to " decant " the workmen from the " Gowring " locks after rapid decompression to atmospheric conditions, passing them quickly into horizontal auxiliary chambers of the type mentioned by Mr. Taylor. After recompression in those chambers the men would be slowly decompressed with the rate of pressure reduction, temperatures, and ventilation carefully controlled. Three of those auxiliary air-locks would be provided together with a fourth one fitted out as a hospital air-lock for medical cases.

The regulation referred to would require twice the amount of available compressed air given in the Author's rule and a decompression time at maximum pressure of 93 minutes. In the event of a total failure of the air-supply, about 120,000 cubic feet of air would be trapped in the working chamber, allowing about 2,000 cubic feet of air per man with the full complement of men in the caisson.

AIRPORT ENGINEERING DIVISION.

Airport Paper No. 9.

" The Trend of Hangar Design." †

By JOHN BIDNEY FARRANT HAWKINS, C.B.E., M.I.C.E.

Correspondence.

Mr. H. S. Crabtree observed that he wished to submit the following comments upon the Paper from the point of view of a civil-airline engineer with experience of managing airline engineering bases.

Civil Aircraft Operators' Requirements

(1) The hangar design should enable work on aircraft to be carried out at the highest rate of efficiency and at the cheapest cost.

(2) The introduction of a new type of aeroplane should not render the hangar redundant. (That should apply for a minimum of 20 years, sufficient to cover three successive types of aircraft).

(3) The hangar should be constructed so that extensions could be made without interfering with aircraft work in the existing building.

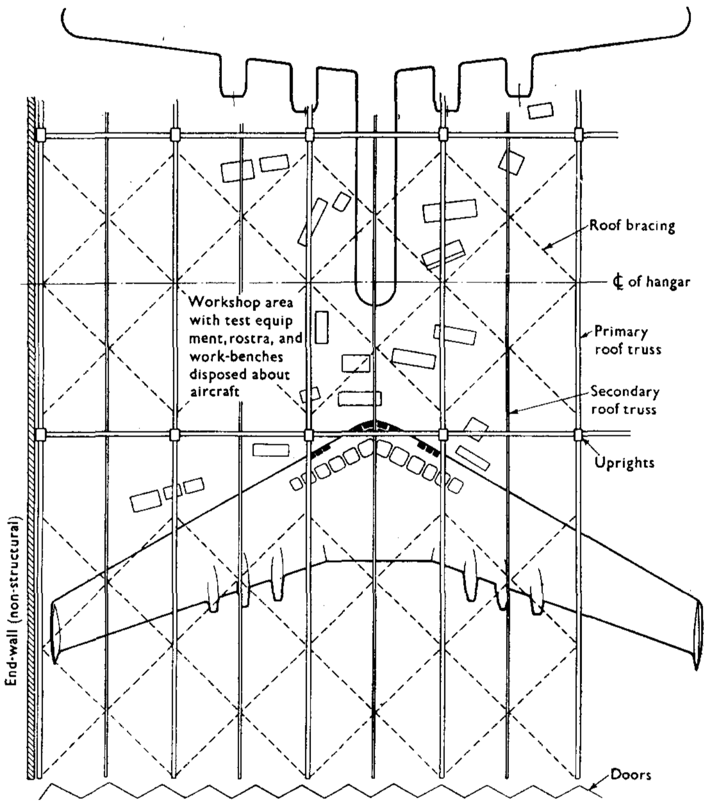
Other requirements included low first cost, low heat-losses, good artificial and daylight lighting, watertightness under conditions of high wind, availability of services (compressed air, electric power, etc.), good working conditions, and low fire risk.

† Discussed at meeting on 25 January, 1949.

Form and Design of Hangars

Cheapness and efficiency of aircraft work required that several aircraft (say, not fewer than four) should be capable of being housed at one time in one hangar, so that work would be brought to the employees and the equipment, in preference to the wasteful process of taking employees and equipment to the work. Any single aircraft should be movable in or out of the hangar independently of all other aircraft. Such movement should

Fig. 29 (a).



