Discussion.

The President. The PRESIDENT, in proposing a vote of thanks to the Author, remarked that he had never known a case in which greater cleverness and inventive ability had been shown than in dealing with the problems that had arisen in connection with the erection of airship sheds. He had not the slightest doubt that the Paper would be of very great interest, especially to the younger members.

Dr. Brightmore. Dr. A. W. BRIGHTMORE remarked that it had fallen to his lot, more or less as an outsider, to investigate some of the designs submitted for the larger sheds, of which such a comprehensive description had been given by the Author; and he desired to express his admiration of the amount of very important work which had been done both in designing and in erecting the large steel structures. In tackling that big problem the Government Department responsible could not be charged with wasting public money by using unnecessarily heavy sections to cover any lack of care in calculations; in fact, some of the earliest designs went rather to the other extreme. In the later designs, when the permanency of the structures became an important consideration, the factor of safety was increased to the more comfortable value of 4. It would be noticed that the larger structures consisted chiefly of three types. In the first place there was the girder roof supported by **A** trestles; secondly, there was the three-hinged roof supported on trestles. In the case of the large twin sheds, which had been very carefully described, the two lower pins were not at the same level, which, of course, introduced some complications into the calculations. It was of interest to note that in the single sheds the two lower pins in the later designs were at a higher level than in the earlier designs. Thirdly, there was the two-hinged type with the pins at the ground level, the structure being continuous between them. That type was, of course, only suitable when no question arose in connection with the foundations. In one of the latest designs for a smaller shed a pin was introduced at the centre of the roof, which enabled the stresses to be more readily determined and enabled it to adapt itself to any slight difference of level in the foundations due to settlement, although it added appreciably to the weight of the structure. The first two types were statically determinate, except as to the distribution of the horizontal reactions at the points of support. Those could, however, be determined by the deflection method. In the case of the two-hinged structure the method of deflections had to be relied upon for determining the stresses, but the method of sections could be employed as a useful check. One of the most interesting problems arose in connection with the doors, each leaf of which weighed 200 tons more or less, the wind-pressure being counterbalanced by a dead load of concrete. When the wheels were directly connected to the door-frames it was found very difficult to get the load approximately equally distributed between the wheels, except in a case in which they were arranged with a pair of two wheels at the centre and a single pair of wheels at each end, when the elasticity of the structure distributed the load approximately uniformly. When two pairs of wheels were connected at each end of the frame of the door, it was found impossible to get uniform distribution on the wheels. That was overcome by the very simple expedient of fitting the pairs of wheels on separate frames and articulating those frames to the door-frames. Dr. Brightmore.

Mr. E. A. W. BARNARD said the Author had alluded to some of the difficulties which had to be contended with in providing airship sheds and accessories, but the greatest trouble was the all-important question of time. The sheds were required at the earliest possible moment, as the ships had been ordered; thus it became a race between the ship and the shed as to which would be ready first. In ordinary circumstances, before embarking upon the construction of one of those huge structures several months would have been devoted to the preparation of preliminary designs, calculations and models, in order to determine the most economical form and the easiest methods of manufacture and erection. That course had been, however, quite out of the question in the present instance. It was necessary to get on with the work and provide some sort of shed without delay. The result of the method adopted for obtaining the designs was that several skilled staffs were working on the problem at the same time, and, as the clear dimensions of the shed, permissible stresses, wind-pressures, etc., were fixed by the Admiralty, the lowest tender usually showed which was the most economical design. All the contractors' calculations and drawings were carefully examined and checked by the Admiralty staff to see that the requirements laid down in the specification were fully met, and, in the few cases where they were not met, alterations were made in the working-drawings by the contractors at their own expense before the work was put in hand. After the contracts for the sheds Mr. Barnard.

