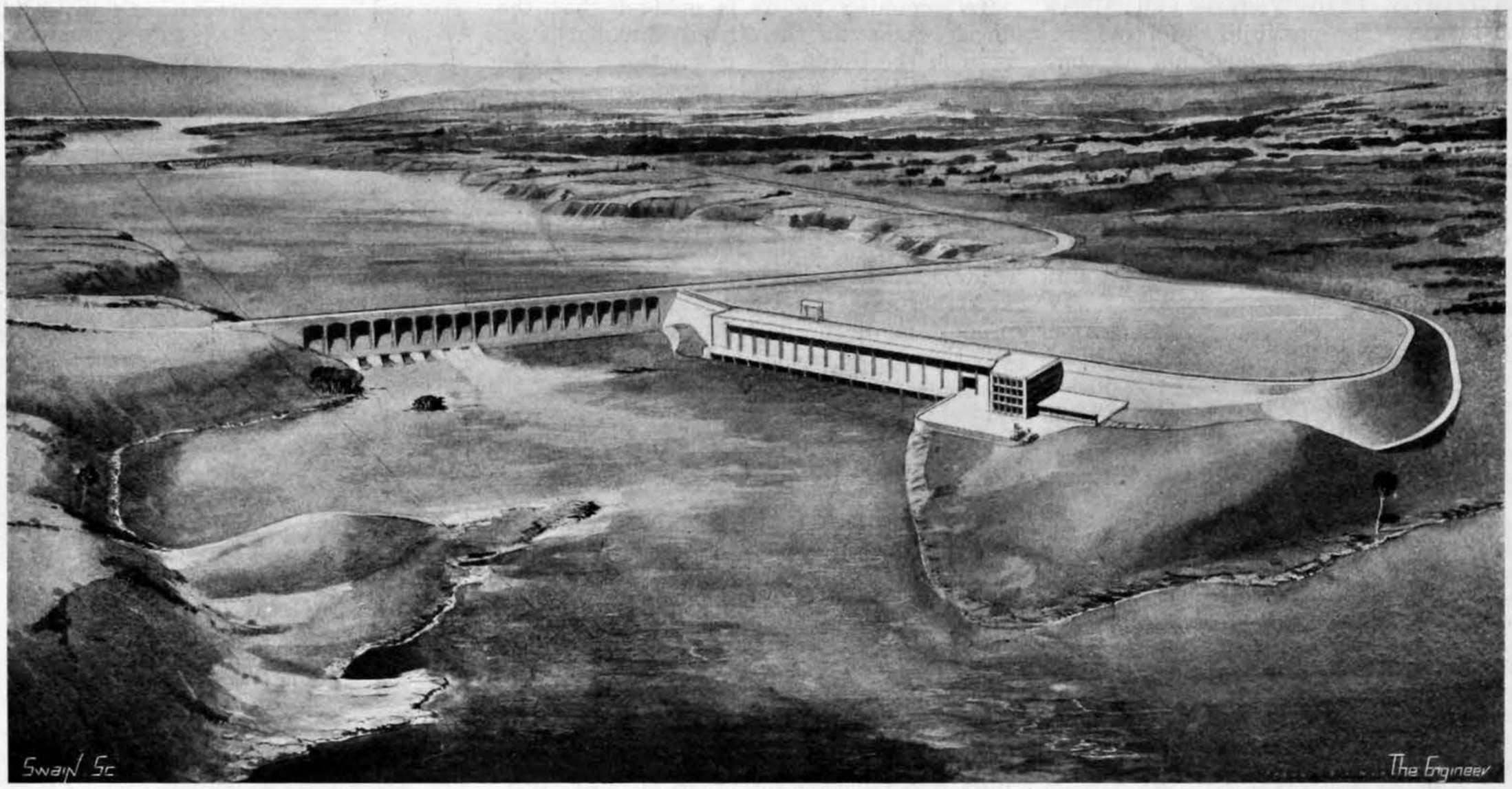
Owen Falls Works

The proposed hydro-electric station at Owen Falls would involve the construction of a dam closing the eastern channel, and a second dam incorporating the power station closing the western channel. The former is a mass concrete gravity structure about 650ft in length and 66ft in height, pierced by six culverts controlled by sluice

gates, which would permit the release of water from Lake Victoria in addition to that utilised by the hydro-electric station. The dam incorporating the turbine intakes and the power station is about 590ft long and of similar height, and is also constructed in mass concrete. An accompanying illustration gives an impression of the completed works and another illustration gives sectional views through the dam and power station. The power station building proposed is of modern design, complete with control room, offices, workshops and stores. The head of water available for power purposes is approximately 60ft, and it is proposed that turbines of the Kaplan type should be utilised.

It is proposed that power should be generated at 11,000V, this voltage being stepped up to higher voltages for transmission to other parts of the Protectorate. The cost of the initial development, including three 15,000-kW units and all those features which are necessary to facilitate the future increase in the number of units to a minimum total of eight, is estimated at £4,160,000, the estimated cost of the completed project, with eight 15,000-kW units being £7,120,000.

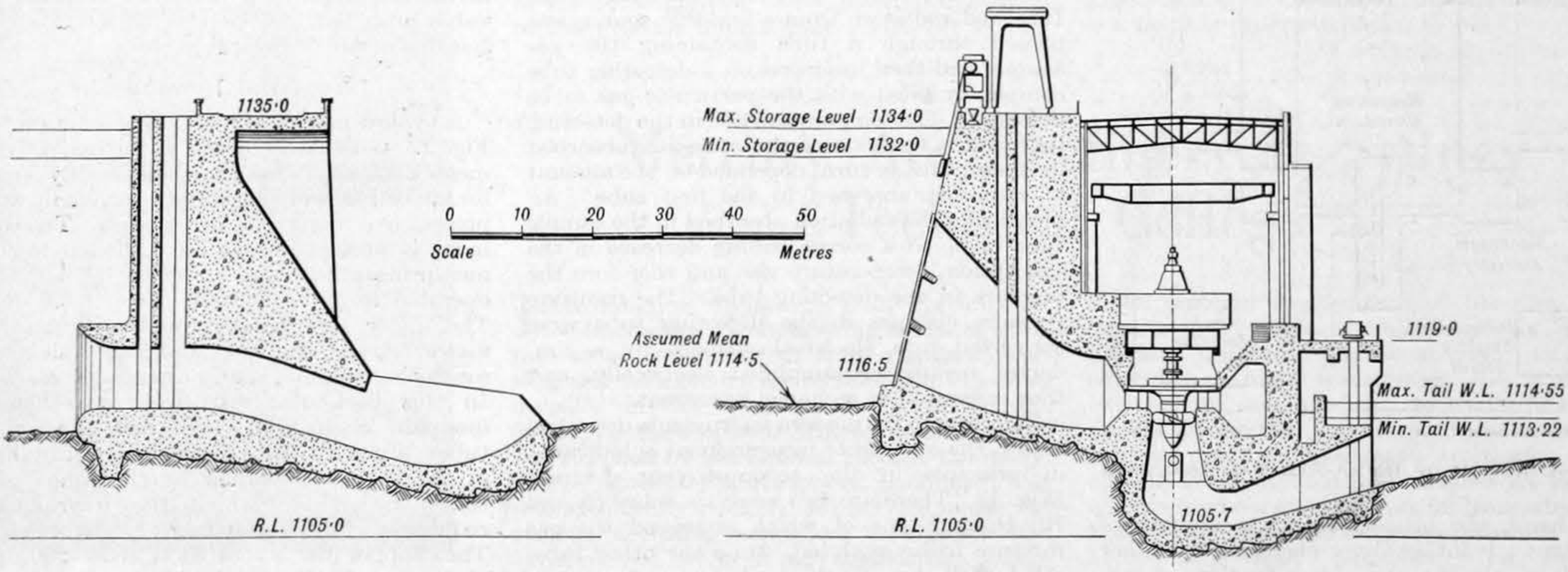
If the electrical demand in the Protectorate enabled the whole of the regulated flow in the Victoria Nile to be utilised for power purposes at a continuously steady rate, that is to say, if the annual load factor of electrical supply approached 100 per cent, the cost of energy at the station when developed to the minimum suggested ultimate capacity of eight units would be 0·841 cents per kWh. At the correspondingly lower annual load factor of 70 per cent the cost would be 1·203 cents per kWh. During the initial stage of development, with three units installed, the cost of energy is estimated at 1·71 cents per kWh at 100 per cent annual load factor, 2·45 cents per kWh at 70 per cent annual load factor, and 2·92 cents per kWh at 50 per cent annual load factor (100 cents=1s.). It will thus be seen that even in the early stages of development power can be made available at an exceptionally low cost.



IMPRESSION OF OWEN FALLS PROJECT

The report recommends that provision should be made for possible future transmission of power at very high voltages, as it is felt that due to the low cost at which electrical energy can be made available at Owen Falls, as compared with any other source of power in East Africa, the demand may be both widespread and far-flung.

The increase in the river level between Lake Victoria and the Owen Falls dam will submerge the existing road bridge at Jinja, and it is proposed to replace this by a public road, which will be carried on the sluice dam at Owen Falls and will cross the west channel by means of a bridge upstream of the turbine intakes. Rail sidings are provided



CROSS SECTIONS THROUGH DAM AND POWER STATION

to a point on the western embankment of the river adjacent to the power station, from which access to the power station building will be obtained by means of a roadway.

The report states that the proposals made in it will not hinder the provision of navigational locking facilities at Owen Falls should these be required to cater for through navigation between Lakes Victoria and Albert in the future. The possibility of providing a fish-pass has been studied but is considered unnecessary.

Acknowledgment is made in the report of the earlier studies which have been made on the same subject, notably a report dated June, 1935, by Messrs. Preece, Cardew and Rider, and Messrs. Coode Wilson, Mitchell and Vaughan-Lee, entitled " Hydro-Electric Investigations of the Victoria Nile," and the Uganda Electricity Survey, 1947, by Mr. C. R. Westlake, M.I.E.E., now Chairman of the Uganda Electricity Board. The report underlines that the proposals made in it differ substantially from those in both those earlier reports, in that the capacity of installed plant which is now suggested has been considerably increased. A direct comparison between the estimates of expenditure made in the various reports is, therefore, impossible.

In summing up, it is evident that the development of the Owen Falls scheme, both in the initial and ultimate stages, will make available firm electrical energy at a cost which, in many other schemes, is associated with the production of off-peak energy. It is felt that the Owen Falls scheme offers an unrivalled opportunity for raising the standard of living by attracting new industries to the Protectorate, and by making a domestic supply of electricity available at a price which a much greater proportion of the population can afford to pay than is the case at present.

Infra-Red Gas Analysers

THERE is no novel principle involved in the estimation of gas concentrations by spectroscopic analysis, which is based on the well-known fact that many of the common gases have distinctive absorption bands in the infra-red spectrum. This method of analysis is, however, limited in its application, since the apparatus required for spectroscopic examination is too expensive and delicate for general use outside scientific laboratories. On the other hand, the method enjoys a number of important advantages over chemical and other possible methods; the identification of any particular gas in a mixture can be positively obtained and, under favourable conditions, very small traces of the gas can be measured accurately.

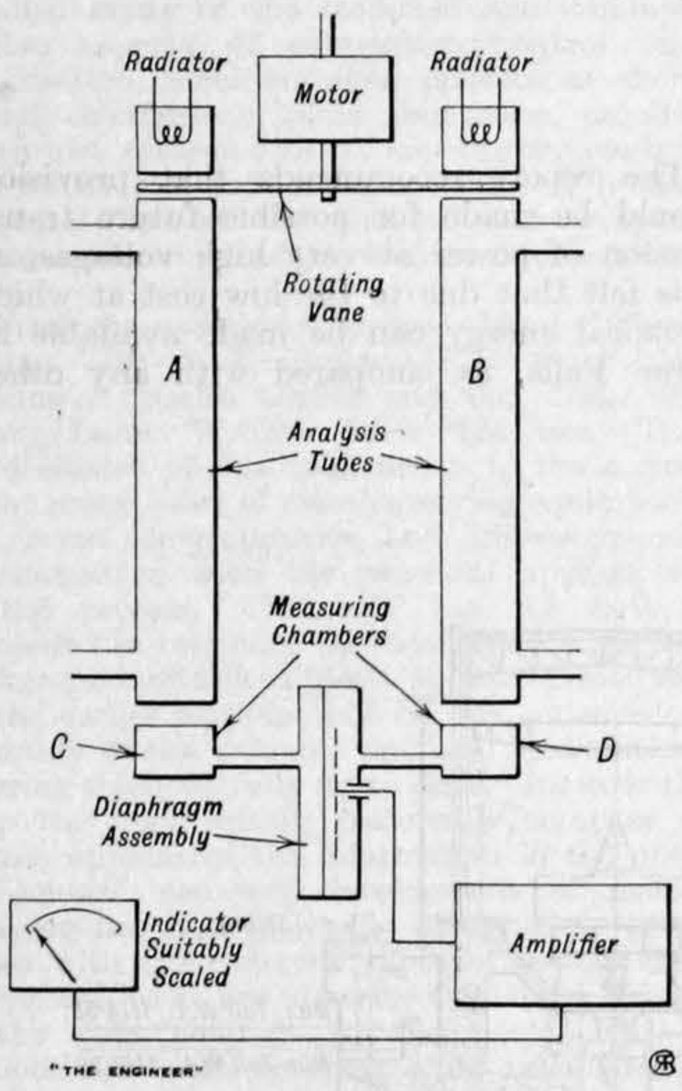


FIG. 1—DIAGRAM OF INFRA-RED GAS ANALYSER

In view of these advantages, it is not surprising that considerable attention came to be given to the possibilities of applying the principles of infra-red absorption to a commercial method of measuring gas concentrations. Just before the late war a practical method was evolved by K. Luft and E. Lehrer, in Germany. In effect this method was based on a neat device for measuring the pressure change caused by the temperature rise associated with the absorption of radiation by a specimen of the gas under test. This principle, which is briefly described below, was embodied in apparatus known as U.R.A.S. (ultra-rot-absorption Schrieber), and was used extensively in Germany during the war for process control in the petroleum and chemical industries.

