CONCERNING FLYING-BOATS

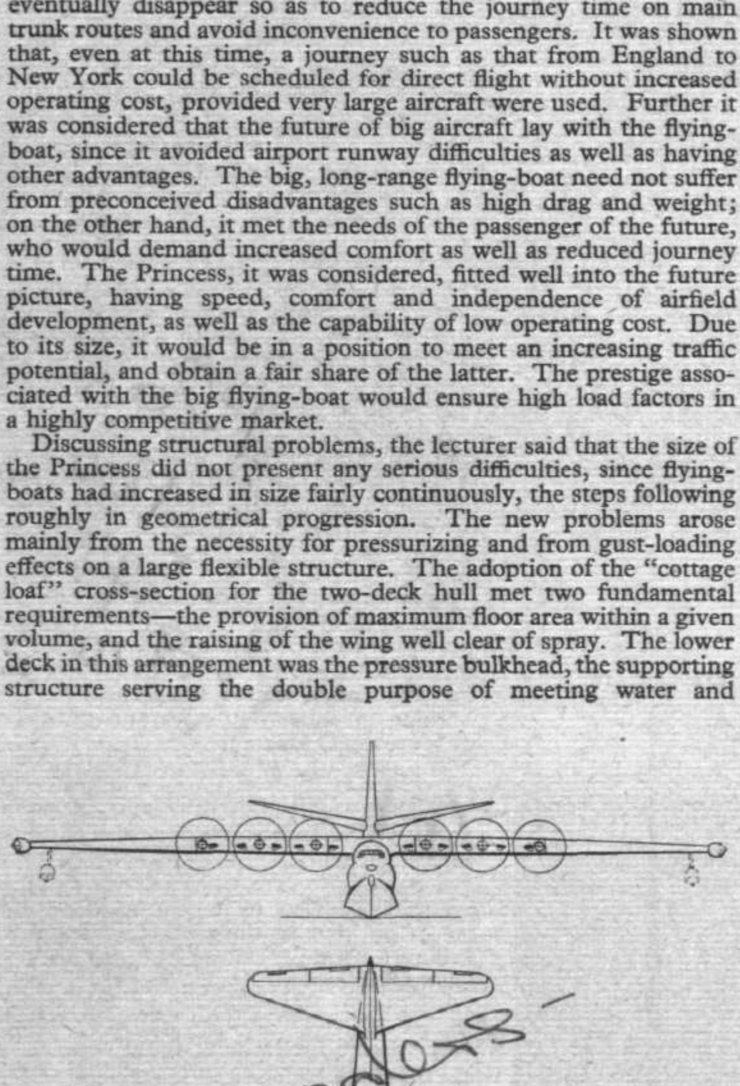
Saunders-Roe Technicians Discuss Aspects of Marine-Aircraft Design and Equipment

IN recent weeks two Saunders-Roe personalities—Mr. Henry Knowler, A.M.I.C.E., F.R.Ae.S. (chief designer), and Mr. P. R. Dowden, his technical assistant—have made valuable contributions to the literature of marine aircraft. On June 13th Mr. Knowler addressed the American Society of Mechanical Engineers on the subject of the flying-boat, with special reference to the Princess, and in a recent issue of "The New Slipway," house journal of Saunders-Roe, Ltd., Mr. Dowden surveys the variants on the lateral stabilizing theme. An abstract of a portion of Mr. Knowler's paper—the value of which is in no wise lessened by the decision to use the Princess for military purposes—is given here, and Mr. Dowden's article is paraphrased, with acknowledgements to "The New Slipway."

THE first part of Mr. Knowler's paper dealt with considerations which determined the size of the Princess flying-boat, and with power plant questions; the second portion was devoted to a discussion and description of novel engineering features incorporated. The paper was designed to show that the use of a large aircraft to achieve long range (and hence the elimination of refuelling stops) did not increase operating costs, and suggested that the large aircraft made it possible to provide improved comfort.