Mr. Barnard. had been arranged and the drawings and calculations had been examined, difficulties arose from shortage of steel and labour. Generally speaking, after the steel had been delivered rapid progress was made with the manufacture of the sheds in the contractors' shops, but the time taken in erection exceeded anticipations. One great difficulty was the scarcity of skilled erectors who could work at the great heights at which some portions of the structure had to be fixed. In spite, however, of the difficulties, he thought he was correct in saying that with one exception the sheds were ready in time to receive the ships, the one exception being a small shed required for the construction of the S.S. type of ships. The cause of the delay in that case was very serious labour trouble. The Author's remark on p. 170 with regard to the number of "wasted designs" might give rise to some misconception. It was generally the case that several sheds of the same size were required at the same time, and the orders were distributed to several firms. For instance, at one period there were nine large sheds being constructed by four contractors to five different designs, and eight smaller steel sheds by three contractors to three designs, besides several of the smaller timber structures. Very few designs, therefore, were wasted. The Paper dealt so fully with the trouble experienced with the doors of some of the earlier sheds that he need not go further into the matter; but he desired just to refer to the doors of the large twin shed. Each leaf was 76 feet wide and 130 feet high. In ordinary circumstances they were worked by eight men on the fast gear and four men on the slow gear, but at an official test at which he was present the number of men on the slow gear was reduced to two and the door was moved without difficulty. Finally at his request one man operated the door. He was certainly a strong man and he had hard work to move the door, but nevertheless he moved it. So far as he was aware, the doors of that shed had not given the slightest trouble. A civil engineer from the Admiralty staff, Mr. S. C. Bailey, Assoc. M. Inst. C.E., accompanied the mission which proceeded to Germany in 1920 in connection with the transfer of the airships, etc. Mr. Bailey had submitted a very full and valuable report on the German sheds, and he hoped Mr. Bailey would be permitted to give The Institution some of the information he had obtained, possibly in the form of a Paper. It was very gratifying to learn from Mr. Bailey's report that, so far as the sheds were concerned, this country had very little to learn from Germany. The doors of the German sheds were different from the type usually adopted in this country, more nearly resembling the alternative type referred to by the

Author on p. 197. That type of door had many advantages, but those responsible for the design in this country considered that the balance of advantage was in favour of the **A** type, which was adopted. In addition to the sheds themselves, quarters, offices, workshops, housing for electric-light, power, and gas plants, roads, railways, drainage and water-supply had had to be provided, and that had involved a considerable amount of work. In connection with the water-supply they were very greatly indebted to the Metropolitan Water Board, who lent their staff for the purpose and rendered most valuable assistance. He desired specially to mention in that connection the late Sir James Restler and Mr. C. F. Marsh, MM. Inst. C.E. Dr. Brightmore had also rendered very valuable assistance in connection with the drainage and the analysis and examination of the calculations of the sheds. Mr. Barnard.

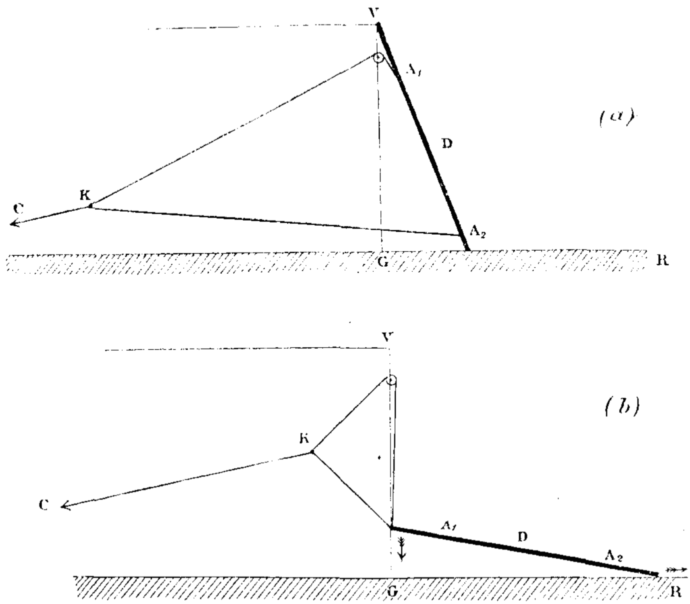
Mr. R. St. George Moore, referring to the question of the method and plant for erection, said the Author had described erection by poles and masts, by derrick cranes and by travelling platforms. There was one combination which he thought would be of great use in erections of the type described, namely, a combination of a travelling stage and a mast. The heel of the mast, which would take the place of the derrick crane, would be slung below the deck of the stage and pass through a hole in it, the top of the mast would be supported and manœuvred by stays in the usual way. For roof-work similar to that under discussion there would be masts at each of the four corners of the stage. By shortening one sling and letting out the other, the angle of the mast could be brought to any required position, enabling pieces to be lifted from the ground. For erection of the roof members the mast would be brought up to the vertical, and raised or lowered by the slings. Another great advantage was that the whole platform was left free for working on; all the gear for hoisting, etc., could be either under the platform or on the ground. The Americans were using that method of erection for the very high towers, 820 feet high, near Croix d'Hine. Mr. Moore.