Since the war apparatus, based on the same principle, has been developed in this country (due largely to the efforts of Mr. C. W. Grove-White, of the Royal Aircraft Establishment, Farnborough), and commercial analysers are being manufactured independently by the Infra-Red Development Company, Ltd., Welwyn Garden City, and also by Sir Howard Grubb Parsons and Co., Newcastle-upon-Tyne. Although the equipment and the technique used are probably quite well known in certain branches of the chemical industry, it is doubtful if they are equally familiar to engineers. The purpose of this article, therefore, is to give a brief outline of the principle and construction of infra-red gas analysers, with some indication of their usefulness.

Principle of Operation

Luft's apparatus was simple and ingenious. Infra-red radiation from a suitable source was passed through a tube containing the gas sample and then impinged on a detecting tube completely filled with the particular gas to be detected. The temperature rise in the detecting tube was a function of the radiation absorbed in it, and this, in turn, depended on the amount of radiation absorbed in the first tube. An increase in the radiation absorbed in the sample tube involved a corresponding decrease in the absorption, temperature rise and therefore the pressure in the detecting tube. The resulting pressure changes in the detecting tube were converted into electrical changes by a condenser membrane, amplified electrically, and then measured as a change in current.

Referring to the modern instruments described below, the method of measurement is indicated in principle in the accompanying diagram (Fig. 1). There are two analysis tubes (A and B), through one of which is passed the gas mixture to be analysed, while the other tube, filled with dry air, is used as a reference of absorption. The radiation from two separate heater filaments, supplied from the same source, is passed through the tubes, and the energy of all wavelengths transmitted through the tubes impinges on a pair of measuring chambers (C and D). Each of these chambers contains a pure dry sample of the gas to be measured. The chambers are connected to a diaphragm assembly and the common wall is a very thin diaphragm forming one plate of a polarised electrical condenser.

Any difference in the value of the radiation falling on the chambers C and D due to the extinction of some part of the spectrum in the absorption tubes causes a temperature difference, which, in turn, produces a pressure difference on the opposite faces of the diaphragm. Since the gas samples are heated only by the energy within their own absorption bands, it is only the extinction of this particular part of the spectrum that is measured. But this very part of the spectrum is also the absorption band of the gas being measured, so that the resolving power of the device for the particular gas molecule is complete.

To allow amplification of the voltage from the diaphragm condenser, and to avoid zero shift, the whole effect is observed as an alternating process by interrupting the output from the radiator elements, using a rotating vane. The " chopped " voltage thus generated across the diaphragm condenser is passed to a valve amplifier, rectified, and indicated on a suitable meter or recording chart.

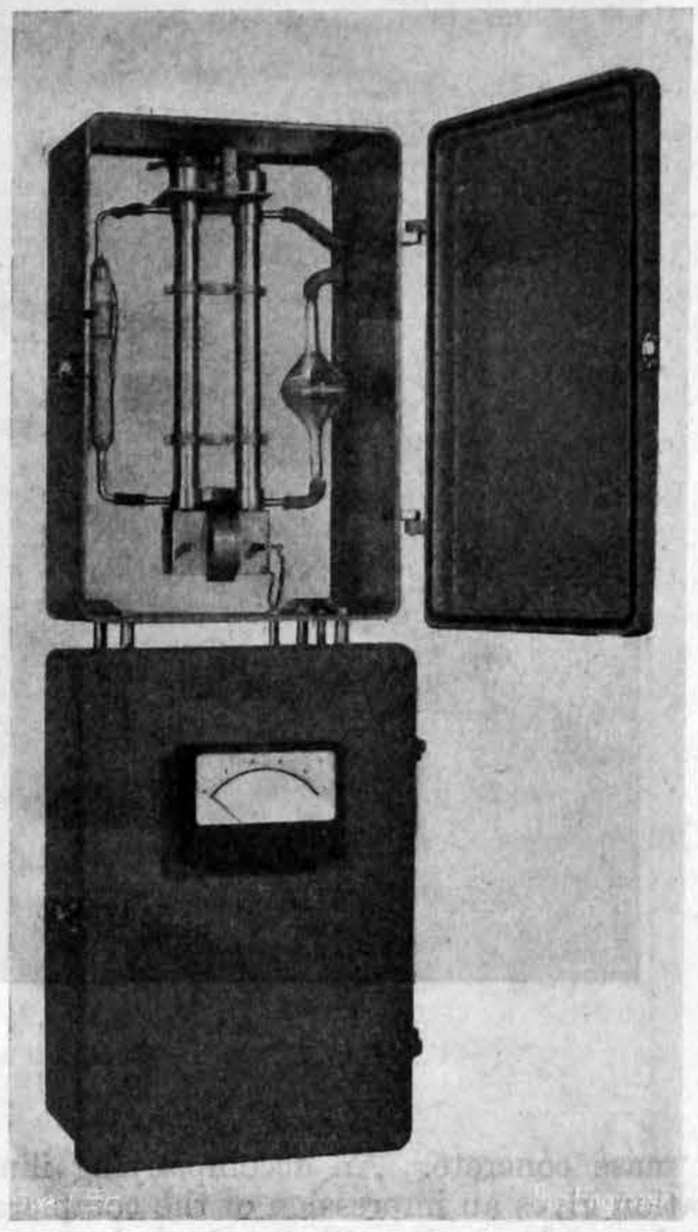


FIG. 2—GAS ANALYSER—INFRA-RED DEVELOPMENT CO.

Indicating Instruments

A typical instrument of this kind is shown in Fig. 2. It is made by the Infra-Red Development Company, Ltd., and is specially suitable for detecting and measuring carbon monoxide present in a mixture of other gases. The equipment is housed in two enamelled cases, each measuring about 19in by 12½in by 8in, and is operated from 200V–250V, 50 c/s, a.c. mains. The upper case houses the heater filaments, motor-driven chopper disc, analysis tubes, measuring chambers, and diaphragm assembly. In this particular instrument the filaments dissipate about 7W each, and the analysis tubes are 12in long. Evidently the length of the tube is governed by the range of gas concentration for which the instrument is required; long tubes imply high sensitivity. The chopper disc is rotated at about 200 r.p.m., giving a fundamental frequency of about 6½ c/s to the oscillation of the diaphragm.

The amplifier and power unit with the necessary controls is housed in the lower case and mounted on the door is the indicating meter, which has a scale-length of about 5in. An analyser of this kind can, it is claimed, be made to have a full-scale sensitivity for less than one part in 1000 of carbon monoxide in the gas mixture.

Another form of analyser, which works on the same principle, is the two-box model (Fig. 4) made by Sir Howard Grubb Parsons and Co., Ltd., and exhibited at the recent Physical Society's exhibition in London. This equipment is a compact version of the original three-box instrument, made by the same company; it uses short absorption tubes and has about

one-third the sensitivity of its predecessor. Above the absorption tubes in the upper box is the power unit, mounted on a removable chassis. The indicating meter is flush-mounted in the cover of the upper box. The amplifier, with its controls, is housed below the diaphragm

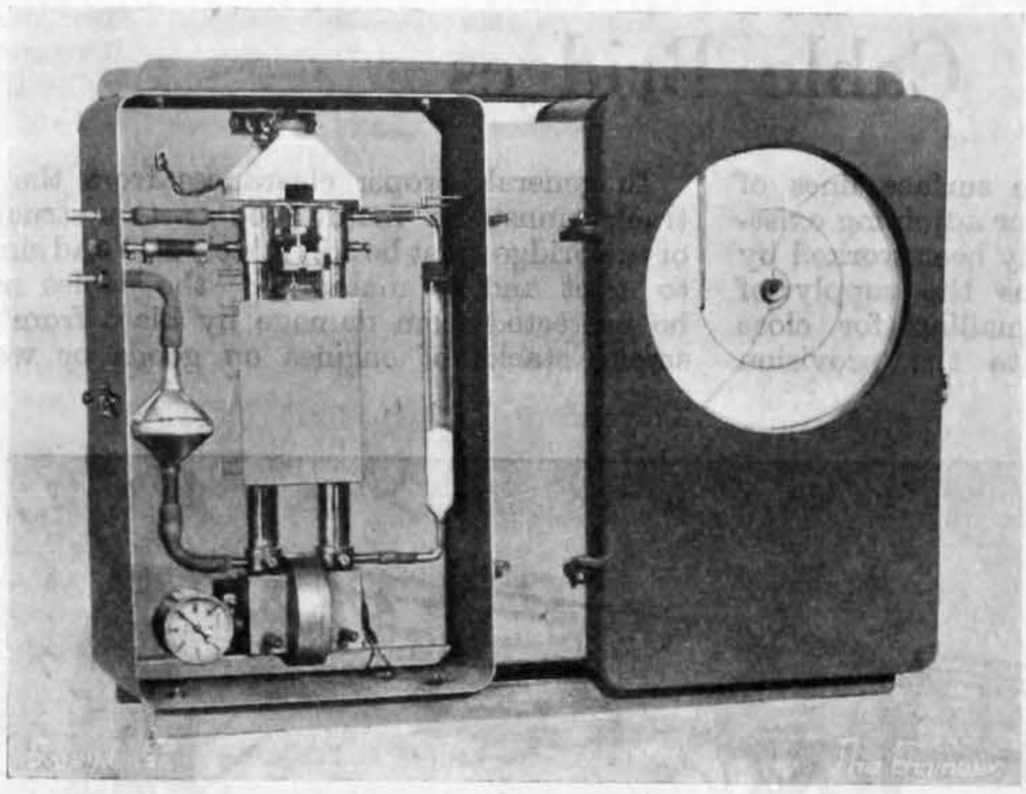


FIG. 3—RECORDING ANALYSER—INFRA-RED DEVELOPMENT CO.

unit and detector tubes in the lower box, as illustrated in Fig. 4.

This instrument is stated by the makers to be suitable for concentrations of CO_2 (full-scale for 1 per cent or more); CO (full-scale for 0·5 per cent or more); CH_4 (full-scale for 0·3 per cent or more), and for many other gases in complex mixtures. A calibrated scale can be provided to suit the particular gas and concentration range required. Where high concentrations are to be measured very small absorp-

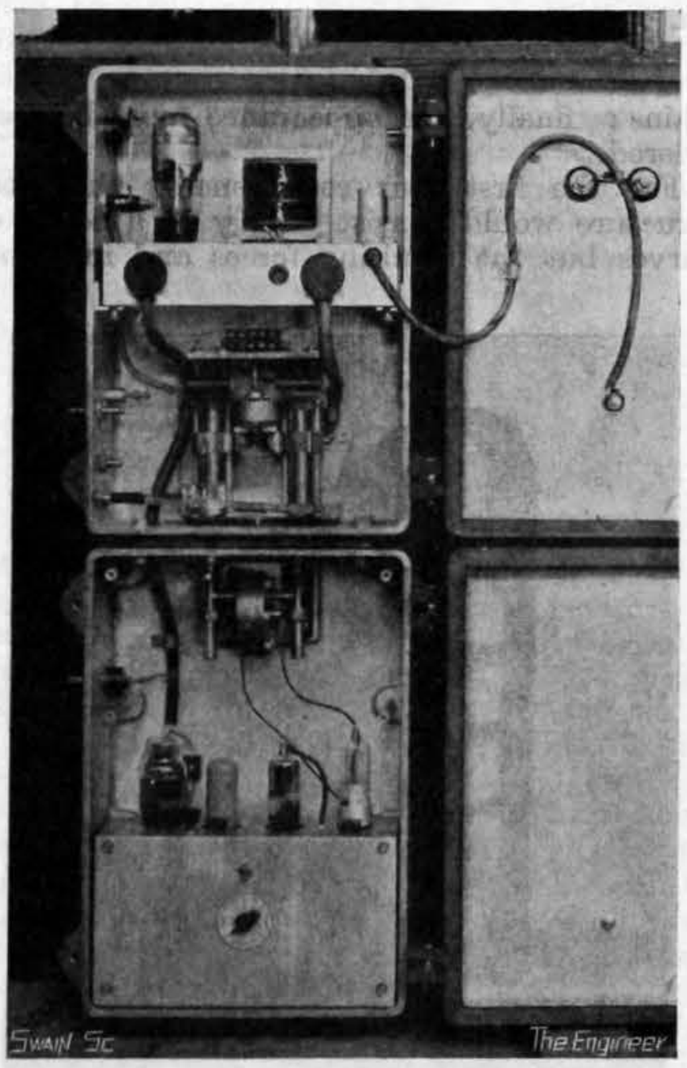


FIG. 4—GAS ANALYSER—HOWARD GRUBB AND PARSONS

tion cells (down to 1 c.c. capacity) can be used, so that rapid changes in concentration can be detected and measured.

