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No. 254

THE PRACTICAL DIFFICULTIES OF COMMERCIAL FLYING.

By F. T. Courtney.

(Paper read before the Royal Aeronautical Society (Scottish Branch.)

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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THE PRACTICAL DIFFICULTIES OF COMMERCIAL FLYING.*

By F. T. Courtney.

Since the commencement of commercial aerial transport very great results have been obtained in certain directions. In the first place, the mere fact of flying has been reduced from a great adventure to a commonplace method of travelling. In this respect it is interesting to notice, on Croydon terminal airdrome, the very great variety in the classes and types of people travelling by air. Men and women, old and young, daring and nervous, calm and fussy, clergymen, commercial magnates, school children and nurses, babies and helpless invalids, and in fact every sort of persons that you will find on a railway, travel regularly and peacefully by air. And it is certain that a very large proportion of these persons would have told you four years ago that they would not go in an airplane for anything. The day has certainly gone when even the well-informed would sometimes ask "Will there ever be anything in air transport?" That much air transport has done so far - it has established the fact of flying as a means of conveyance for the general public.

On the technical side also a certain amount of valuable work has been done. The reliability of engines has been brought up to an extraordinary pitch while commercial methods have effected

* Paper read before the Royal Aeronautical Society (Scottish Branch).

considerable economies in matters such as overhauls, as compared with the expensive methods of military aviation. Probably the most directly important work done on the practical side has been the Customs and passport systems, which would in any case have required a great deal of test and practice which civil flying, so far, has enabled them to have. Wireless and meteorological services, though they are, as I contend, of little direct practical value at the moment, have also the advantage of having been tried out, with much valuable experience as the result. No fundamental improvements have been made in the airplanes used, but the experience gained has indicated very clearly what sort of airplanes is wanted, and they can easily be built.

Yet the very plain fact remains that air transport does not nearly pay its way, and that it is very far, at the moment, from being a commercial proposition. The obvious cause of this is mainly that, although, as I have said, you may find every class of persons on the airways, you will not find them in the numbers necessary to make the business pay. Large quantities of goods are sometimes carried by air, but generally this is owing to the general disorganization of other forms of transport throughout Europe, and these other forms of transport would probably be used if they were available. The class of goods going ordinarily and regularly by air is comparatively very small. As to mails, if there is anything one would expect to see travelling regularly by air it is mails. Yet, I believe General Williamson has told us recently that the patronization of the air mails is comparatively

negligible.

Flying is popular in the sense that the people like flying, but it is unpopular in the sense that people will not fly.

In examining the causes of this the question of danger is frequently brought up. Now I say, with a close experience of the matter, that I am sure that the element of danger is only a very minor cause of the lack of passengers. Dear, nervous old ladies who are frightened to cross the street travel regularly by air; and I have several times been told by passengers that, though they were terrified of airplanes, they preferred air travel as a much more convenient form of transport. An old Dutchman of seventy once told me that he liked flying because he would much sooner be sick for $2\frac{1}{2}$ hours in the air than for 14 hours on a boat. Again, the fear of airplanes is generally dissipated by the first flight. And statistics, in any case, do not reflect unfavorably on the safety of air travel.

It is sometimes said that the public will not pay the present costs of flying. This has very little to do with the matter. The whole matter boils down to this - that, compared with other forms of transport, airplanes do not provide anything like a regular, sure, continuous and definite form of transport. In fact, though we may pride ourselves on the achievements of our commercial airplanes, they cannot, compared with the ground services, be said to provide a service at all. They do not fly at night, and a comparatively large portion of their flights are cancelled, delayed or broke by weather that does not hinder the boat or train. I

keep using the word "comparatively" because those of us who have worked hard to get certain results in aviation, and are somewhat proud of the results, are apt to forget that, from the commercial point of view, those results have to be considered in comparison with other forms of transport.