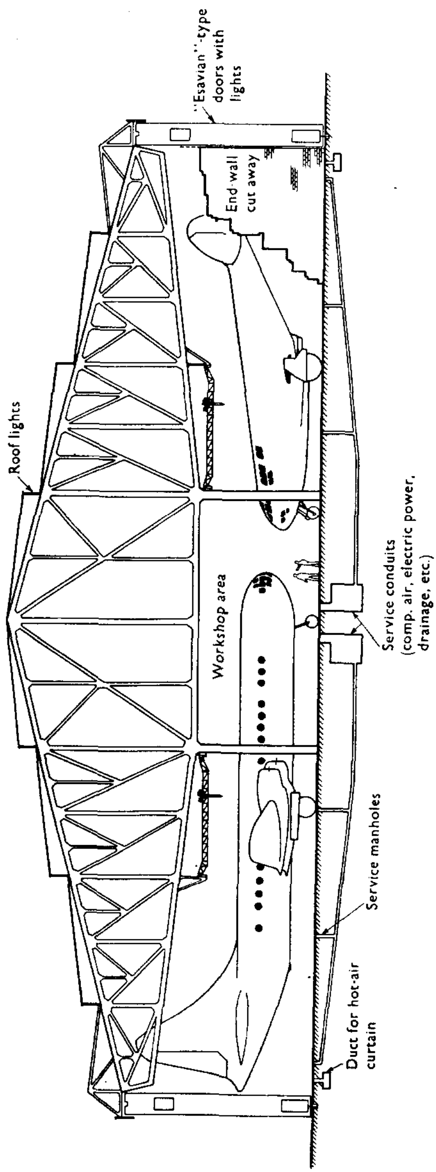
PLAN OF PROPOSED HANGAR.

not necessitate the movement of equipment such as rostrums, ladders, scaffolding, and engineering docks.

Those conditions could be met if aircraft were fed in from opposite directions with their noses to the centre-line of the hangar, the centre space of the hangar becoming the workshop-area.

The second main requirement could be met by providing adequate width of doorways. By using a cantilever type of roof structure, as illustrated by *Figs 29* (*a*), (*b*), and (*c*), doorways of infinite breadth could be pro-

Fig. 29 (b).

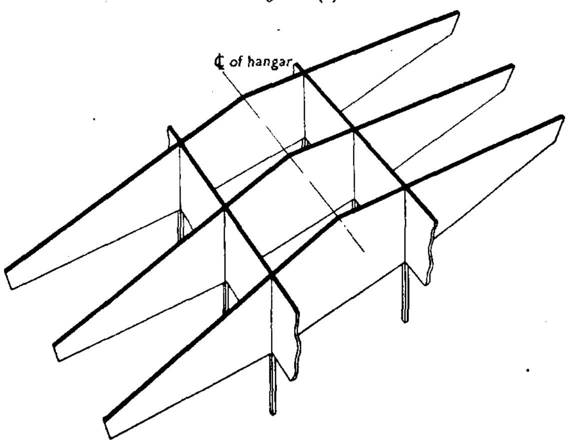


END VIEW OF PROPOSED HANGAR.

vided. Experience had shown that that was the most vital feature for civil-air-line hangars. By the addition of further verticals and roof trusses, the breath of the hangar doorways could be extended almost *ad infinitum*. By leading the nose of the aircraft in first, and by careful design of the roof trusses and top door guide rail, some possible increase in rudder height could be absorbed by locating such rudders between the trusses.

Flexibility in width in the cantilever hangar, in order to cover increased fuselage length, could be achieved by pushing the nose farther through the openings between the uprights, and it would be further assisted by the use

Fig. 29 (c).



Diagrammatic Lay-out of Primary Roof Trusses.

in the near future of buried power plants in the wings, and possibly even of tailless aircraft.

Other minor points required by the operator were :—

(1) Upward lighting located in the floor was as important as overhead lighting.

(2) Gantry cranes were needed for the removal of power plants, etc.

(3) The number of ground services and their capacities and size would tend to increase, but such increase should not lead to major building operations. They should be located in two separate passageways, built under the floor, with minor ducts leading off to strategically located manholes in the hangar floor. Into those passages could be laid such services as electric power (at various voltages, etc.), high-pressure air (1,000 lb. per square inch), compressed air for tools (100 lb. per square inch), main and sludge drainage, water, etc.

(4) The whole of the floor of the hangars from door to door should be clear of permanent structures, with the exception of the vertical uprights

of the roof. Annexes such as offices, sub-stores, emergency first-aid bay, and even lavatories, should be made of partitioned structures, quickly removable, and their service (water, drainage, electric lights, etc.) connexions could be made through the appropriate manholes. That would allow for the alteration of rostrum and engineering dock equipment to meet the requirements of new aircraft.