Calibration is simple; a single sensitivity control knob in the lower box is adjusted until the correct reading is obtained to correspond with a known concentration. A periodical check of the complete apparatus can therefore be made easily.

APPLICATIONS

As described above, infra-red gas analysers can be used to measure the concentration of any gas which has characteristic absorption bands in the infra-red region of the spectrum. The method has few inherent limitations. For example, certain gases such as hydrogen, oxygen, nitrogen, argon, and the other rare gases have no infra-red absorption, and cannot therefore be detected by the analysers described.

Of these gases, however, oxygen can be estimated indirectly by converting it into CO_2 and making a determination of the latter. Another possible difficulty is that the analyser will fail to discriminate between any gases which have overlapping absorption bands. Any confusion can, however, be avoided by introducing, in the paths of the two radiations, filter tubes containing the unwanted gas or gases to absorb the interfering radiation bands.

Apart from these fundamental limitations, the apparatus typified in Figs. 2 and 4 is capable of very wide application. For example, some models of the gas analyser made by the Infra-Red Development Company, Ltd., are listed

Gas	Ranges, per cent	Possible applications
CO ...	0— 0·05 ...	Toxic limits in atmosphere
	0— 0·05 ...	Exhaust fumes from gas appliances, I.C. engines, &c.
	0— 0·25	
	0— 0·2	
	0— 1·0 ...	Boiler control
CO_2 ...	0— 0·03 ...	Biological research
	0— 0·2	
	0— 1·0 ...	Ventilation engineering
	0— 1·0	
	0— 10·0 ...	Exhaust fumes from burners, &c.
	0— 20·0 ...	Boiler and furnace control
CH_4 ...	0— 1·0 ...	Explosion hazard
	0— 5·0	
C_2H_2 ...	0— 20·0 ...	Coke oven gas analysis
C_2H_4 ...	0— 5·0	
	0— 30·0 ...	Ethylene preparation
	80—100·0 ...	Ethylene purification
HCN ...	0— 0·05 ...	Toxic limits in atmosphere

in the accompanying table, with an indication of the possible applications. This list is suggestive rather than exhaustive. Engineers are likely to be interested in the possibilities of using infra-red analysis of the flue gases for combustion control in furnaces and boilers. For this class of work determinations can be made rapidly and accurately. The method has special advantages when used for analysing exhaust gases from gas turbines; in these measurements high sensitivity is essential because the large quantity of diluting air passing through the turbine considerably reduces the concentration of any gases representing the result of incomplete combustion.

RECENT DEVELOPMENTS

The recording analyser shown in Fig. 3 is typical of one of the trends in instruments now being manufactured for various gases and ranges by the Infra-Red Development Company, Ltd. Six similar recorders, for example, are being made for the determination of up to 0·05 per cent carbon monoxide in flue gases.

In these instruments a conventional form of electro-mechanical servo mechanism links the analyser and the pen recorder.

The pen is driven by a reversible inching motor, which responds to a system of relays actuated by the current from the amplifier. The restoring agency for this servo control system is a vane, which is attached to the pen and which is arranged to cut off more or less of the radiation reaching the gas sample analysis tube (A or B, Fig. 1), according to the direction of movement of the pen. The maximum speed of response is stated to be such that the pen travels across the chart in forty-five seconds.

We are informed that the Infra-Red Development Company is making a number of direct reading analysers for measuring heavy concentrations of CO and CO_2 in steel furnaces. The instruments, made to the customers' own requirements, will be suitable for industrial, as distinct from laboratory use, and each unit will be housed in a single dustproof case.

Extension of the use of these analysers to gases and vapours other than those referred to in the table above involves practical difficulties rather than fundamental objections. The Infra-Red Development Company, Ltd., for example, is at present working on the determination of sulphur compounds.

Another interesting idea, which is, perhaps, indicative of future trends, is to make a modified form of gas analyser suitable for liquids, and a recent article in *The Heaton Journal* suggests that the design of such an instrument is a feasible proposition.

Mercury Arc Rectifiers at Sydney Technical College

THE design of apparatus built specially for the instruction of engineering students offers rare scope for variations from standard practice, and the mercury arc rectifier plant recently installed in the Granville Technical College, Sydney, is no exception. This equipment, which was supplied by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, was specifically designed for service under the various operating conditions associated with experimental work in an engineering college laboratory.

In addition to its normal function as a grid-controlled rectifier, the equipment can be operated without grid control, and can also be used as an inverter up to full load capacity. The grid-control gear, which starts up automatically from the main "start" push-button, provides full control of output voltage down to zero, the adjustment being made through a phase-shifting transformer actuated by a handwheel on the control panel. To allow voltage and current measurements to be made and recorded, all important connections are readily accessible, and the control panels are fitted with links so that the auxiliary apparatus may be disconnected when not required.

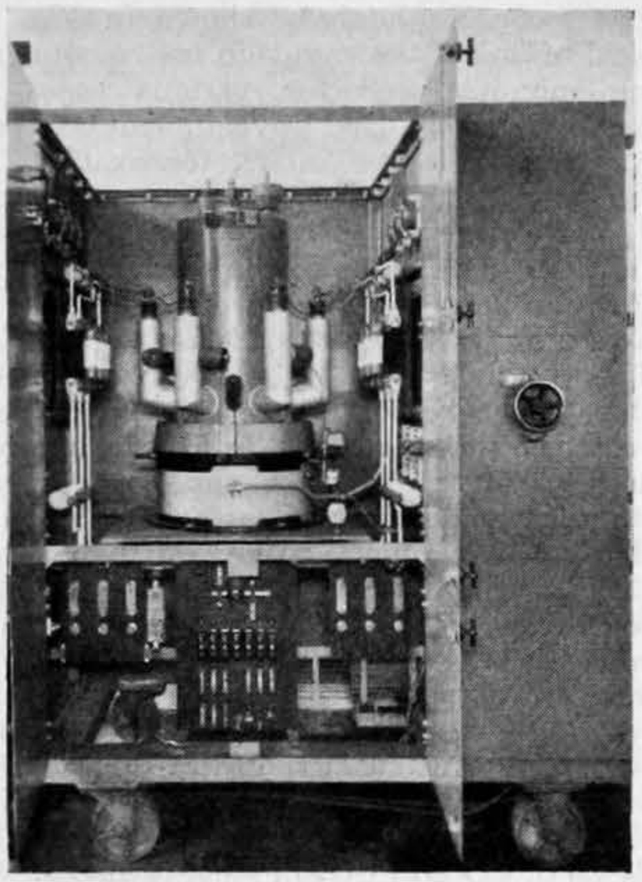
The installation, which is designed to operate in an ambient temperature of 104 deg. Fah. from a 415V, 3-phase, 50 cycle supply, has a full load output of 100kW at 240V d.c., and comprises a main transformer, d.c. and a.c. switchboard, and a sheet steel cubicle which houses the rectifier cylinder and the associated control gear as illustrated overleaf. The cubicle is mounted on 6in castors so that it can readily be moved for ease of demonstration. Special care has been taken to provide a neat, accessible layout.

The main transformer is of the standard G.E.C. oil-cooled indoor design, with primary windings arranged for star or delta connection, tappings being provided at ±5 per cent of normal by links at oil level. The anode circuits of the rectifier are fed from a six-phase secondary winding, which is normally used in conjunction with a separate interphase transformer mounted in the main tank, but links are provided to enable the interphase transformer to be disconnected and the secondary winding to be used in diametric connection.

Control of the equipment is centred at an a.c. switchboard, which is equipped with a push-button-operated 300A triple pole contactor and a d.c. board with a 500A hand-operated line contact circuit-breaker incorporat-

ing a no-volt release, overload trip, and time lags. Links are also provided on the d.c. switchboard to allow the polarity of the impressed d.c. to be reversed during inverted operation, and protection against voltage rise on light load is given by a loading resistance, which is used when the interphase transformer is in circuit.

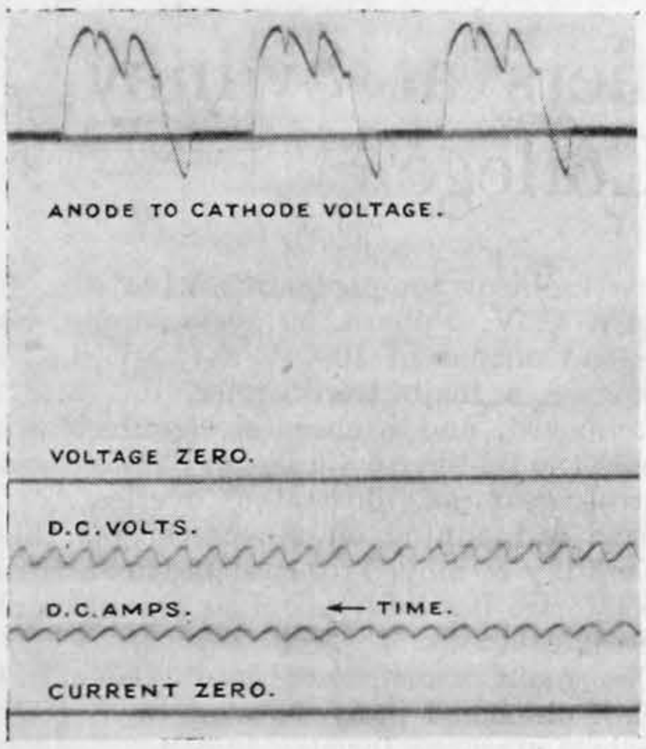
The rectifier itself is a steel-tank, air-cooled, pumpless unit, incorporating the "Victric" seal developed by the G.E.C., and is fitted with six side-arm anodes and control grids, together with auxiliary anodes and ignition apparatus.



RECTIFIER CUBICLE

Cooling is provided by a propeller fan mounted below the rectifier cylinder and the anode circuits are protected by high rupturing capacity fuses of the high-speed type and adjustable gap surge arresters.

An interesting feature of the equipment is the grid control gear, which provides complete control of output voltage and also allows the rectifier to be used as an inverter. The oscillogram reproduced herewith shows the anode-to-cathode voltage waveform during inverted operation under the following conditions: primary-star, 720V; secondary, 2 × 3-phase with interphase transformer, d.c. choke in,