Now the failure of air transport to provide a sufficiently regular and dependable service is not the fault of the airplanes or the engines. Not only is it the case that landings of British airplanes from mechanical troubles are very rare, but also it is possible immediately to build airplanes so provided with engines that forced landings through engine trouble will be rendered almost impossible, I believe there still remains a general impression that aero engines are very unreliable, but personally I think that the engines used on British commercial airplanes are almost unreasonably reliable. The whole trouble of this unreliability of air transport is on the purely flying side. We have, or can build at once, perfectly safe and reliable aircraft, but we cannot at present fly them as and when we want to. Until we can fly them in all weathers in which boats and trains can run, until we can fly them regularly and safely at night, airplanes cannot compare or compete with other forms of transport. And here the great point arises that, until you can compare them with other forms of transport, you cannot say what the public will or will not pay for the service. In the matter of mail-carrying alone, it is almost impossible to estimate the revolutionary effects of regular night aircraft services. But it is no use travelling, at naturally

higher cost, at twice the speed of other forms of transport if this can only be done for a small part of the available time, and then only if the weather is comparatively fine.

Now let us consider the conditions under which the modern commercial airplane flies.

In the first place it is important to consider wherein the airplane differs fundamentally from other forms of transport. There are two main differences:- (1) The airplane is a vehicle with a certain minimum speed. It cannot remain stationary, and its very lowest possible speed is very high compared with the ordinary speeds of other transport. For example, the lowest reasonably safe speed of a commonly used commercial airplane is in the neighborhood of 70 M.P.H. (2) The airplane travels in three dimensions, whereas all other forms of transport, including the original walking man, have travelled in two only.

If one considers closely these two fundamental facts, it is not difficult to realize that air transport has come up against a completely new set of problems, quite unlike those dealt with in the past, and unlikely of solution without special treatment. And it seems somewhat surprising that, though much time, money and effort have been spent in experimenting with the construction of airplanes and engines, practically no experimental work has been done in operating them.

Now, if we are going to try and operate airplanes in a commercially sound manner we must consider the difficulties strictly practical, and deal with them in a purely practical manner. The

reason I say this is that such considerations as have been given in the past to this matter have been so much in the realms of nebulous theory. For example, the matter of high minimum speed is going to be solved by the helicopter. And any problem arising from the high landing speed of aircraft has been met by, or rather shelved by, such answers as "Of course, when we have perfected the helicopter, which will rise and descend vertically, and which can hover over one spot, etc., etc." In the first place, we have not got the perfected helicopter, nor do we appear to be anywhere near getting it, whereas we have to get on with commercial flying. This fact saves the trouble of an argument as to whether the helicopter will be of any use when we get it; for, in the matter of minimum speed, I personally do not think we shall desire to or need to eliminate it; in fact, it seems possible that minimum speeds will increase.

Similarly, when it comes to the problem of flying for great distances inside clouds, we are told of wonderful instruments just about to be perfected which will control and direct the airplane without the aid of the pilot. Doubtless these will come, but at the moment we have not got them, and in any case we have the question as to how far the pilot will trust these things unless he has an additional means of being able to control the airplane himself in case of trouble.

So the only thing to do seems to be to consider the difficulties as we actually have them, and to see if we can deal with these difficulties with such equipment as we have at our disposal. Per-

sonally I am quite sure we can.

In order to get a real idea of the difficulties of flying an airplane through really bad weather it is necessary to imagine an actual case. It must be remembered, firstly, that a pilot is taught to fly, and to maintain the correct altitude of the airplane, entirely by eye. He controls his three-dimensional craft by its attitude in regard to some fixed spot outside the airplane. If, therefore, he is, say, inside a cloud, he is in the same trouble as a blindfolded cyclist, with the additional dimension to multiply his troubles. This means that, so far as the ordinary flying taught to a pilot is concerned, he is liable to get out of control when he cannot see some fixed spot outside the airplane. In other words, he cannot fly safely inside clouds. A certain amount of flying can be done by "feel," but this applies only slightly to heavy airplanes, and in any case it is only serviceable for a very short period, and only maintains a very erratic course.

In addition to this there is the problem of navigation, or finding one's way. The only available means of doing this inside a cloud is by dead-reckoning, which is, so far as concerns selecting a definite spot in a few hundred miles of flight, a quite impossible proceeding, owing to the currents of unknown and varying strengths and directions in which the craft is navigating.

