almost universally adopted, and leading the fuel through flexible petrol-proof tubes, there is every reason to hope that petrol system troubles will soon be a thing of the past.

It may be accepted that absolute engine reliability will never be attained, and cannot be attained; but a reliability which is absolute to all practical purposes may be hoped for. In this connection it is not without interest to refer to opinions expressed in two papers read before the International Air Congress, and extracts of which are published elsewhere in this issue. Handley Page and Savage in their paper advocate the three-engined machine as offering greater immunity from total engine failure, and J. D. North gives, in an appendix to his paper, methods of calculating the relative chances of a forced landing with single, twin, three and four-engined machines. Mr. North arrives at the result that when half of the available power will fly the machine the twin is better than the three-engined machine, but that when more than one-half of the total power is required the three-engined machine will be the less liable to forced landings. According to Mr. North, if the chance of total failure in one engine is 1 in 20, *i.e.*, 95 per cent. reliability, the chances of a forced landing are, roughly, 1 in 10 for the twin-engined machine and 1 in 140 for a three-engined machine. In other words, the three-engined machine is 14 times as reliable. If the chances of total failure of one engine is 1 in 100 the three-engined machine is, roughly, 67 times as reliable as the twin. These figures are based upon the assumption that flight is impossible with a single engine running.

Thus it may be admitted that, although the three-engined machine is probably not as efficient as the single-engined or twin-engined, its greater reliability cannot be doubted, especially in view of the fact that it is scarcely likely that it will be a commercial proposition to run a machine which is capable of flying on one of the engines with which it is fitted. Thus the case for the three-engined machine seems to have been proved, and the reason for the present non-existence of a British machine of this type may be ascribed to the fact that there is not yet sufficient demand for passenger accommodation to justify running a machine so large as to take three of the power units at present in use. With the coming of longer routes, however, it may be hoped that the three-engined type of machine may be given a thorough test under actual working conditions, and it should then be possible to establish definitely and in practice whether figures based upon theory are correct.

The second desideratum to which we referred, *i.e.*, controllability at all speeds, even below stalling speeds, is a subject that is receiving the most careful attention, and research and experiment seem to indicate that this problem may be capable of solution. If that should prove to be so we shall have gone a long way towards a degree of safety which will compare favourably with that of train and steamer and exceed that of travel by motor vehicles.

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Long Distance Aircraft

Accepting as proved—at least theoretically—by the figures and opinions given in the two extremely interesting papers published this week, the fact that for reliability coupled with economy the three-engined commercial machine is the type which offers the greatest prospects of freedom from breakdown due to engine failure, the question arises how to make the best use of such a reliable type. In this connection it is interesting to recall that the specifications for three new commercial types of aeroplane have recently been issued by the Air Ministry, and that at least one of these is required to have a range of 1,300 miles, cruising at 90 m.p.h.

Without wishing to go into detailed criticism of the specifications sent out by the Air Ministry, we may say that to us it appears that by the time such a machine is loaded up with fuel for the range required and with a large crew there will be but little lift left for paying load, quite apart from the fact that to maintain such large crew on each machine would be a serious drain on the financial resources of an operating company. It is obvious that the larger the paying load that can be carried the less important becomes the crew of a given size. If, therefore, the machine contemplated is to be a commercial proposition, and a large crew is considered essential, while the range must be 1,300 miles, it would seem that, as far as can be seen at present, there is but one way of attaining economy, *i.e.*, to reduce the amount of fuel carried.

Let us suppose that the machine contemplated is fitted with three engines of 600 h.p. each when throttled down to a cruising speed of 90 m.p.h., and that their consumption is ½ lb. of petrol per h.p. per hour (which is a low figure to take). The petrol consumption per hour will then be 900 lbs., and, as the journey of 1,300 miles will take 14½ hours, the amount of petrol carried, without allowing any excess for emergencies, will be 13,000 lbs., or 7·2 lbs./h.p. for petrol alone. If, now, this amount could be reduced to one-fourth, or about 3,250 lbs., there would be available a further paying load of 9,750 lbs., which is equivalent to about 40 passengers and luggage.

Frankly, we fail to see how a machine carrying fuel for such a long non-stop flight could ever be made to pay, and if these long stages are necessary it will be imperative to find means of cutting down the quantity of fuel carried at any given time. The recent duration flight made in America demonstrated, for the second time during the last few months, the feasibility of refuelling during flight, and although we would not go as far as to claim that this operation has yet reached a stage where it can be considered to be commercially possible, we do think that sufficient has been proved to demonstrate that the rest is only a matter of development. We do most seriously urge that experiments on these lines be initiated in this country, so that by the time we get going with our long-distance air lines the problem of refuelling during flight may have been reduced to an everyday manœuvre presenting no special difficulties. In his paper Mr. J. D. North calls attention to the subject, and it should be remembered that this paper was written before the recent American performance, which has thus in a most striking manner proved the views of Mr. North correct.

The problem is one which concerns the Royal Air Force as much as it does commercial aviation, and we think the initial experimental work might very well be undertaken by the R.A.F. who should have available several types of machines suitable for the purpose. For instance, certain twin-engined machines capable of flying on one engine only should have the reliability necessary for prolonged flight, and should be capable of providing useful data on several subjects other than the transfer of fuel.