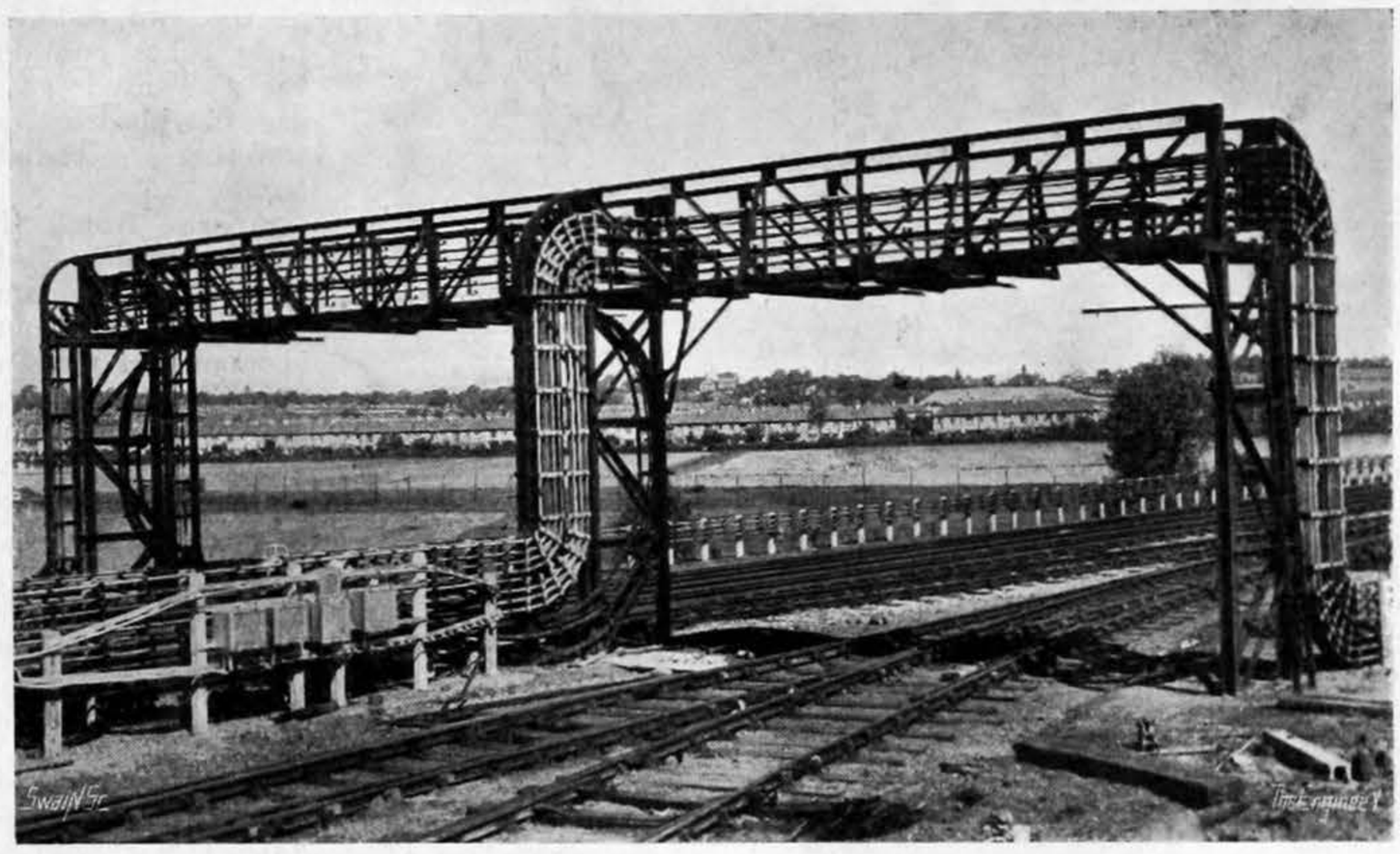


INVERTED OPERATION OSCILLOGRAM

d.c. voltage 285, d.c. current 416A. Voltage regulation is effected by varying the phase relationship between the control grid voltage and the main anode voltage, thus controlling the instantaneous value of voltage at which the main anode commences to conduct. This adjustment is made by a phase shifting transformer, which feeds the primary of a special six-phase peaking transformer, the secondary of the peaking transformer being connected to the control grids of the rectifier through 1000-ohm current limiting resistors. Negative bias is provided by a three-phase bridge-connected metal oxide rectifier fed from a bias transformer, the positive pole of the metal oxide rectifier being connected to the cathode of the mercury arc rectifier and the negative pole to the neutral of the peaking transformer secondary winding. The bias thus applied to the control grids prevents each main anode from carrying current until the peaking transformer secondary voltage reaches a positive value, which is greater than that of the negative bias supply.

Cable Bridges

RECENT extensions of the surface lines of London Transport are on or adjoining existing lines which have previously been worked by steam. On these extensions the supply of electric power and the signalling for close headway working necessitate the provision of numerous runs of electric cables, which frequently have to cross the tracks, particularly at junctions, in depots, and at station goods yards. From considerations of accessibility for maintenance, such crossings are generally made overhead in preference to underground and, in consequence, bridges are required.



BRIDGE FOR L.T. AND SIGNAL CABLES AT FAIRLOP

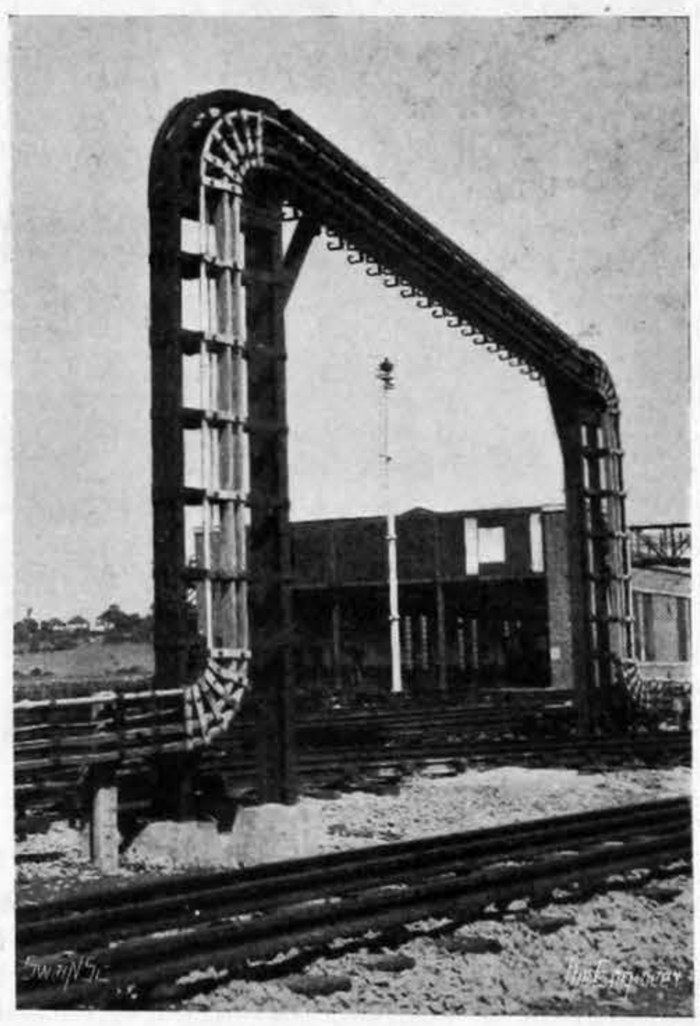
Since the war eighteen additional cable bridges have been required and the design of these structures involves interesting problems, some of which are briefly touched upon in this article.

In normal runs the cables are hung from brackets on posts on one or both sides of the line. These posts are 4ft apart and the larger cables span the gap between the posts. The smaller cables require support at 2ft centres, and this is obtained by using an intermediate bracket, designed to hang on the compressed air supply main, which is a 1½in diameter galvanised pipe and always occupies the top way of the post brackets. Signal cables, which are ⅝in diameter, are laid together up to a maximum of twenty-one in one way. Larger cables for traction current, 2⅜in diameter, and for h.t. transmission, up to 3½in diameter, are supported singly.

In designing a cable bridge a number of special considerations are involved. First, the lead-off to the bridge must be arranged so that some cables may pass by the bridge and others run on to the bridge with smooth curves in a regular manner. Secondly, the relative position of the cables must not change in passing over the bridge; cables on top on one side must be on top on the other. In each way, the signal cables laid together must remain in the same relative position without reversal. An important point is that cables must not be bent to a radius sharper than that specified for each kind. In some cases provision must be made for cables to leave the bridge at an intermediate pier, which may not be at the centre of the bridge.

In general, proper clearances from the rail tracks must be maintained; the structure of the bridge must be adequately stiff and simple to erect and to maintain; the cables must be protected from damage by blast from the smoke stacks of engines on goods or works trains; finally, the appearance must be considered.

For the first four requirements the ideal structure would consist largely of a series of curves but the resulting forces and moments



40-FT SPAN CABLE BRIDGE AT HAINAULT

could not economically be provided for in such a design. Moreover, in cases where a walkway is required, provision must be made for a man to walk or climb erect. For structural simplicity and for economy in material, a beam or light lattice girder on vertical columns is the solution, but the cables cannot

make a sharp turn between the columns and the beam, nor at the foot of the columns.

For appearance, projections beyond the sweep of the cables should be avoided, and the structure should look light and simple. Cases where a double span is required are the most difficult to design with a good appearance, particularly where the spans are unequal in length or in the number of cables carried. In some cases this last difficulty can be avoided by providing two separate bridges of similar outline but of a different width.

Careful attention to detail, the use of welding in some cases for shop fabrication and the pressing of sections to curved shapes, has enabled great economy to be made in the weight of steel required and, at the same time, a pleasant appearance has been obtained.

The photographs reproduced herewith show two examples recently erected.

Our first illustration shows a two-span bridge crossing main lines and siding connections at Fairlop, providing twelve cableways with access walkway and ladders. It will be noted that the signal cables are taken vertically up the supporting columns while the l.t. cables are carried with larger radius curves on the floor of one span.

The second illustration shows the bridge for eight ways of signal cables, with a clear span of 40ft, sited among the connections at the entrance to Hainault depot. The arrangement of the supports in relation to the plane of the beam was dictated by the required clearances. No walkway is provided and the beam consists simply of a 22in by 7in R.S. joist riveted below a 5in by 4in R.S. channel.

Another recent cable bridge is the one adjoining the new north signal cabin at Harrow-on-the-Hill. This lattice structure has a clear span of 60ft, crossing three main lines, and it provides twenty-four ways for cables with an access walkway and ladders.

Simpler designs have proved adequate in many instances, such as at Newbury Park, where eight ways of signal cables are taken across two tracks by a bridge in the form of a flat topped arch, built up of cross-braced R.S. joists. An even simpler structure consists of a bent steel channel forming an arch, designed to carry four ways of signal cable. Two such bridges are installed near South Woodford junction. An example of welded construction is to be seen at Loughton, where a light lattice girder bridge of 50ft span has provision for eight ways of signal cable without a walkway.

Mechanical Handling Convention

In addition to the Mechanical Handling Exhibition, which opens at the National Hall, Olympia, on Monday next, July 12th, there is to be a Convention during the whole period of the exhibition, until Wednesday, July 21st. At the exhibition there will be more than 120 firms showing mechanical handling equipment of all types, and we intend to describe some of these exhibits in a forthcoming issue. At the Convention no fewer than seventeen papers are due to be read. The exhibition and convention, the first of its type in the British Empire, has been organised on a non-profit basis by our contemporary journal *Mechanical Handling*.

Convention Programme

The papers to be read, briefly listed below, have been compiled and are to be presented from two viewpoints, that of the mechanical handling engineer, and that of the user of mechanical handling plant.

July 13th : 11.30 a.m. "Mechanical Handling in the Motor Industry," Sydney Gilbert, M.I.P.E.
3.30 p.m. "Mechanical Handling in Agriculture," D. R. Bomford.

July 14th : 11.30 a.m. "Mechanical Handling at Coal Mines," A. J. Beeley, A.I.Min.E., A.I.Struct.E.
3.30 p.m. "Handling on the Railways," David Blee, M.Inst.T.

July 15th : 11.30 a.m. "Aerial Ropeways," H. C. Dixon.
"Aerial Cableways," R. E. Spain, M.I.Mech.E.
3.30 p.m. "Handling of Britain's Cereal and Seed Supplies," F. Raby Jolley, M.Sc., A.M.I.C.E.
4.30 p.m. "Mechanical Handling in the Shipbuilding Industry," Denis Rebbeck, M.A., M.Sc., B.Litt., A.M.I.C.E., A.M.I. Mech.E., M.I.N.A.

July 16th : 11.30 a.m. "Mechanical Handling Methods in the Steel Industry," G. W. Grossmith, M.I. Mech.E.
3.30 p.m. "Mechanisation in Foundries," J. Bain, A.M.I. Mech.E.

July 19th : 11.30 a.m. "Coal, Coke and Ash Handling at Power Stations," F. G. Mitchell.
3.30 p.m. "Mechanical Handling at Gas Works and Coke Ovens," W. Morland Fox, B.Sc., M.I. Gas E., A.M.I.Mech.E.

July 20th : 11.30 a.m. "Mechanical Handling as Applied to Industrial Processes," D. Cherry Paterson, M.I.Mech.E.
3.30 p.m. "Fork Trucks," Colonel Raymond T. Hartmann, M.A.
"Power Trucks," J. R. Sharp.

July 21st : 11.30 a.m. "Hand Trucks in Materials Handling," H. H. Springett.
3.30 p.m. "Time and Motion Study in Relation to Materials Handling," Charles Cooper, A.M.I.P.E.

Mechanical Handling Film

A colour film, "Mechanical Handling," will be shown in its entirety on Monday, July 12th, at 4 p.m.; on Wednesday, July 14th, at 5.30 p.m., and on Saturday, July 17th, at 2.30 p.m. The film is in five sections and has a screening time of one hour and fifty minutes, so it has also been arranged to show the sections separately on various days.

This film, which may be described as an excellent documentary, has been sponsored by the Mechanical Handling Engineers' Association, 94–98, Petty France, S.W.1, with the object of demonstrating, in a form which is both entertaining and informative, the wide possibilities of mechanical movement of goods in industry. It has succeeded admirably in its object. The five sections of the film are: introductory; coal and ash handling; bulk material handling; metal handling; and industrial handling. All the scenes are filmed in colour and there are some notable shots dealing with such things as the locomotive coaling plants at King's Cross and Rugby, pneumatic grain-handling plant at docks, equipment at a continuous strip mill, and many other mechanical aids to movement of materials.