Mr. A. S. E. Ackermann said that, early in 1916, the problem of the doors came before him in connection with a proposal by Admiral Sir Percy Scott to place the sheds in chalk-pits and quarries, thus getting protection for the sides and ends of the structures. For that purpose it was necessary to place the sheds side by side. Sir Percy Scott proposed that there should be three or four of them in a group. The **A**-frame doors which had been described in the Paper were quite unsuitable for sheds in such a position, because there was no room for the half-doors, when in the open position. The Mr. Ackermann.

Mr. Ackermann. annexes to the sheds described in the Paper were necessary to take the thrust of the arch, and were roughly 35 feet wide at the base. They went away to a point at about 80 feet or even more above the ground-level, and were something of the order of 700 to 750 feet long. It did not need much imagination to see that the weight of steel work in the annexes was very great, and he would like to ask the Author what proportion of the total weight of a shed of that description was utilized in making the annexes. It was true that a virtue was made of a necessity, and they were utilized for workshops and repair-shops; but the provision of a floor 750 feet long was, he thought, more than was necessary. If some of the annexes were done away with—as would be possible if the sheds were placed side by side—it was only necessary to have an outside pair of annexes to take the thrust, so that four annexes were done away with in the case of three sheds arranged in that manner. The trouble then arose as to what was to be done with the door. The model of the door which he proposed was inspected by Admiral Sir Percy Scott during the war and apparently approved by him. The side elevation of the end of an airship shed, 750 feet long, was as shown in *Fig. 44* with the door in position. There were vertical rails at each side of the door openings and horizontal rails at floor-level outside the shed. The door moved as a slipping ladder. To produce the motion two pulleys were required, attached to the end stanchions as shown in *Fig. 44*. In the down position of the door the ropes were as shown and passed under the upper end of the door. When the two ropes were pulled to lift the door to the closed position they acted as a sort of inverse toggle joint, which lifted the top of the door, at the same time pulling its lower end towards the shed. In the designs described in the Paper, two-thirds of the weight of the door was ballast, i.e., about 200 tons of ballast, and 100 tons of steelwork; that did not appeal to him as an engineering way of tackling the problem. A great structure 100 feet high and 35 feet wide at the base had 100 concrete blocks to prevent its being blown over. He had seen the structures, and, in his opinion, they did not look like engineering; they looked like a game for a boy who put a lot of stones on a thing to prevent it blowing over. He was told at the time that the ton blocks were costing £3 each. On the other hand, the door he had described needed no ballast whatever. A complete door for a shed measuring 100 feet high and 100 feet wide weighed only about 100 tons, and, by using a counterweight, the maximum pull on each of the two ropes was only 6 tons; so that a steel rope 1 inch diameter would suffice for the work. A 20-HP. motor placed in the centre of the shed, so that it could be clutched to drums working the doors at either end, would raise the door in 10 minutes, whilst with a bigger motor it could be done in much less time. There was no particular advantage in the door as a door, although it was quite impossible for the wind to blow it over when it was open, because it went flat into a suitable recess with rails at the bottom. Three objections were raised by Mr. (now Sir) Thomas Sims, of the Admiralty, to this design. The first was that the door would press against the end

Mr. Ackermann.

Figs. 44.



ACKERMANN DOOR FOR AIR-SHIP SHEDS.