Now let us imagine ourselves on a trip, in very bad weather, from Paris to London, and see what the pilot of a modern passenger airplane does, and why he does it. This is a sort of composite

description of a number of flights I have done. At Le Bourget the clouds are at about 800 feet, rain or drizzle is coming down on and off, and the visibility is about 2000 yards. A wind of about 20 M.P.H. is blowing from the west, apparently considerably stronger up above than on the ground. This means, at any rate, that it is of no use to work out a compass course, as I have no idea as to what height I must fly. I examine the weather reports, which are more or less the same - west wind, low clouds, poor visibility, occasional rain. St. Inglevert, the airdrome between Boulogne and Calais, reports clouds 50 feet and visibility 200 yards. This means that this airdrome is impossible for flying. On the other hand, I know it is hilly country, and therefore having worse weather than the low ground. I therefore ignore this report, which means that, for the weather in that part of France, I am quite uninformed, and I must take a chance on the state of the weather in the Channel. So far as England is concerned, Lympne airdrome, also on hills, reports very low clouds, but it looks as if the Channel will be passable.

While I am taxiing out to take off, I am getting wet with the rain, which raises the point that the pilot is becoming uncomfortable to start with. I leave the ground, and find that, when still comparatively close to it, I am just below the clouds. I start off on the usual compass course with a rough mentally-calculated correction for drift which I intend to correct on a known landmark about ten miles away. But after about six miles I find that on this course there are tree-covered hills, and the

trees are covered in wisps of clouds. So I must go round these hills. It is now clear that a compass course is impossible, so I turn to the left and pick up the main road from Paris to Boulogne. I follow this road over open country for some time, but the ground is gradually rising to the hills south of Beauvais, the clouds are becoming slightly lower, owing to the effect of the wind on the hills, and the visibility has correspondingly decreased to perhaps 500 yards, a distance which I am covering in about ten seconds. Under these circumstances I find myself compelled to fly about 150 feet off the ground, which actually looks and feels like about 50 feet. I am now compelled to stick to this road as completely as a motor-car would be, for if I lose sight of it I am practically lost. I know from experience what obstructions this road will lead me to, whereas if I leave it I do not know what is ahead. Furthermore, when flying so low in such visibility I am so busy looking for obstructions that the compass is doubly useless to me, for in the first place I cannot fly straight for long enough for the compass to settle down to a correct reading, and in any case I am literally unable to take my eyes from looking ahead. Finding the way by compass in these circumstances is practically impossible.

This gives a very good illustration of the comparison between ground and air vehicles, since like the car I am to all intents and purposes confined to the road. Under these circumstances the car can proceed with practically the same ease as in fine weather. But the airplane, which could not fly actually close over the

housetops, is in a region of lower visibility due to cloud, and the value of this visibility is reduced owing to the high minimum speed. Moreover, if the car suddenly ran into such visibility that it could not see ahead at all it could stop, whereas the airplane, more likely to meet those circumstances, could not stop, and could turn only at a great risk, and must therefore be prepared to turn before getting into such a position. And on the more heavily-loaded airplanes this is even more difficult than on the lighter airplanes with which commercial flying was started.

However, after some minutes of this very uncomfortable flying we pass the hills, and with the lower ground we come into comparative peace again for a bit. But I must still stick to that road, for I know the ground rises again further ahead. Gradually the ground rises towards Poix; I get lower and lower until I see I cannot pass. I am right on the tree-tops, and wisps of cloud increasingly blind me. So I must turn back. It is difficult to explain to a non-pilot how tricky the turning of a heavily-loaded airplane can be under such conditions. Moreover, I must not lose my road. I am tempted to leave it and take a short cut across to the lower ground near Amiens, but I must not do so, as these low clouds are drifting about in patches, and I may find myself in a position where I cannot go forward and cannot find my way back. So I go back along the road until I come to the branch road or railway that I want, follow this in a detour to Amiens, and so along the low ground by the Somme to the coast. The next part is easy, for although the clouds are very low, and actually on the