Hydraulic Transmission on Mines Locomotives

To examine the behaviour of a hydraulic transmission in a mines locomotive an installation was made at Lofthouse colliery, West Yorks, some months ago, and since then the diesel locomotive, built by the Hunslet Engine Company, Ltd., Leeds, has been operating in heavy coal haulage with satisfactory results. This installation has certain technical attributes not usually found in hydraulic transmissions. We have now received from the locomotive builders some views on its operation. It may be recalled that the locomotive was described in our issue of May 7, 1948.

The Brockhouse transmission system adopted has characteristics different from the existing Voith, Lysholm, and Trilok types in that the efficiency is high at the top end of the speed scale. Transmission losses are concentrated more at the low end of the speed scale, where they do not matter so much, as full power is not used over that range. A second difference is that the full range of speed and torque is transmitted through the converter itself, which does not need the supplementary separate fluid flywheel as in the Voith drive, or friction clutch as in the Lysholm system, for direct drive conditions. Thirdly, as only a preliminary investigation was being made, the Brockhouse turbo-converter was fitted on the standard locomotive together with a standard gear-box, and the combination of four speeds and hydraulic transmission has given, it is said, extraordinary flexibility in operation.

The locomotive at Lofthouse is of the 100 b.h.p., 15-ton six-wheel type, running on 3ft gauge tracks of 60 lb rails and hauling cars of 185 cubic feet capacity each. Tests with the standard Hunslet locomotive of this power with mechanical drive have shown that on bottom gear a tractive effort of over 9000 lb can be obtained in bottom gear step; but with the converter in operation in sequence with the gear drive tractive efforts of 12,000 lb and more have been recorded under suitable sanded-rail conditions, corresponding to a factor of adhesion of less than 3·0 to 1.

The normal work undertaken by the locomotive down below is the haulage of the large-capacity cars over a first-class track—all part of the major reorganisation of Lofthouse working undertaken over the last few years. Though the hauling capacity on the level is up to 400 tons at about 4 m.p.h., the critical point in their operation at Lofthouse is to brake safely trains of eight or nine cars, weighing up to 60 tons, down a long gradient of 1 in 40, normally traversed at 9 to 11 m.p.h. The needs at Lofthouse are not very heavy trains, but loads of about eight cars hauled expeditiously up and down the gradient and with a quick turn-round. The journey uphill with the empty cars is usually made in top gear at speeds of 10 to 12 m.p.h.

In its action, the converter produces direct drive at all speeds when the torque required of the output shaft will allow a 1 to 1 ratio. Under certain traffic conditions, where low gear is being maintained for some time at comparatively low torque, this feature is of some importance, and here the Brockhouse turbo-transmitter drives through this 1 to 1 ratio throughout most of such a period; it goes into conversion only intermittently, when acceleration is necessary.

One of the principal advantages claimed for this type of converter installed in conjunction with the Hunslet drive is smooth performance over undulating roads—a point that has been well proved at Lofthouse, where many of the drivers are said to prefer the diesel mechanical-hydraulic locomotive, though some time elapses before a driver actually gets the "feel" of a hydraulic-drive locomotive after he has been handling a geared-drive unit. The improved performance given over purely mechanical drive is not of such a high order when the track is level or the gradient uniform; but compared with previous forms of hydraulic drive there is always the advantage of the substantially higher efficiency at the top end of the rotational-speed scale, the order rising to 97 per cent at low input torques and from 80 to 100 per cent of full speed, and 88–90 per cent at high input torques. As in most other hydraulic drives, the present turbo-transmitter is non-reversible, and a reversing gear is incorporated in the locomotive transmission.

Another Main Line Diesel-Electric Locomotive Completed.—The second diesel-electric locomotive to be built for main line express duty on British Railways began its trials on July 5, 1948, at Derby Works, London Midland Region. After a short period of preliminary running, this 1600 h.p. unit ("No. 10,001") will be tried out in conjunction with its forerunner ("No. 10,000") on the West Coast route express passenger trains between London (Euston) and Glasgow (Central), the two identical units being coupled together as one 3200 h.p. locomotive. Comparative tests will be made between the performance of this twin-diesel electric unit and that of the latest improved design of steam locomotive.

The Evolution of the Design of an Aeroplane.*

By R. L. LICKLEY, B.Sc., D.I.C., F.R.Ae.S.†

THE aeroplane is an extremely complicated piece of engineering and is daily growing more complex. However much we simplify a part, a new requirement comes along needing some other part to be more complicated. Thus the evolution of an aeroplane design is a long and tricky business in which there are many pitfalls and possibilities of error and in which compromise is constantly required in finishing any one part of the design. Because of the complication, because of the necessary compromises, and because of the wide choice of initial shapes and methods, aeroplane design is still an art rather than a science and is, I feel, likely to remain so, although a good deal more sound engineering common sense is still required in certain sections of the industry throughout the world.

The design of an aeroplane might be likened to the creation of a picture from a jigsaw puzzle, with the added difficulties that there is no replica of the final result on the outside of the puzzle box and that frequently individual pieces of the puzzle change shape while waiting to be fitted into the picture. The only guide to the completion of the picture is, first of all, a rough one given by the tender and the specification and a generalised procedure, varying from firm to firm but built up on past experience, which gives the order in which the picture develops.

THE START OF A DESIGN

It is rarely easy to say when exactly a design started or what caused it to start. The most likely way is that someone in the firm has an idea and from it rough sketches are made and the beginnings of a design emerge. This idea may be brought into being in a number of ways, the first and best probably being that in which it is stimulated by the instinctive feeling that such a design is needed to fulfil a certain purpose. This feeling is often stimulated by the formulation by an interested body of very broad requirements. The exact opposite to this is when a firm is presented with a rigid specification prepared by an outside body and giving little overall freedom of design. Obviously there can be any number of possible variants between these two extremes. I firmly believe that the best designs come about in a manner most closely approximating to the first type : the resultant aeroplane has been called a private venture or P.V. type and for speed of design and excellence of type very few other machines have equalled the P.V. types of recent years.

With increasing costs and decreasing markets, most firms nowadays require someone to pay for a prototype and in whichever way the design starts, a tender and specification have sooner or later got to be prepared and in consequence, the stages leading to this must be studied.

STAGE 1 : THE DEVELOPMENT OF THE DESIGN

When either Air Staff or an operating corporation require a new aeroplane, the respective branches in the Ministry of Supply issue to selected firms a statement giving the main requirements of the new type, such requirements being chiefly connected with speed, range, disposable load, and so on, and from this the Project Branch of the firm can start investigating varying designs, the best of which will eventually be submitted as a tender.

During the preparation of the tender, a considerable amount of initial investigation and project work is done by the firm and this can often be used later if the order is placed with them. The tender represents in some cases thousands of hours of work and needs drawings and lay-outs of most of the main sections of the aircraft.

The preparation of the tender involves stages which are the kernel of the whole design and decisions taken on them can certainly make or mar the whole design. They include such matters as aeroplane shape, wing loading and high lift devices, and most important of all, the choice of a power plant and the estimate of the all-up weight.

Apart from the sound structural work and efficient detail design which are necessary during the whole period of the work, these four items are the most important in the evolution of the design and by their very nature must be decided in the early stages.

The shape of the aeroplane allows the designer to show to the full his individuality and the looks of the aeroplane are determined at this stage, for once general lines are decided they are rarely altered, except in detail. It is not always realised how much responsibility rests on the designer at this stage. The full requirements are not known, the ultimate objectives are somewhat dim, but the designer must use his experience and instinct to produce something which will still be the best possible shape for the ultimate duties of the aeroplane. It is sometimes said that at this stage an effective crystal gazer would often be of great use.

Coupled closely with the overall shape is the wing plan form, the decision to have small wing areas and extensive flaps, or large areas and simple flaps, and so on, and in this the design is to some extent influenced by what the shops can do and what materials are available, and by the selling cost required.

Next comes the choice of power plant. This was a difficult enough matter when there was only the piston engine. Now, with jets, propeller turbines, reciprocating types and compounds, the choice is a matter needing great forethought and skill.

The successful choice of a power plant can only be made after a detailed study of the offers made by various engine manufacturers in relation to the duties of the aeroplane. In the past there has often been a tendency to take too much for granted in an engine maker's statements and delays and unsatisfactory aeroplane types have resulted. Whether or not this could be overcome by having in the firm's project branch an engineer specially trained to deal with propulsion problems, or whether general training of all design engineers in the principles of the subject is the better way, I will discuss later. The designer is to a great extent in the hands of the engine man with respect to engine weights, powers, specific consumption and so on, and the desire to believe what are obviously optimistic values is a hard one to fight down, especially as they all tend to make the aeroplane seem better than ultimately it will be. The best designs are those in which the designer has guessed right as to the best future power plant and has tempered the optimism of the engine firm with more conservative estimates.

The over-optimism of the engine people on the future of propeller turbine units, in particular their very optimistic claims relating to the time to develop new engines, has led to a difficult situation in this country with regard to new civil types. Greater faith in the piston engine by designers might have given a very different answer to the operators' problems.

The accurate estimation of the all-up weight is the most fundamental problem before the designer in the project stage. Bad weight estimation will, in the limit, destroy any chance of success the aeroplane might have. It can render it unable to perform the duties for which it is designed, so reduce the payload that no company will operate it, and so on and so on. In the past, insufficient attention was often paid to this and fantastic estimates were often submitted with tenders, so much so that in some quarters there is still a saying that the aeroplane goes into service 20 per cent heavier than the tender estimate. This is not entirely the manufacturer's fault; equipment changes and goes up in weight, and power plants increase in weight; nevertheless accurate weight estimates of structure and installations are required early on and to ensure that they are adhered to, close control is needed. A strong weight section, with plenty of data and in close touch with the project section, can produce a much more realistic estimate than was often used in the past and with effective weight control in addition, the wide divergence in weight between tender and prototype should disappear.

The completed tender is then submitted, and represents an important stage in the evolution of the aeroplane. To take a simile from another type of evolution, the chicken might be said to be starting to chip open the egg.

STAGE 2

At this stage the committees get to work and it is difficult, as one closely connected with design, to speak objectively on the matter. Neither works of art nor works of engineering can be produced by committees. They are undoubtedly necessary in small quantities and at long intervals in the design to ensure (*a*) that the contractor is provided with a firm contractual document ; (*b*) that he has all the help (technical and otherwise) which he needs to get on with the design, and (*c*) to check at the end that the final design bears some close relationship to the specification.

This, however, is digressing somewhat and is caused by the next stage in the evolution : that of a meeting which might be called the tender acceptance committee. This body, composed of Ministry of Supply and user representatives, decides which tender is the best—normally without any representatives of the design firm present—and what changes can be asked for or inflicted on the designer.

The next stage therefore is that the prospective purchaser and the designer get together and hold a bargaining match. The purchaser to see how much extra he can get, the designer to stand firm by his existing tender, which, after all, represents his best ideas on the subject. However, the designer's firm probably needs the order and against his better judgment he may be forced to accept alterations or amendments which in his opinion do not improve the design. On the basis of this latter meeting, a full specification can be prepared and this represents the contractual requirements of the design and in most cases is a never-ending source of argument from then on.

While these committees have been discussing the matter and R.A.E. and Ministry of Supply officials have been vetting the design, the firm has not been idle, particularly if it has been given advance information regarding the award to it of the contract. The aerodynamics branch of the firm is checking the data used in the tender, estimating control areas, balance percentages, and so on, and preparing a programme of the necessary wind tunnel tests. The project office or drawing office are continuing their work, making more detailed layouts of cockpits and so on, scheming engine installations and other details needed for the wind tunnel tests ; and the design section of the stress office is scheming out the most efficient types of structure and disposition of load-carrying members.

If this work is delayed, because of time wasted by committees, or the firm being given no advance information, it represents a very genuine delay in the overall time to produce the type. The reason is partly psychological, partly practical, and is caused by the fact that staff taken off an aeroplane design and then started again, have to regain interest, to try and pick up the threads where they left them and to resist the temptation to redesign the whole aeroplane in accordance with a new set of ideas. This last is fatal and results in a half-and-half approach, particularly if it is combined with attempts to satisfy too many of the points raised by the meeting on the specification.

STAGE 3 : MOCK-UP

Assuming that all is going well, an important stage in the design evolution is now taking place. This is the construction in the experimental shop of a more or less elaborate full-scale model of the aircraft, called a mock-up. This is prepared to the drawings and instructions of the design group engaged on the preparation of lines, cockpit layout and so on, and is used to give the firm's personnel—and the customer and his agents—a better idea than they can get from a tender. It is used to

* Royal Aeronautical Society, February 26th. Abstract of lecture.