Diagrammatic vertical longitudinal section through the door and end of shed. (*a*) Position of door when shut; (*b*) ditto when nearly open. A_1 and A_2 are the points of attachment of the steel ropes to the *under* side of the door D. GV is one of the two vertical rails. GR is one of the horizontal rails. K is the equivalent of a knot. KC is one of the two ropes attached to the haulage drums.

stanchions of the shed. The force could be calculated and a small amount of additional steel, which could be saved out of the four annexes, could be put in to take that extra thrust. The second objection was that there was a hole in the ground when the door was shut, and that difficulty might be experienced in preventing men from falling into it. It had to be remembered, however, that

Mr. Ackermann. there were wet docks and dry docks, and men had to take care not to fall into them. Mr. Sims further said that water would get into the hole. He replied that that would be a good thing, because it would break the fall of the man when he fell in. Iron structures at the seaside had to stand the action of sea water, and even if a pump was not put in to pump the pit dry the water would not destroy the door.

Admiral Sir Percy Scott had shown the model of the door to the Admiralty, and four builders of air-ship sheds (including two on the Author's list) had put the design before the Admiralty in 1916.

Mr. Thorpe. Mr. W. H. Thorpe said that one matter of great importance to anyone interested in steelwork was the relative cost of the designs. One could not expect to get the cost in money, but the cost as represented by steelwork weight was given, and it was of some significance. Particulars were given in the Table on p. 208 of seven types of sheds, including the total weight of steelwork and the weight per square yard of effective floor-area. The latter was a useful figure, but it was not perhaps so instructive as the weight per cubic foot of total capacity. Generally the sheds had 150 feet clear opening and ranged in height from 100 to 130 feet. They were broadly comparative. He had worked out the weight in pounds per cubic foot, and going down the list in order they were as follows:—0·32, 0·41, 0·39, 0·28, 0·33, 0·31, and 0·30. It was significant that with so many minds brought to bear upon the question, all doing their best, the results were so very much alike. The second one, with a span of 180 feet, might be expected to work out heavier as, in fact, it did, but the others might very well be compared one with another, except perhaps the twin span, and that having timber purlins. That they came out so nearly alike showed that there was not a great deal to choose between the various designs in point of economy.

Sir G. Scott-Moncrieff. Sir George Scott-Moncrieff, K.C.B., remarked that the Paper showed one of the many ways in which the members of The Institution had come to the assistance of the Government during the war, particularly in helping to solve some of the novel problems which the war presented. In the present instance it was to be hoped that the work done might also be of great value in the development of commercial aviation. With regard to his own connection with the subject, about 12 years ago he was Chief Engineer at Aldershot, where, among other duties, he superintended the erection of what was considered at that time to be a very large airship shed. Ten years in a science of the kind with which the Paper dealt passed away very quickly, and left one a sort of Rip Van Winkle in the matter of airship shed design, and his apologies were therefore due to the members for saying anything on the subject. It might be of interest, however, if he placed before the meeting some of his experiences, not with a view to criticize in any way the excellent work the Author had done, but rather to show how the same problem presented itself in the early stages of airship-shed design and to indicate the proposals which were then made for solving it. The first airship shed at Farnborough was somewhat of the description shown in *Fig. 45.* It had a main nave and two annexes, with a span of 65 feet and a height of about 60 feet. In plan the end of the building was semicircular; it had what was called in ecclesiastical architecture an apse, and it had only one door. After the

Sir G. Scott-Moncrieff.

Fig. 45.