Mr. Knowler summarized his conclusions as follows: It was probable that refuelling stops at other than traffic centres would eventually disappear so as to reduce the journey time on main trunk routes and avoid inconvenience to passengers. It was shown that, even at this time, a journey such as that from England to New York could be scheduled for direct flight without increased operating cost, provided very large aircraft were used. Further it was considered that the future of big aircraft lay with the flying-boat, since it avoided airport runway difficulties as well as having other advantages. The big, long-range flying-boat need not suffer from preconceived disadvantages such as high drag and weight; on the other hand, it met the needs of the passenger of the future, who would demand increased comfort as well as reduced journey time. The Princess, it was considered, fitted well into the future picture, having speed, comfort and independence of airfield development, as well as the capability of low operating cost. Due to its size, it would be in a position to meet an increasing traffic potential, and obtain a fair share of the latter. The prestige associated with the big flying-boat would ensure high load factors in a highly competitive market.

Discussing structural problems, the lecturer said that the size of the Princess did not present any serious difficulties, since flying-boats had increased in size fairly continuously, the steps following roughly in geometrical progression. The new problems arose mainly from the necessity for pressurizing and from gust-loading effects on a large flexible structure. The adoption of the "cottage loaf" cross-section for the two-deck hull met two fundamental requirements—the provision of maximum floor area within a given volume, and the raising of the wing well clear of spray. The lower deck in this arrangement was the pressure bulkhead, the supporting structure serving the double purpose of meeting water and pressurized air-loads; this was found to be economical in weight and in simplifying construction.



General arrangement of the Saunders-Roe Princess, powered with ten Bristol Proteus turboprops—eight coupled in pairs and two single units outboard. Gross weight 315,000 lb.

Mr. Knowler remarked that with very large aircraft the gust loading with flexibility of structure was the deciding criterion for the strength of wings, tail and hull afterbody. To indicate the gust effect on a flexible structure he mentioned that the manœuvre factor of 3.75 was increased to 5.2, with even higher loads locally.

A simple box-beam structure, with two shear webs, was used for the wing as there was no necessity to depart from what was probably the most economical construction; this was also convenient for the particular arrangement of integral tanks adopted. Initially the wing floats were positioned mid-way along the outer wings and retracted completely into the wings just outboard of the outer engines. Subsequently, however, a more precise detail study showed that considerable weight expenditure was necessary to reinstate the wing strength and stiffness in the region of the recesses provided for the retracted floats, and also for the retraction mechanism. It was decided, therefore, to redesign the float system to retract to the wing-tips, since this was a much simpler procedure. Though some increase in drag had to be accepted, there was an overall saving in weight, the extra fuel weight being more than balanced by the reduction in structure weight. A further advantage was a small benefit to induced drag, arising from the improved aspect ratio effect.

The lecturer had earlier referred to the possibility of circumventing the so-called square/cube laws of weight increase with size, and now remarked that the structure-weight percentage of the Princess was 27 per cent—this being a lower figure than for any flying-boat constructed heretofore.

He went on to explain the installation of the Bristol Proteus power plants forward of the front shear web, through which the jet-pipes passed. The aircraft air intakes were positioned at the junction of the leading edge and the cowling, ducting the air to reverse-flow engine intakes. Hot gas for de-icing was bled from the turbine stages and circulated around the walls of the duct; thence it was passed through radiators which heated the auxiliary air and oil-cooler entries. Additional entries adjacent to the engine intakes supplied air for generator cooling and for leading-edge anti-icing, the supply for which passed through muffs around the jet-pipes. Power for the generators was taken from the coupled-engine airscrew drives and, since the Proteus had a free-running airscrew turbine (independent of the engine compressor) the r.p.m. could be maintained at a high rate, although the engine might be idling, thus ensuring electrical power under all conditions. The outer airscrews (on the two single Proteus) were arranged to reverse for ease of manœuvre when taxying.

In his consideration of hull design Mr. Knowler observed that flying-boats had been criticized because hull drag was greater than that of a corresponding fuselage. In recent years intensive research and model testing had resulted in greatly improved form. In large flying-boats where the size of body was dictated by payload requirements rather than buoyancy considerations, the chief cause of increased drag was the main step. A new design of step had been introduced in the Princess. Elliptical in plan form and without a break in depth, this allowed the forward lines to fair into the afterbody. An indication of the cleanness was afforded by the figure for profile drag coefficient for the aircraft as a whole—$C_{do}=.0175$, which compared favourably with landplanes of similar size. From the hydrodynamic aspect the new hull lines showed a great improvement in stability over pre-existing forms, and this had been attained without sacrifice in water resistance or spray cleanness.

Introducing his remarks on the electrical-supply system, the lecturer said that a power system of high reliability was required, since the safe flight of the aircraft depended on the electrically driven powered flying controls. This, coupled with the need for