Mr. R. G. Edkins observed that the Author had provided some very useful basic figures for those interested in the design of hangars, and had illustrated many interesting and original arrangements. But the Paper appeared to give too much weight to the plan form, and paid little attention to the form of section. It was, for instance, possible to vary the height of the ceiling to suit the form of present aircraft in side elevation, and important economies in enclosed volume could be affected in that way, without a change in the plan form. The possibility of the tail gate in combination with a cantilever or other form of structure had not been mentioned, although that could be an economical method of expansion in stages.

The Author had given consideration to the cantilever, but it would be interesting to know why he had not remarked upon its many advantages—both those shown by his own tabulations, and others, of which no mention was made in the Paper, such as the facility for lateral (or spanwise) expansion, which was inherent in the cantilever type. His assumption that the whole cantilever should be built in the first stage seemed to be unwarranted, and the important misconception of tail-first entry of the aircraft obscured the obvious economy in floor space which could be obtained by passing the nose of the aircraft (always very long in modern civil types) between the main stanchions. The stanchions did not, therefore, have to be spaced, as had been suggested, sufficiently far apart to pass the aircraft tail. To bring the aircraft into the hangar tail first was very inconvenient from the point of view of rapid repair and overhaul routines, for at present most of the parts requiring attention were in front of the wings.

The Paper indicated the trend towards a single shed for a single aircraft, caused by the increase in modern aircraft dimensions and, indeed, aircraft design was already being affected by the limitations of economical hangar design, as was evidenced by the folding tail fins already introduced by some aircraft designers.

It was, therefore, very important that civil engineers should seek economy of volume without loss of capacity to accommodate extreme dimensions, even at the expense of some complication of structural design. There could be no doubt that the cantilever type showed economy and flexibility, both for multi-aircraft and single-aircraft sheds, with an unrivalled flexibility for stage-by-stage expansion laterally. It could also be erected with the minimum of falsework and in accordance with a systematic sequence of operations starting from one end of the building, so that the earliest possible use of the completed part of the building could be provided while the construction proceeded with its later stages. Mr. Edkins considered that those advantages heavily outweighed any ordinary difficulty with foundations.

Mr. E. C. Hodgson observed that hangars for civil aircraft were required chiefly for maintenance purposes. An important factor affecting civil airline operation was the utilization of the aircraft, and the maximum utilization obtainable should be the aim. Much of the time spent by the aircraft on the ground was due to maintenance requirements; therefore hangars and workshops should be designed and equipped to allow that work to be accomplished with the maximum efficiency, thus providing further available time for revenue-earning utilization of the aircraft.

"Dead flying" between bases was very expensive and should be avoided wherever possible; therefore, the establishment of special bases for maintenance at some distance from the operational base was undesirable. Under present-day conditions, however, other factors had to be considered, such as available runways, hangar and workshop facilities, skilled labour, and housing for operatives, and "dead flying" could not be entirely eliminated.

The use of mobile lifting cranes had many disadvantages when working in hangars congested with aircraft, and it was not good policy to allow mobile vehicles unrestricted access to those areas. There was always the risk of accidental damage through minor collision with the aircraft and explosions from various other causes. Moreover, test-rigs and tools used when working on the aircraft had to be supplied with electricity and/or compressed air and, because those supplies were frequently located at or near floor-level, the cables, etc., were often damaged by the passage of the vehicles. The lengths of jib required for height, or radius, together with the load lifted, made the vehicle awkward to handle in the hangar and caused dislocation of other work. Overhead travelling cranes gave facilities which were infinitely more efficient under such conditions and, when necessary, enabled engines and other aircraft components to be lifted over adjoining aircraft to the various assembly-points or workshops.

The drawings and diagrams prepared by the Author appeared to provide for tail-first entry of the aircraft into the hangar in all cases. That might not be practicable with all "nose-wheel" aircraft. In addition, increases in hangar spans involved alterations to roof steelwork to carry the loads from the overhead cranes. Most of the work to be done was located at the forward end of the aircraft, and it would seem better to design the hangar for "nose entry," thus placing the forward part of the aircraft always relatively close to workshops, stores, etc. Thus, the overhead cranes and the hangar-roof steelwork would not require such extensive alterations as those shown by the Author, to meet increased sizes of aircraft. Consideration of the various requirements involved, pointed to further investigation of schemes for hangars constructed with cantilever roofs.

When Certificate of Airworthiness overhauls were undertaken, it was necessary to weigh the aircraft under cover.

The Author considered that the points raised by Messrs. Crabtree, Edkins, and Hodgson had been covered in the remarks he had made when introducing the Paper and replying to the oral discussion.

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