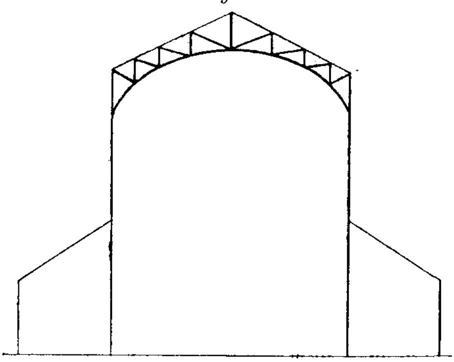
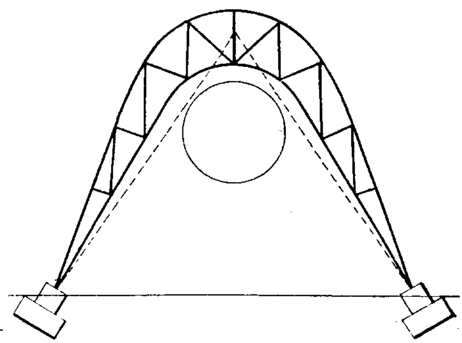


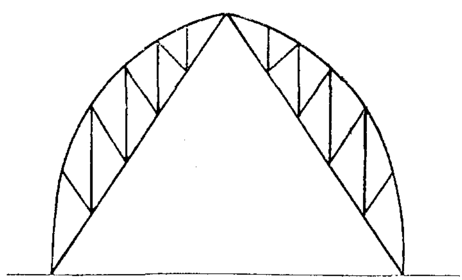
Fig. 46.



shed had been constructed it was found that it was 5 feet too low to house the largest airship which was on order at that time, and the shed had to be raised 10 feet in order to admit the new airship. That set him thinking—he was not at all responsible for the design, being simply in charge of the erection—as to how any such mistake could be avoided in the future. In talking the matter over with a friend of his, who was a great aviator and also a very capable engineer, certain conclusions were arrived at. The first thing done was to settle the largest cross section of the airship, for the purpose of deciding what floor-space was required for the efficient working and handling of the ship in and out of the shed. As far as he remembered, a span of about 90 feet and a height of about 70 feet was decided upon: a clear height of 70 feet would allow the ship in and out, and would give sufficient room on the floor for the men to be working backwards and forwards. At the time it was con-

Sir G. Scott-Moncrieff. sidered that that was better than having it like the airship shed at Farnborough, with rigid walls or stanchions at the sides, hampering to some extent the men who had to get the ship in and out. They then considered the question of covering this space. A double parabolic arch was designed, as in *Fig. 46*, which showed a two-pin arch of 90 feet span and 25-foot spacing. He was working at that design about the year 1912 and had got so far as deciding upon the dimensions of the steel, the possibility of clothing the stress diagram with market sections, and calculating the wind and other stresses, when, before there was time to put what had been done into practice, an order came from the Government that all airships were thenceforward to be dealt with by the Naval authorities, and that the military engineers were to take up the question of aeroplane-shed design only. That limited his subsequent researches to the question of aeroplane-shed design, which presented many

Fig. 47.



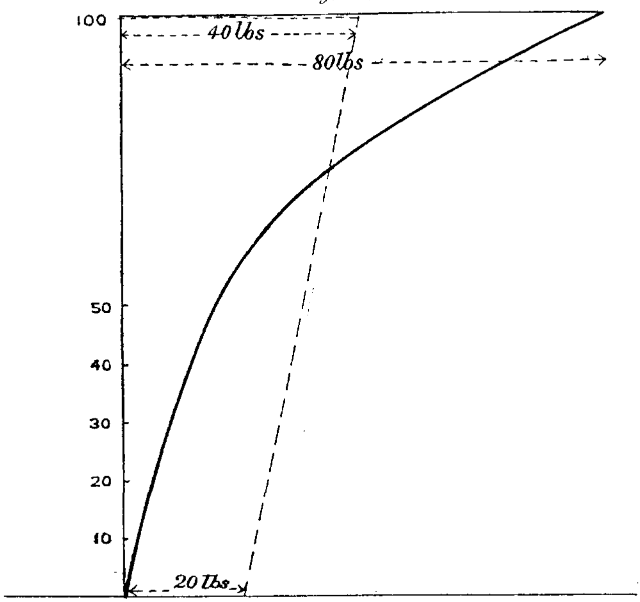
problems entirely different from those to which he had been referring. Thinking the subject over afterwards, as one often did when one had had a problem to tackle and had not completed its solution, he came to the conclusion that it would be better, instead of a two-pin arch, to have a three-pin arch with a pin at the top and two parabolic curves, as shown in the sketch, *Fig. 47*, somewhat on the principle of the late Professor Claxton Fidler's stiffened suspension bridge, which had been applied in many cases with great success. He was interested to find in the Paper that the three-pin arch design had been adopted in some cases, although the deviation from the parabolic curve had been very marked. He was not aware of the size of the airships which it was proposed to put into the sheds, nor was he quite clear why the deviation from the parabolic curve had been adopted. The more nearly the parabolic form was approximated to, the greater was the economy; and most stress was put upon those members which deviated most from the parabolic arch. He believed that was demonstrated by the stress diagrams in some of the designs given in the Paper. Moreover, as the height above the ground increased, the wind-pressure became greater, and there was therefore an additional advantage in having the parabolic form of roof which gradually sloped more and more as it ascended, so that the normal pressure became considerably less. Those were two points in connection with the parabolic design which he thought were worth considering. There was also the question of possibility of constructing such sheds in reinforced concrete. It was quite understandable that during the war it was impossible to do otherwise than utilize steel; but it was to be hoped that, if such constructional work went on, it might be possible to utilize reinforced concrete in the construction of the sheds. Sir G. Scott-Moncrieff.