sand dunes, I can fly as low as I like over the flat sands. I intend to leave the coast at Boulogne, but I now notice, from the high waves, that the wind in the Channel is much stronger than over the land, and therefore to lessen the risk of error in a compass course in the very bad visibility, I follow the coast right up to Cape Grisnez. From there I start off over the Channel, flying at about 150 to 200 feet, with a visibility of 500 yards and patches of drizzle. It is easy flying, but rendered extremely uncomfortable by the knowledge that a patch of no visibility might turn up at any moment, and careful look-out ahead must be kept for this. This makes compass flying sometimes difficult and often very erratic. At last the cliffs turn up ahead, with perhaps clouds all over them. I am not quite sure whether they are the Dover or the Folkestone cliffs, but it does not matter, as I follow them round until I can cross the low ground at Dungeness. A straight line from there to Croydon is impossible, as there are many sets of cloud-covered hills to pass. So I select a known low-ground course, and in similar conditions of low visibility and a steady look-out ahead as far as is possible, I traverse a considerable detour and possibly arrive at Croydon. I have been tempted to try a short cut, but probably the clouds will block my way and I shall only have to go back again to Customs Airdromes.

I am not giving this description to make a fearsome picture of the danger of air travel. But the sort of day described is one on which the ground services are hardly incommoded, and would hardly be a minute late, whereas the airplane has had a very difficult

journey which it has only just been able to accomplish. With the weather even a little worse it could not have done so. Moreover, the completion of the journey has been entirely dependent on what risks the pilot was prepared to take. And here, perhaps, I had better state the painful but definite fact that on such a flight, which is fairly common in bad weather, the avoidance of a collision with an airplane coming in the other direction is frequently a matter entirely of luck. We have had one such collision, and although certain precautions since taken have somewhat reduced the risk, it is in no way definitely eliminated.

Try and keep a picture of such a flight in your minds and then imagine what could be done at night time under circumstances even only partially as bad. Of course, one sees then at first sight little hope for regular commercial night flying.

But the whole of these troubles arises from treating the airplane as if it were only another form of ground transport. A good airplane, a map and a compass are given to a pilot and he must get there as best he can. It has apparently been hoped that, as in other forms of transport, he will get better and better at this, until finally he can fly regularly. In other words, he is going to obtain perfect flying by evolution.

Although this may be so in certain particulars, the big difference between the flying done and the flying required makes it clear that some form of experimental flying must be done to try and make a regular day and night service possible.

The reason for that is this - the problem appears to be entirely one of visibility. It is clear that the third dimension in which the airplane travels is very largely and for prolonged periods full of clouds, which correspond to what ground transport is for. These clouds are frequently so low that, while not incommoding trains and boats a few feet underneath, they are completely enclosing an airplane flying high enough to avoid ground obstructions. Moreover, the high minimum speed reduced so greatly the value of such visibility as may be left that what is a perfectly good visibility for a boat or train is quite unsafe for an airplane.

For exactly similar reasons the provisions for ground lighting of the air routes, for lighthouses and for other similar attempted assistances for night flying appear to me to be useless, for the great problem is to fly and navigate in weather when these lights cannot be seen. For example, I suppose the pretty red and green navigation lights are to prevent collisions at night between airplanes. Exactly how these lights operate when the airplanes are inside clouds I fail to understand. And it is to be remembered that, on a dark night, the clouds themselves are not visible. I could point out many reasons why the system of lighting for night flying is useless except for fine nights. Further, I suggest that the lighting schemes, apart from the actual lighting of airdromes, are a definite hindrance, as they tend to obscure what seems to me to be a fact, namely, that so long as the flying of commercial airplanes depends on ground aids to visual

flying, whether landmarks by day or lights by night, so long will airplanes be an undependable method of travel.

Navigation is pretty much in the same state. The navigation applied is of a nautical or semi-nautical character, and depends on the possibility of seeing ground objects, stars, etc., whereas I have tried to show that the problem is to navigate when nothing outside the airplane can be seen. There is no doubt that this form of navigation will be necessary when we have our very long range journeys, but before we can have these we must be able satisfactorily to carry out the comparatively short ones now in operation. It is of little use being able to navigate a ship over a great stretch of ocean if one cannot find the port at the finish.