† Professor of Aircraft Design, College of Aeronautics.

position seats, controls, instrument panels, and such things, in the early stages and, depending on its expenses and elaborateness, it may, in the case of a civil aeroplane, include all the final equipment and furnishings. It develops and is kept up-to-date during the progress of the design and it is important to keep a close link and careful control to ensure that design changes are incorporated in the mock-up and vice versa. The more elaborate the nature of the aeroplane, the more important is it to have a good mock-up incorporating all the equipment layout, as without this help the design staff and the shops would find the task of piecing the aeroplane together much more difficult.

After some weeks or months of preparation, depending on its size, an important conference is held, which, if properly handled, can be most useful. This is the mock-up conference and is the stage at which the chicken might be said to have discarded the protection of the egg shell (in this case the general arrangement and layout drawings of the tender) and come out into the light of day. At this conference the representatives of the user, the supervising authority, or authorities, and the firm, get together and attempt to reach agreement on all the installational problems shown by the mock-up. The success or otherwise of the conference depends on how far agreement is obtained and this is not easy when thirty to sixty persons, all with their own pet theories, are each and everyone trying to get his own way. To be successful mock-up conferences must be held with the minimum of people all sufficiently senior to make decisions on the spot which will be upheld by the bodies they represent. The mock-up conference over, the firm bring the mock-up into line and for a period there is a welcome freedom from conferences and so on.

Stage 4 : Initial Design Work

While the mock-up has been going ahead, the other sections of the design staff have not been idle.

The wind tunnel tests are being made to check that the main aerodynamic features of the design are satisfactory and the problem of how many tests, how much to believe and how far to alter the aeroplane to meet these tests, is a big problem for the designer. Wind tunnel tests are a fundamental necessity and no design should be allowed to go ahead without them ; but, and this is not always realised outside a design staff, they take time and if the design is held up until the wind tunnel answers are available, considerable delay may ensue. Further, because of scale effect, inability to reproduce manufacturing inaccuracies on a small scale and (as the model is rigid) inability to reproduce distortion, the results are always suspect to some degree and have to be interpreted. Here the experience of the designer and his aerodynamics staff are necessary to guide the critical decisions of how far to trust their own ideas and how far to trust the wind tunnel ; their judgment in this matter has a great bearing on the successful flying qualities of the aircraft.

During this period, also, the designer is getting, with or without his seeking, general advice on his aerodynamic problems from the various research establishments. This is generally very helpful and no designer will neglect it, but it is sometimes forgotten by those in these establishments that the responsibility for the design is the designer's and that any opinions they may offer should be guided by the realisation that somebody else has to do the job and that the designer will be blamed if the result is unsatisfactory.

The structures section of the firm, having received preliminary loading data, is proceeding with the estimation of loads, the choice of the most economical structures to take these loads and the preparation of preliminary sizes and loads to enable the drawing office to make a start on the detailed design of the major structure. The structure weight estimates are checked, stage by stage, with the development of the structure and the loads to ensure that proper weight control is achieved. The weight section is also keeping a close watch on the mock-up to ensure that only equipment called for in the specification is being included and notifying the designer when any departure from this is noted. From this stage on, no move either in the structure, the detail design, or the mock-up should be made without the weight section knowing of it and checking its overall effect on the aeroplane.

The drawing office at the same time is going ahead with the overall lines of the aeroplane, usually nowadays by lofting methods, and getting from these lines the necessary dimensions to enable the more detailed parts to be drawn. Discussions are held with the experimental shop to decide on the best order for the issue of manufacturing drawings. Good co-operation here between experimental shop and design department can eliminate many delays at a later stage and if a timetable be prepared, giving the stages at which information is required, this can be used as a check throughout the design to decide which drawings should be accelerated and so on. Here, however, there can often be a conflict of ideas. The shops want to make a good show and as a result like an early issue of units which are easily completed, such as tailplanes. These are the very units which the designer wants to hold up as they are the most in doubt while the wind tunnel tests are incomplete. These arguments can usually be ironed out and the shops encouraged to go ahead with the major structure and with the parts of the aeroplane which will contain most equipment, i.e., the structure round the cockpit should be built long before the rear fuselage, as a great deal of installation work is required on it.

Also, now that the design is taking shape, discussions take place with the production side of the firm to decide on methods of manufacture, size of units, amount of tooling and a host of similar matters. Here, again, compromises and co-operation are highly desirable if the ultimate successful production aeroplane is to result. The designer would like everything new ; materials, methods and so on, and the works would like to use all the parts they had used on the last aeroplane, although they might be strung together in a different way. The problems are often thorny ones and the chief designer has considerable responsibility as he is the final arbiter as to which type of construction is to be used and this may involve his firm in considerable changes of workshop methods and plant.

Stage 5

The next period is one where continual supervision is needed over both design offices and experimental shop if time is not to be wasted. The first enthusiasm is waning, nothing seems to be happening and unless considerable drive is given to the whole organisation the whole programme will get out of gear and considerable delay will result.

The first stage to prevent this is to prepare a chart showing the order of issue of drawings to the shops against a set of dates and to ensure by constant supervision that this is kept to, even when stressing problems may get difficult, the equipment will not go into the space provided, and so on.

The second stage is to see that the experimental shop has a similar set of dates to work to and to make sure that delays, such as in material supply and alterations to drawings, are not used as excuses to fall away from this timetable. As it is the nature of man generally to make excuses and to blame others, this period is one where the designer, in addition to ensuring the highest quality of design and drawings, has to act as slavedriver, mediator, and detective in turn or all at once, to separate sections and his skill in these directions, although not improving the actual design of the aeroplane, goes far to cut down the time of manufacture.

The design is now proceeding steadily, the main structure should all be issued and things are beginning to take shape in the shops. Other mock-ups are also being made. These are functional mock-ups and represent parts of the aeroplane which the designer wishes to check before incorporating them in the aeroplane. They include fuel systems, new forms of flap operation, the pressurising equipment if fitted and other matters of a similar nature. These mock-ups are expensive and can take up a great deal of valuable time, both in the drawing office and experimental shop. Their justification is that they are said to cut down troubles in the development flight trials and to improve maintenance ; when this claim can be substantiated then they can be very useful, but if proceeded with, then the best brains of the design section should be employed on them to ensure that maximum value is obtained.

Closely akin to these functional mock-ups, which must in most cases be made from actual parts of the aircraft, are the strength test specimens. These are decided on, bearing in mind the duties of the aircraft, the departures from conventional structures and similar matters. Nowadays it seems as if only a test on the complete aircraft will satisfy everybody.

Passing quickly now from this period to the stage at which the various parts are assembled together, we reach the final hectic period in the evolution. Equipment is all coming along at the last minute, the systems have to be checked, the retractable undercarriage tested, the wing stiffness measured, vibration characteristics determined and a thousand and one other things all seem to be conspiring to prevent the first flight.

At last the whole matter is complete and the new design takes the air. The period which then starts is a most interesting, but most harassing period, but it is not within the limits of this lecture and here we must leave the evolution of the design.

Conclusion

This leads to the concluding part of my lecture. Too often in the past and at the present day, the design offices of an aircraft firm are peopled with warring sects : the drawing office and the stress office being the chief ones. The continued arguments between these sects often lead to hold-ups, poor design (due to stressmen without design knowledge) or, constantly nowadays, poor detail design either from a strength or a weight aspect (due to draughtsmen without stress knowledge).

It seems to me that optimum efficiency will not be achieved unless the walls between these sections are removed and a universal design office takes their place : this office to be aided by a research group, aerodynamics group and detailing group (either doing detail drawing or detail calculation).

This involves giving draughtsmen considerably more technical training than they have at the moment, and at the same time widening the training of the present type of stressmen to include drawing office and design experience, and also to see that they get a certain amount of shop experience. Only by these two approaches can we reach the optimum in design from all points of view. By doing this, I feel that designs would be got out more quickly. The detail design would be greatly improved, leading to better structure weight and fewer maintenance problems. This system would, with advantage be further widened in scope by having in the power plant section men having sufficient basic knowledge of propulsion problems to discuss fundamentals of engine design with the engine manufacturer and thus enable the data put forward on any given engine to be carefully checked at an early stage.

With the increasing complexity of modern design, I feel that much greater attention must be paid to technical education in its widest sense, particularly in the design offices. This can only be achieved by encouraging all concerned to widen their knowledge, by having a system which gives the best apprentices a chance of further education at a university, and by giving those with the highest technical qualifications a chance to get further in the firm than the present boundary walls of the stress office. Only by integrating the whole design staff into one unit, can aeroplanes nowadays be designed in comparable times to those taken some years ago.

Industrial and Labour Notes

Industrial Health

A session devoted to "Occupational Health" was included in the programme of the annual scientific meeting of the British Medical Association, which was held at Cambridge last week. One of the papers presented for discussion was by Sir George Schuster, Chairman of the Human Factors Panel set up by the Industrial Productivity Committee, and in it the suggestion was put forward that, wherever possible in industry, there should be full-time medical officers who should participate in all discussions about a firm's work.

These medical officers, Sir George considered, ought to take a broad conception of their duties and should concentrate on positive health in an industrial undertaking. The suggestion might seem idealistic, he said, and possibly smaller firms might find it useful to group together for the purpose and share a medical officer. The real end of industrial activity, Sir George asserted, was threefold; it should achieve excellence in production, provide satisfying activity as the foundation for a good life for those engaged in it, and it should fit in as part of a satisfactory pattern of society.

The Wire-Drawing Industry

On the motion for the adjournment of the House of Commons on Wednesday of last week, the present situation of the British wire-drawing industry was raised by Mr. Martin Lindsay. He contended that many other sections of the steel industry were relatively far better supplied than the wire industry, which, he said, had received no benefit whatever from the increased home production of ingots.

Mr. F. J. Erroll, who also spoke, suggested that there was something seriously wrong with the system of allocating steel supplies. A comparatively small additional tonnage for the wire industry, and of the right qualities for individual firms, could remove some of the worst bottlenecks in the engineering and allied trades to-day, and could secure the most valuable export markets. He thought that steel at present being exported in simpler forms could yield much more foreign exchange if sent abroad in the form of wire.

The Joint Parliamentary Secretary to the Ministry of Supply, Mr. J. Jones, replied to points raised during the debate. In the course of his speech he said that the wire-drawing industry was getting a percentage increase of the increased total production of steel in this country. His Ministry's job was to make it possible to give every section of industry a fair allocation of the overall production of steel. The Government had been promised 8500 tons of wire rods by Belgium and Luxemburg in the near future, and it was hoped that more hard steel rods would be forthcoming from Sweden. It was also hoped that France would be able to supply 6000 tons of billets in the second half of this year, and possibly 500 tons of rods.

Wage Rates and Working Hours

The Ministry of Labour has published, in the latest issue of its *Gazette*, details of the changes in wage rates and in working hours in the United Kingdom which came into operation during the month of May. The alterations in wage rates affected about 326,000 workers and resulted in an aggregate increase of approximately £104,000 a week. Among those who participated in these increases were skilled craftsmen in the coal-mining industry, certain ironstone and iron ore miners in Cleveland and North Lincolnshire, asbestos cement workers, some workers in the iron and steel and scrap industries, and those employed in railway workshops. In the first five months of this year, changes in wage rates have resulted in an aggregate weekly increase of £831,600 in the wages of 2,887,000 workers.

The changes in normal hours of labour reported to the Ministry as having come into operation in May resulted in an average reduction of about four hours a week for about 7000 people. Those affected were employed mainly in the cement manufacturing industry, in which the normal weekly hours were reduced from forty-eight to forty-four for workers other than shift workers, although the forty-eight hours are to be worked so long as the shortage of labour continues. In the first five months of 1948, changes in working hours reported to the Ministry of Labour indicate that there has been an average reduction of approximately three hours a week affecting 270,000 workpeople.

Trade Disputes

Statistics concerning industrial disputes, which were issued last week by the Ministry of Labour, show that there were 174 stoppages of work through disputes reported as beginning in May, and that 15 earlier stoppages were still in progress at some time during that month. In these 189 stoppages 32,000 workers were involved directly and indirectly in May, and it is estimated that the aggregate number of working days lost was 86,000. In the preceding month 206 stoppages through disputes were in progress, involving 86,000 workers and causing an aggregate loss of 628,000 working days. Of the stoppages in May, 112 occurred in the coal-mining industry, involving 15,500 workers, and resulting in a loss of 37,000 working days, while 40 occurred in the metal, engineering and shipbuilding industries, involving approximately 11,000 workers and causing a loss of 35,000 working days.

The Ministry of Labour's report adds that 179 stoppages of work ended during May. Of this number, 73 lasted not more than one day, 39 lasted two days, 21 lasted three days, 32 lasted from four to six days, and 14 continued for more than six days.