The effect of wind-pressure, on which the author had rightly laid emphasis, was one of the most important problems to be dealt with. He noticed the Author stated that in one case the horizontal wind-pressure was taken as 35 lbs. upon the roof and 30 lbs. per square foot upon the sides and the ends; in another he said 40 lbs. at eaves level above and 20 lbs. at ground level. It seemed to him to be almost unthinkable that near the ground anything like a 30-lb. wind-pressure would be experienced. On the other hand, at a height of 90 or 100 feet above the ground a good deal more than 30 or 40 lbs. pressure would be obtained in heavy gales. The pressure upon a vertical plane corresponding to the projection of an airship-shed, instead of being a quadrilateral figure (as indicated in the dotted lines), would be rather of a form approximating to that shown in the curve in *Fig. 48*. The pressure at great heights would be much higher than 40 lbs. per square foot, and down below it would be practically nothing. In designing work of that description it was necessary to allow for much greater wind-pressure above than below, and that affected very largely the reactions at the base. Another point he noticed was that in one or two of the sheds which were given as examples in the Paper there were some ridges and valleys. He would be interested to know Dr. Unwin's views on that matter. As far as he remembered, in a lecture which Dr. Unwin gave at Chatham about 25 years ago, it was pointed out that the effect of wind, especially upon high buildings of that description, was particularly severe in the case of a roof which was broken up into ridges and valleys, and that it was necessary to pay special attention to the design of that part of the structure which was at a great height above the ground. Dr. Unwin also mentioned that negative pressure at the leeward side of the building would have to be

Sir G. Scott-Moncrieff.

carefully considered. He did not know whether any of the members present had had experience of wind having directly blown in any roof. After many years' experience he could not remember a case in which a roof had been wrecked by the actual pressure of wind upon it directly, but he knew of numbers of cases in which the wind had wrecked the building through getting under the roof and inside it, or under a shed. A large number of sheds were erected under his supervision during the war, not only for aeroplanes, but for all sorts of other purposes, and he could remember only one serious accident caused by wind. That occurred in a case in which

Fig. 48.



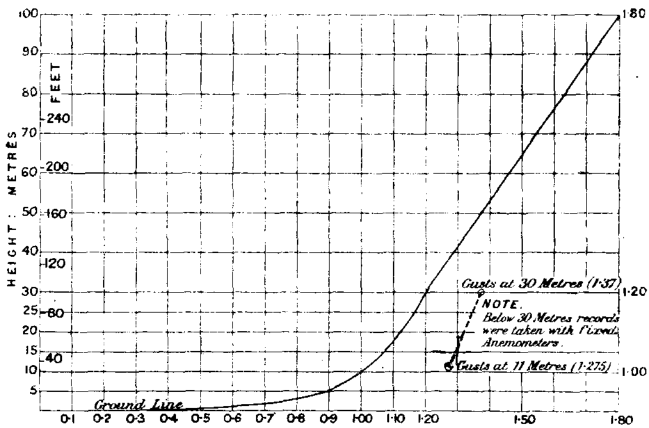
the contractor put up his stanchions and then put his roof on the top of them without the walls and buildings which would have given the necessary shelter. It seemed to him therefore that the whole question of wind-pressure was so important in connection with airship-shed design that it required most careful consideration. He did not think, with all due deference to the Author, that the data he had given in connection with the designs were supported by the experiments which had hitherto been made, and he thought special attention should be paid to those parts of the building under which there was any possibility of the wind getting, as was the case with an airship shed.