I have looked at these matters from all points of view, and it seems to me absolutely inevitable that we must find a method of flying and navigating airplanes in no visibility at all; we must be able to fly quite blind.

Now this seems at first sight a tall order. We are to operate a new form of transport under conditions representing ships in continuous fogs, and that at very high speeds. But that is exactly why I have contended that experimental work in the operation of aircraft must be done, for we have here a set of conditions never before encountered in the history of moving things from one place to another. And I am convinced that a study of the matter will show that it is possible to do what is necessary - even that it is moderately easy.

Other forms of high-speed transport could not, as a practical possibility, run blind; but the airplane has the advantage of the third dimension, which, while it has serious visibility troubles, has no obstructions.

The first thing to recognize is that flying blind is the exact reverse of what a pilot learns originally; his training is essentially visual, both as to flying and navigation, so that we have a new form of flying to tackle straight away. The two problems of blind flying and blind navigation are quite distinct.

Blind flying has been, to a small extent, catered for, in that instruments called turn indicators of various patterns have been fitted to commercial airplanes for flying inside clouds. But flying by turn indicator is essentially different from visual flying, and must be assiduously practiced before a pilot can hope to fly blind for prolonged periods. And it happens that, for sundry excellent reasons, these instruments are all practically inaccurate in some degree. But so are almost all aircraft instruments, and experience shows that, with the most inaccurate of turn indicators, it is possible to keep a good course inside clouds if the pilot has plenty of practice. Naturally he cannot carry out this practice in a very satisfactory manner if he has the primary duty of getting a load of passengers somewhere. One's first serious efforts with a turn indicator generally result in a course which would considerably worry passengers. But as I say, the flying by turn indicator for, say, 200 miles, is quite a new form of flying, and, like anything else, needs practice. And I strongly contend

that all commercial pilots should be given plenty of practice in this blind flying when not engaged in their ordinary flying.

The problem of blind navigation is quite a different one. Assuming that the pilot has become able to control and maneuver his airplane in continuous cloud, he must, under these conditions and at night, be able to find his way from one airdrome to another without colliding with other airplanes on the same route, without colliding with airplanes on another route crossing his route, he must be able to descend out of his clouds when they are in many places on the ground and yet not strike ground obstructions, and under these conditions he must be able safely to bring his airplane in to land.

Although this looks difficult I am quite sure it can be done. I will go so far as to say that with proper experiments an airplane could fly, with no better equipment than is now available, in all weathers, by day or by night, and be able to do all that it wanted except actually land on an airdrome which is in thick fog. And in this/^{last} respect it is no worse off than ground transport.

For, fortunately, the progress of directional wireless is now sufficiently advanced to do practically all that is necessary in this problem of blind navigation. Clearly, of course, the solution is not such a simple one as merely following the direct route towards the required station by means of directional wireless fitted to the airplanes. There is the importance of making collisions impossible. However, making all allowances for inaccuracies in

the directional wireless, I am quite certain that, by a simple system of wireless direction and elementary trigonometry, definite courses could be steered, quite blind, sufficiently accurately to avoid all possibility of collisions.

Under such a system, there would, of course, arise such problems as two main air routes crossing and bringing into an airdrome without collisions a number of airplanes which have arrived at the same time in very bad weather, at night of fast airplanes overtaking slow ones. This, I do not doubt, would be fairly easy if somewhat elaborate. I do not see that it would be any more difficult than the organization of the signaling system at Clapham Junction.

To try and summarize the main points of the paper I would say:-

Commercial flying must operate before it can be a success in any weather in which other forms of transport can operate. This is rendered difficult by the fact that the mists and clouds with which the air is filled, combined with the high speeds of the airplanes, tend so to destroy the visibility necessary for flying that we must learn to fly without any visibility; therefore we must learn to fly and to navigate blind. As this is something which has never been done in any form of transport, it is obviously the subject for experimental work. And the indications are that such experimental work could be done now, with success, without waiting for the perfection of instruments which will be able to do this one day, but cannot do it yet. And I think that, if these problems had been investigated with the money so far spent on subsidies, there might be no need of subsidies now.