Unofficial Strikes

The Minister of Labour, Mr. Isaacs, was asked in Parliament on Thursday of last week whether he would set up a Commission of Inquiry on unofficial strikes, in view of their menace to the food supply and other necessities of life. In his reply, the Minister said that he did not think such a Commission would be a satisfactory method of dealing with the problem, but "the position was being explored." The Minister added that unofficial strikes did not come within the purview of the Ministry of Labour until it was approached by the organisations involved. While the Ministry was very much concerned about these continuous outbreaks of resentment against trade union authority, it was not in a position to intervene until it was asked to do so.

The Burden of Public Administration

The National Union of Manufacturers has addressed a memorandum to the Prime Minister asking that there should be an immediate reduction in the heavy burden of public administration, in which, it states, one-ninth of the whole working population is now engaged. The National Union asserts that the country can no longer support this burden of national overhead cost or be deprived of the manpower thus occupied.

Reiterating that about one in nine of the civilian employed population is engaged in public administration, the memorandum says that manufacturers are alarmed at the wide disparity between this heavy national overhead and the difficult conditions in which they are compelled by present circumstances to operate. Furthermore, they feel that, in these days of financial stringency, the heavy cost and the absorption of human effort cannot possibly be justified. This large army of civil servants, the memorandum continues, constitutes for industry a burden of a threefold character: first, the cost which must be borne by industry; secondly, the loss to industry of valuable manpower often of the best administrative type; and lastly, the work imposed upon industrial staffs by the multifarious demands for information and returns by Government Departments. The National Union feels very strongly that this is a position which cannot be allowed to continue if British industries are to maintain their position in the markets of the world, where price competition is becoming more and more acute.

Frustrated Exports

The President of the Board of Trade stated recently that the Association of British Chambers of Commerce had undertaken to advise the Board concerning applications for permission to release for the home market "frustrated" export goods. These, of course, are goods which are stated to be shut out of the markets for which they were originally intended and for which a buyer has not been found in an alternative market overseas.

The Association of British Chambers of Commerce has now announced that the Advisory Panel for this purpose will include the President, Mr. J. McLean, Mr. A. H. S. Hinchliffe, Colonel R. H. Goldthorp, and Mr. J. K. Tyre. In reaching its conclusions, the Advisory Panel will draw upon the large reservoir of expert commercial opinion available to it throughout the United Kingdom. All information supplied by applicants will be treated confidentially. It is emphasised that applications should not be addressed to the Advisory Panel; they should be sent to the Government Department which is the production authority for the goods in question, or, in the case of goods imported for re-export, to the Import Licensing Department of the Board of Trade.

The National Union of Mineworkers

The annual conference of the National Union of Mineworkers is taking place this week at Whitley Bay. An early item on the agenda was the presentation of the National Executive Committee's report, one section of which is devoted to the present situation in the coal-mining industry. The report refers to a recent meeting between the Executive and the National Coal Board, at which the general position of the industry was discussed.

On the question of unofficial stoppages, it was decided at this joint meeting that the Divisional Coal Boards in those areas where the stoppages were most prevalent should combine with the union in making an investigation into the causes leading to the adoption of "go-slow" methods and strike action, and in putting forward recommendations for securing an improvement. The report goes on to say that the National Coal Board's representatives also expressed concern about the implementation of the five-day week agreement, and it was decided to set up a working party, which would call for the full facts relating to this question and report upon any further steps which could with advantage be taken to secure maximum production. It was also agreed that the working party should examine the plans and prospects of the industry over the next two or three years and the possibility of some stabilisation of the wages position during that period.

The Executive affirms in its report that it does not condone "the action of a small minority of the workmen who refuse to recognise the conciliation machinery and take strike action without any regard to the effect of such action on their colleagues or the action of those workmen who fail to accept their responsibility under the terms of the five-day week agreement by unduly absenting themselves from their work." At the same time, the Executive believes it to be necessary "to remind the opponents of nationalisation of the improvement which has been brought about since the Government in 1945 announced its intention to nationalise the industry, and to remind them that the results of the coal-mining industry since nationalisation point to success." It is added that, in so far as criticism of the working of the machinery of the National Coal Board is concerned, the Executive has consulted the union area committees, and intends to make a supplementary report on the matter to the annual conference.

French Engineering News

(From our French Correspondent)

Reasons for the financial difficulties of the nationalised coal mines, although the price of coal is relatively high, are given in the report issued by the commission set up on the Charbonnages de France in November, 1947, presided over by Monsieur Wahl, inspector-general of roads and bridges. The Wahl report states that the average index of price compared with 1939 was 17·5, whereas the cost price index was 21. The difference is mainly due, the report says, to the increased cost of labour, the index being 21·7 against an index of 19·6 for equipment and 15·2 for general expenses. Out of a sale price of 2880 francs per ton and a theoretical cost price of 2873 francs, labour represents 2100 francs. The salary index is only 13·7, however, the labour force having increased while output has fallen off. Absenteeism is twice as high as before the war, the miners' statute preventing action against unjustified absences being taken.

The Wahl report attributes these abuses to authoritarianism, which caused excessive weeding out of skilled men and was far too slow in designating councils and directors for mines. Importance is attached to the composition of these councils. The report proposes that the composition should be modified to give more representation to independent personalities chosen for their competence. It also suggests sanctions against absenteeism, and in return improved pay for increased output.

* * *

An increase in the value of coal from the Nord and Pas de Calais basins as a result of improved washing and sorting is strongly advocated in industrial circles. At the moment mechanical installations in the basin are among the least modern in the country, some being over fifty years old. The price of modern equipment, it is asserted, could easily be recovered from improved coal prices. In January, 1948, out of 3,900,000 tons of coal mined in the Nord and Pas de Calais, 1,300,000 tons were composed of stones which were dumped, and this figure would have been greater had the washing installations of the basin been capable of treating all the coal mined. In January, 1948, out of 2,600,000 tons net, 500,000 tons were unable to be treated and contained over 20 per cent incombustible matter.

Plans for modernisation are going ahead and certain important installations have already been ordered. In from ten to fifteen years it is hoped that equipment will be satisfactory. Unfortunately it is not possible to reduce this delay as all basins wish to equip themselves at the same time and shortage of foreign currency makes it impossible to order abroad all that French industry cannot produce quickly.

* * *

A convention has been signed at Brussels by which the Charbonnages de France will participate financially and technically with Belgium in future work on underground gasification. The first tests made near Liège showed encouraging results, and a second set of tests are to be made. The French mines will participate on equal terms with "Socogaz," to which a capital contribution of 50 million Belgian francs is being made.

* * *

The main French steel firms have formed a limited company, the group for the Reconstitution of Destroyed Steel Plants and Iron Mines, with a capital of 1,000,000 francs, with the object of issuing loans, with State guarantee, to finance expenditure for reconstruction. The Administrative Council, presided over by M. Louis Charvet, general delegate of the Steel Chambre Syndicale, includes the following companies: Hauts Fourneaux, Forges et Aciéries de Denain et d'Anzin, Aciéries de Longwy, Metallurgique de Normandie, Aciéries de Rombas, Les Petits-Fils de Francois de Wendel, l'Union des Consommateurs de Produits Metallurgiques et Industriels, Aciéries et Forges de Firminy, Forges de Leval-Aulnoye, Mines et Produits Chimiques, Société d'Errouville.

Notes and Memoranda

Rail and Road

THE KWANTUNG COALFIELD.—It is reported from China that work was started early in May on the construction of a branch line of the Canton-Hankow railway to the Kouyatung coalfield in the north of Kwantung province. Kouyatung is said to be one of the richest coalfields in the province, containing sufficient deposit of coal to supply power to the Canton-Hankow railway for forty years, in addition to meeting the needs of the entire province.

SUBWAY AT LEICESTER SQUARE STATION.—London Transport has brought into use a new passenger subway at Leicester Square Station. The subway, about 100 yards long, links the Northern and Piccadilly lines and will greatly improve interchange between those two lines. Work was begun in April, 1947, with the sinking of a 100ft deep working shaft from street level in Upper St. Martin's Lane. Fluorescent lighting has been installed in the subway, but because of shortage of materials finishing work, such as decorative tiling, will have to be delayed.

RAISING A BUS GARAGE ROOF.—As the increased height of certain modern types of London bus has in a few cases interfered with their accommodation in older garages, structural alterations have been carried out by London Transport at some of these garages. An example of one method is furnished by work recently completed at Palmers Green Garage, where the entire roof was raised by 10in. The roof, consisting of light steel trusses carried on stanchions superimposed with boarding, slates, asbestos and glazing, covers some 4000 yds super, and the approximate weight lifted was 300 tons. The roof was raised by jacks at forty points, with a lift at each jack of 1in at a time, in sequence. Four jacks were used for this purpose. At each lift 1in iron packing pieces were inserted and when a suitable height had been reached these were removed and stools substituted. After each lift, fixing bolts were inserted and tightened, resecuring the roof to the bedplates. The work was completed in twenty weeks, with no interference to normal bus services.

RECONSTRUCTION SOUTH OF THE YANGTZE.—Reports concerning reconstruction work in China, south of the Yangtze River, indicate that on the 850-mile Canton-Hankow railway, all temporary bridges have been replaced by permanent spans during the two years since traffic was resumed. On the Chekiang-Kiangsi railway traffic has been restored on 625 of its 750 miles, and the remaining section will be reopened next month. On the Hunan-Kwangsi-Kweichow railway some 605 miles have been repaired. Improvement on roads is also progressing rapidly with special attention being given to the inter-provincial communications. In addition, the construction of the Whampoa Harbour near Canton has been partially completed, many buildings and warehouses having been built. Electric power supply is also an important part of the reconstruction schemes. Work on a hydraulic power plant at Wongkiang in northern Kwangtung has started under the auspices of the National Resources Commission. It will, upon completion, supply the power needed by the many cement factories, sugar refineries, paper mills, textile industries and breweries in that province.

Air and Water

SWEDISH SHORT-WAVE RADIO STATION.—A new short-wave radio transmitter has been put into operation at Onsala-Vallda on the West Coast of Sweden, and will, it is believed, prove of considerable assistance to Swedish ships sailing in foreign waters. Tests of the transmitter have given favourable results and reports indicate improved audibility, especially in regions in the "shade" of the Magnetic North Pole, such as the Caribbean Sea and the Gulf of Mexico.

AIR SURVEY IN NORTHERN CANADA.—Contracts for carrying out an aerial survey of 21,700 square miles in the area of the iron ore deposits in Northern Quebec and Labrador have been placed with the Photographic Survey Company, Ltd., of Toronto. The largest of these contracts covers 19,650 square miles south of Fort Chimo, Quebec, for the Federal Department of Mines and Resources. It must be completed during the summer months and involves the photography of the area at a scale of 2640ft to the inch. The results of this airborne exploration work are expected to reveal much information about what it is thought may be one of Canada's richest and most important mineral deposits.

Miscellanea

BRITISH STANDARDS INSTITUTION.—The annual general meeting of the British Standards Institution will be held on Wednesday, July 21st, at 3 p.m., at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

ALLOCATIONS OF TIN METAL.—The Ministry of Supply announces that final allocations of tin metal for the first half of 1948 have been made by the Combined Tin Committee. The quantity of tin metal now allocated to meet requirements for the first half of 1948 totals 39,486 long tons.

THE LATE MR. F. H. VAUGHAN.—We have learned with regret of the death, on June 24th, of Mr. Frank Howard Vaughan, chairman and managing director of Vaughan Bros. (Drop Forgings), Ltd., Eagle Works, Willenhall, Staffs. He was sixty-one years of age, and had been actively associated with the business for the past forty-five years.

WIGAN MINING AND TECHNICAL COLLEGE.—The Wigan and District Mining and Technical College has recently celebrated the ninetieth anniversary of its foundation. A souvenir brochure has been published setting out the steps that led to the establishment of the college in October, 1857, and the progress which it has made through the years. The work of the college is now mainly organised in departments teaching mining and geology, engineering, chemistry, physics, biology, mathematics, building and handicraft, commerce and economics and art.

COMMERCIAL CONDITIONS IN TURKEY.—The Export Promotion Department of the Board of Trade has issued a report entitled "Turkey, Economic and Commercial Conditions, 1947." It has been written by the Counsellor (Commercial) to H.M. Embassy at Ankara, and is a comprehensive survey of the economic and commercial position of the country. It covers all aspects of finance, foreign trade, agriculture, industry and communications, and a foreword mentions the tremendous strides made by the young Turkish Republic in the economic and social field. The report is published by H.M. Stationery Office, price 4s.

A HAND CLEANING PASTE.—A very useful hand-cleaning paste has recently been introduced by T. C. Arrowsmith and Co., 31, Addison Gardens, London, W.11. To clean the hands with this preparation water is not necessary—and in fact must not be used. It is in the form of a thin paste, which is applied liberally to the hands and left for a few seconds. When the paste is then wiped off with a dry rag it removes with it all dirt and grease and leaves the hands quite clean. We had a very convincing demonstration with the preparation, which quickly and completely removed a thick, greasy deposit from the hands with no harmful effects whatsoever. It is supplied for industrial use only in canisters of 14 lb and 20 lb.