The Author. The AUTHOR, in reply, observed that Mr. Barnard had called attention to the difficulty due to scarcity of skilled erectors who could work at great heights, and it might be of interest to mention that a party of twelve erectors, whose average age was approximately 60 years, having satisfactorily completed the erection of the top work of one of the large sheds, was offered a ground-work job, by way of a change and out of consideration for their age, but they informed the contractor that if they were not good enough for "top" work they had better give up their job and seek some other kind of work. Needless to say, they continued work on the next shed. The type of erection mast referred to by Mr. St. George Moore, although obviously very suitable for towers, would not, in the Author's opinion, be as applicable to airship-shed erection as cranes on travelling stages; there would not be that nicety of joint action in lowering, raising, and sluing which can be obtained with two cranes. He did not agree with Mr. Ackermann that A-frame doors would be unsuitable for sheds constructed in chalk-pits and quarries. Ample space was required in front of the shed to manœuvre an airship, and the side of the shed could not be lined up with the quarry face which flanked the side of the area in front of the shed. The suggestion is made that the annexes were a waste of steel and multiple sheds were proposed. That was, of course, only an extension of the twin shed design referred to in the Paper. Twin shed designs for sheds for rigid airships had been considered in every instance where two sheds had been required on the same station at the same time, but more than two sheds at one time had not, up to the present, been asked for. Reference had been made in the Paper to the burning of a rigid airship, and had this occurred in a twin shed, with an airship in the adjoining bay, two ships instead of one would almost certainly have been destroyed. In the circumstances it was unlikely that twin sheds would be built in the future, and treble spans were still less likely to be given much consideration. Figures giving the proportion of steel in the annexes compared to the total in the sheds were not available, and no useful purpose would be served by making fresh calculations. The approximate weight of several parts of a main rib of the twin shed were, however, given on p. 189 in the Paper, and to these might be added the weight of the centre column, which was 13 tons. It was much cheaper to provide annexes and use them for offices, workshops, stores, etc., than to build separate buildings. In the American design referred to in the Paper, two-storey annexes were contemplated. A number of solutions had been proposed for the important problem of providing

The Author. economical and satisfactory doors for large sheds, but reference to them had been purposely omitted from the Paper as they had not been proved in actual practice. Mr. Ackermann did not seem to be fully acquainted with the conditions required in designing doors for airship sheds. The door panels, in his scheme, would have to be designed as a bridge, with the girders and decking strong enough to carry the heavy tractors which were used for towing rigid airships. To get a proper perspective of the relative merits of A-frame doors and one of Mr. Ackermann's design, it was proposed to consider his type applied to one bay of the twin shed referred to in the Paper. The size of the door panel would be about 150 feet by 140 feet, and say 8 feet deep; the weight of the steelwork in this panel would be about 200 tons; half of this load had to be carried by the two portal columns of the shed, which were 130 feet high. Allowing for counterbalance, etc., the live load to be sustained by these columns was about 200 tons, exclusive of the ordinary roof loads of about 90 tons per column. The total wind load on the door panel was 260 tons, and the overturning moment 18,200 foot-tons. It is obvious that much more than "a small amount of additional steel" would be required in the structure of the shed for these loads. It was estimated that the steel required for this type of door was approximately 50 per cent. more than had been provided in the A-frame doors, and the cost would be increased accordingly. On p. 188 a description of the ground was given, and it would be noted that 7 feet below the surface sand and warp were met with. To construct a pit in this material would be a costly undertaking; the whole of the foundations would have to be piled, great difficulties with running sand and water would be met with, and in all probability the cost of the pit alone would be equal to the cost of the A-frame doors to which exception had been taken. A pull of between 2 and 3 tons was sufficient to move the A-frame doors to one bay of the shed. Taking Mr. Ackermann's figures, his type of door would require a maximum pull of 24 tons. The Author was surprised to find an engineer advocating a scheme which involved the frequent lifting of heavy weights when the same object could be attained by rolling them. In the case of the A-frame doors the pull per ton of door load ranged from 10 to 40 lbs. The Author was indebted to Mr. Thorpe for calling attention to the weight of steel per cubic foot of building. The results were certainly interesting and reflected great credit on the designers.