THE ZINC CORPORATION, LTD.—The annual report of the Zinc Corporation, Ltd., shows that during 1947 the ore milled totalled 454,053 tons, of which 411,373 tons were mined from the lead lode and 42,680 tons from the zinc lode. It is stated that the average grade of the lead lode was 16·1 per cent lead, 3·5 oz silver, and 11·2 per cent zinc, and that the grade of the zinc lode was 5·9 per cent lead, 1·3 oz silver and 15·2 per cent zinc, thus giving an average overall grade of 15·1 per cent lead, 3·3 oz silver and 11·5 per cent zinc. Lead concentrates produced totalled 86,839 tons, containing 64,076 tons of recoverable lead and 1,398,458 oz silver. The zinc concentrates produced amounted to 90,802 tons of an average assay of 51·8 per cent zinc.

"A.1. AT LLOYD'S."—A four-reel documentary sound film entitled "A.1. at Lloyd's," was shown for the first time on Thursday of last week at the Gaumont British Viewing Theatre, London. It has been made under the direction of Mr. Edward Cook, of the Big Six Film Unit, and illustrates very effectively the activities at the James Bridge Steel Works of F. H. Lloyd and Co., Ltd., Wednesbury, Staffs. As well as portraying the various processes employed by the firm in the production of steel castings for a wide variety of purposes, the film demonstrates the working of the joint consultation committees, which have been established at the James Bridge works. It is stated that in the past six months the firm's output of castings has increased by over 30 per cent. At the conclusion of the film, the Minister of Supply, Mr. G. R. Strauss, congratulated Messrs. Lloyd on its production, and also upon the notable contribution which the firm was making to the work of the British steel industry.

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 their 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.*

Association of Building Technicians

Monday, July 12th.—Committee Room 140, L.C.C. County Hall, S.E.1. "Planning and Reconstruction in Poland," Arthur Ling. 5.30 p.m.

Association of Supervising Electrical Engineers

Tuesday, July 13th.—SOUTH WEST LONDON BRANCH: Compton Hall, Wimbledon. "The 13A Plug and the Ring Main," A. Amberton. 8.30 p.m.

Wednesday, July 14th.—BRADFORD BRANCH: Midland Hotel, Bradford. "Electric Lifts from a Maintenance Point of View," C. Rhodes. 7.30 p.m.

British Standards Institution

Wednesday, July 21st.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Annual General Meeting. 3 p.m.

Incorporated Plant Engineers

Thursday, July 15th.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool. "The Blackpool Tower," G. W. Foster. 7.30 p.m.

Wednesday, July 28th.—WESTERN CENTRE: Visit to Swindon Works of British Railways. Assemble 2 p.m.

Institution of Civil Engineers

Wednesday, July 14th.—BIRMINGHAM AND DISTRICT ASSOCIATION: Visit to the Derwent Valley. 8.45 p.m.

Institution of Electrical Engineers

Saturday, July 17th.—SOUTH MIDLAND STUDENTS SECTION: Summer Outing. Depart Hall of Memory, Broad Street, Birmingham. 8.30 a.m.

Royal Institution of Chartered Surveyors

Wednesday, July 28th.—Institution of Civil Engineers, Great George Street, S.W.1. Discussion on "The Central Land Board." 5.30 p.m.

Technical Reports

"*Interim Report on the First Series of Tests on Formulated Priming Paints for Structural Steelwork* (*RJ* 28)." By Joint Technical Panel J/P1., Paints for Structural Steelwork. December, 1946. Copies are available from the British Iron and Steel Research Association, 11, Park Lane, London, W.1.—Extensive recent developments in the ranges of media and inhibitive pigments available for the preparation of priming paints have considerably influenced anti-corrosion researches on iron and steel. Some interim details of such work by the Protective Coatings Sub-Committee of the Iron and Steel Institute and the British Iron and Steel Research Association are given. This work is a natural sequel to the Sub-Committee's previous investigations on the importance of careful preparation of steel surfaces prior to paint application.

A panel was set up by the joint Sub-Committee in collaboration with the National Federation of Associated Paint, Colour and Varnish Manufacturers of the United Kingdom, the Society of British Paint Manufacturers, Ltd., and the Association of Manufacturers of Bituminous Protective Products, Ltd. This joint technical panel is testing 100 formulated priming paints, suitable for brush application, by exposure on steel plates. A standard finishing coat was applied, and the exposure tests were duplicated in an industrial atmosphere (Derby) and a marine atmosphere (Brixham).

Twelve experimental binding media and twelve different pigments are under investigation. Care was taken to ensure that all the paints were prepared under conditions approximating as closely as possible to large-scale production and that they were applied to steel specimens in typical and standardised states of surface preparation. In order to give the maximum practical bias to the results, considerable importance was attached to conducting tests on weathered and wire-brushed steel carrying millscale.

The tests will not reach their first stage of completion until later this year, but after six months certain interim observations were made. These interim results indicate that, when considering the effect of this formulation of a priming paint on the protective value of a painting scheme, due regard must be paid to the factor of paint film thickness, i.e., the behaviour of any given painting scheme must be considered in relation to the average performance of other schemes of the same thickness. Even with skilled application of the paint under good conditions, the specimens concerned showed a variation in paint film thickness between 50 and 120 microns, though 50 per cent of the specimens fell between 60 and 80 microns and over 40 per cent between 80 and 100 microns. Assessments of the deterioration of the specimens based on blistering, flaking and rusting show that there is a distinct correlation between the average performance of a group of painting schemes and their average paint film thickness.

Another variable is introduced by the difficulty of reproducing standardised degrees of descaling on the surface of a large number of steel specimens prepared for painting by weathering and wire-brushing. As a result of experience in this test series, the panel has made certain alterations in the experimental procedure which should reduce these variations and also the variations in paint film thickness mentioned above.

Another interesting interim observation concerns the comparative rates of deterioration of the paints at Brixham and Derby. Although the average paint film thickness at Brixham (52 microns) is slightly greater than that at Derby (47 microns) it appears that up to six months the rate of deterioration is more rapid in the marine than in the industrial atmosphere. This observation is confirmed when the merit figure in each case is correlated with paint film thickness.

Codes of Practice

The Codes of Practice Committee for Civil Engineering, Public Works and Building and Constructional Work is under the ægis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

MAGNESIUM OXYCHLORIDE FLOORING

Code 204.107. The Codes of Practice Committee has issued for comment Code 204.107, which has been prepared by a committee convened by the Royal Institute of British Architects, and deals with magnesium oxychloride flooring, one of the types of flooring commonly known as "jointless." Magnesium oxychloride flooring material is described as essentially a mixture of magnesia with various inert fillers and pigments, gauged with a solution of magnesium chloride. The fillers consist of sawdust, woodflour or ground silica and sometimes a portion of talc, asbestos or sand. A small portion of bitumen in the form of an emulsion is incorporated in certain compositions. The suitability of magnesium oxychloride flooring is considered in relation to the conditions in which it is likely to be used. The main characteristics of the flooring are fully discussed and the precautions required to avoid deleterious effects with adjacent materials are presented. The Code is in draft form and subject, before final publication, to amendment in the light of comments received. Comments are invited and should be submitted by August 14, 1948. Copies may be obtained from the British Standards Institution, 24–28, Victoria Street, London, S.W.1, price 2s. post free.

BROADCAST RECEPTION: SOUND AND TELEVISION BY RADIO

Code 327.210. This Code has now been issued as a draft for comment. It was prepared on behalf of the Codes of Practice Committee by a committee convened by the Institution of Electrical Engineers. It deals with the basic requirements for good reception both of sound broadcasting on all wave bands, and of television broadcasting. It applies only to installations for use in temperate climates and is primarily intended for the servicing of new buildings, although much assistance will be obtained from it where existing buildings are to be equipped. The need is stressed for early liaison between all contracting parties so as to ensure that the type of apparatus required, its accommodation and the arrangement for wiring are satisfactory. The design section of the code deals fully with aerial systems, the siting of aerial, earth connections and power supply, and recommendations are given on these matters as applicable to different classes of building. The causes of electrical interference between various classes of telecommunication circuits, or between other circuits and telecommunication circuits, are examined. Advice is given for reducing this trouble and for minimising the risk of dangerous voltages arising on telecommunication circuits. A sub-section on structural accommodation gives guidance on the requirements in buildings for cabling and wiring in vertical and horizontal runs and on the space needed for central equipment and the accommodation of apparatus at the individual points. Information is given on delivery and storage of equipment and apparatus for new buildings and its location on site, with advice on the installation of aerials, lead-in, and cabling and wiring (internal and external). Recommendations are made on inspection, testing and maintenance, and there are comprehensive appendices on the segregation of electrical circuits and on various types of cables and wires.

Comments, which are invited, should be submitted by July 24th. Price 5s., post free, proof reference CP/B/743.

Personal and Business

MR. W. F. SAXTON, chief engineer of Armstrong Siddeley Motors, Ltd., has been appointed a director of the company.

MR. L. E. VAN MOPPES has been appointed an honorary vice-president of the Engineer-Buyers and Representatives Association.

MR. G. E. RICHARDS, A.M.I.Mech.E., has been appointed sales manager of the railway division of the Pressed Steel Company, Ltd.

GOODMANS INDUSTRIES, Ltd., Lancelot Road, Wembley, states that its telephone number has been changed to Wembley 1200 (8 lines).

THE HOFFMAN MANUFACTURING COMPANY, Ltd., has opened a new branch office at 50, The Wicker, Sheffield, 1 (telephone, Sheffield 20246).

DR. J. H. PATERSON, F.R.I.C., has been elected President and Mr. O. V. S. Bulleid, M.I.Mech.E., a Vice-President, of the Institute of Welding.

MR. G. E. BEHARRELL, managing director of Dunlop, Ltd., has been elected president of the Federation of British Rubber Manufacturers' Associations.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that its publicity department is now at 21, Bloomsbury Street, London, W.C.1 (telephone, Museum 1600).

MR. H. R. HUMPHREYS has been appointed assistant to the general manager of the repair work of Harland and Wolff, Ltd., with headquarters at the London office, 9, Whitehall, S.W.1.

BAYLISS, JONES AND BAYLISS, Ltd., announces the following appointments: Mr. J. Irving, works manager; Mr. H. P. Denny, chief engineer, and Mr. E. J. Page, bolt works manager.

HAWKER SIDDELEY AIRCRAFT COMPANY, Ltd., states that its name has been changed to Hawker Siddeley Group, Ltd. Its headquarters remain at 18, St. James's Square, London, S.W.1.

THE LONDON MIDLAND REGION, BRITISH RAILWAYS, announces the appointment of Mr. J. Dearden as chief metallurgist in the scientific research manager's department, Derby.

SIR JOHN DALTON, formerly general manager and director of the County of London Electric Supply Company, Ltd., has been appointed a director of the Cable Makers' Association.

MR. HOWARD S. CRUMP has been appointed manager of the Liverpool branch of the Brightside Foundry and Engineering Company, Ltd., in succession to Mr. W. Clare, who is retiring on account of ill-health. Mr. Clare is also retiring from the board of the company.

THE BRITISH ELECTRICITY AUTHORITY states that the headquarters of its London Division will be established as from July 19th at Ergon House, Horseferry Road, S.W.1, and that the accountant's department will be transferred to Aldwych House, Aldwych, W.C.2.

THE RUBEROID COMPANY, Ltd., announces the retirement, after thirty-eight years' service, of Mr. O. M. Proudlock-Dunbar, director and factory manager. He will continue to act as technical consultant. Mr. Stewart Proudlock has been appointed factory manager. In view of his infrequent visits to this country, Mr. H. Abraham has resigned from the board of the Ruberoid Company, Ltd. His place is to be taken by Sir Geoffrey D. Burton.

Contracts

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., has received an order from Umfolozi Co-operative Sugar Planters, Ltd., of South Africa, for a 2500-kW turbo-alternator set for their sugar mills at Umfolozi. The set is to operate with steam at 150 lb per square inch and 520 deg. Fah. at the turbine stop valve.

UNITED KINGDOM TIN POSITION.—The Ministry of Supply states that at May 31st its stocks of tin metal amounted to 5177 tons and that consumers' stocks totalled 3005 tons. Stocks of tin ore in the United Kingdom on the same date are reported to have been 5162 tons.

NON-FERROUS SCRAP METAL PRICES.—The Ministry of Supply announces that owing to the disposal of stocks of non-ferrous scrap metals, the items in the list published on January 29th, with the exception of those specified below, are no longer available at fixed prices. The following materials are still available at the prices listed: zinc alloy die cast scrap, £70 per ton ex works; brass S.A.A. muffled and/or mechanically treated cases, £100, and brass broken down fuse scrap 60/40, £93 per ton ex works. All other items are deleted from the list and any remaining stocks or future arisings of the deleted items will be offered for sale by competitive tender from time to time.