The relative cost of the sheds had been purposely omitted; the figures would not have served any useful purpose without the market rates for steel, and also the rates for labour current during the period of each contract; and these particulars were not available. With reference to Sir George Scott-Moncrieff's remarks, the Author understood that the Farnborough shed was raised without being dismantled, and it would be of interest to know how the work was carried out, as this was a problem which might have to be faced in the future in connection with some of the sheds referred to in the Paper. Generally speaking, the sheds were intended to take two ships side by side, and for this reason a parabolic section would not have proved economical. The crucial test as to whether a particular design was economical was the price at which the finished article could be obtained; the extra cost of manufacture and The Author.

Fig. 49.



APPROXIMATE HOURLY MEAN VELOCITIES AT VARYING HEIGHTS ABOVE OPEN GRASS LAND AND COMPARED WITH WIND AT 10 METRES.

erection might more than counterbalance any saving in weight of steel due to the adoption of a particular design. A case in point was Fig. 17, Plate 7, where a considerable saving in steel could be shown; but this system was only adopted by one firm, and they abandoned the design in later sheds. With regard to the question of reinforced concrete for airship sheds, it was somewhat doubtful whether this method of construction would be able to compete with steel-framed structures, and the difficulties in the provision of suitable foundations would be very serious in many cases. In examining the wind-pressures which had been adopted in the designs referred to in the Paper it should be noted that most of the sites of the present stations were favourably located and unlikely

The Author. ever to encounter the full force of the gales which might visit these islands. Data published in the Monthly Weather Report of the Meteorological Office for 1918, showed a graph of approximate hourly mean velocities at varying heights above open grass land compared with wind at 10 metres (33 feet) would be of interest in connection with Sir George Scott-Moncrieff's remarks on wind-pressure. These records, however, had been made in free air, and obviously the results would be modified in the case of air impinging on blank walls rising to heights of over 100 feet, and in length as much as 840 feet, as in the case of airship sheds; such an obstacle to the free flow of air would, in all probability, tend to give a more or less uniform pressure, although it might, at the same time, set up higher pressures on the roof. Engineers were not, however, so much concerned with hourly mean velocities as with gusts, and from information kindly supplied by Mr. E. Gold, Assistant-Director of Meteorology, the relative factors for gusts for 11 and 30 metres in height had been plotted in *Fig. 49* (p. 223). The range of gusts as compared with mean velocity went on decreasing with height. The risk of damage to airship shed roofs from wind-pressure from underneath was an extremely remote contingency, because the doors were only operated on the leeward side; those sheds which have doors at one end only were at airship constructional stations, and trial flights were not carried out except under favourable conditions of weather.

Correspondence.

Mr. Sharp. Mr. W. Sharp wished to make a few remarks concerning the possibility of saving weight in the steelwork by the use of partially suspended doors and the elimination of the annexe. To begin with, it was hardly necessary to point out that in designing high steel buildings, stresses caused by the dead weight of the structure, snow and wind-pressure, have to be allowed for, and sufficient steel must be provided to carry these stresses safely. The Paper had shown that the different contractors met those requirements by different methods of design and principle. The final approximate weights of steelwork per cubic foot of capacity had proved how nearly equal were the results. Side columns or trestles of the type adopted were necessary for a building, the superstructure of which was a three-pin arch. In the other types of sheds, namely, the two-