

An excellent example of a sky trail being made by an enemy aeroplane. The correct effect is obtained if one looks up at the photograph held overhead. Such trails help to give away the movements of enemy reconnaissance aircraft and at night may help the searchlights to locate bombers.



AFTER studying the numerous letters which obliging readers have sent in relating their observations in regard to the white sky trails which are now seen so often, it has become possible to collate the data and to arrive at some conclusions. These conclusions cannot be called "definite" in the strict scientific sense, as they have not been derived from experiments deliberately undertaken to prove them with scientific observers in the aircraft taking readings of temperature, altitude and humidity. But the careful manner in which most of the letters have set forth the details of the phenomena seen leads one to place considerable weight upon the statements in them and it is thought that certain conclusions, "definite" in the ordinary sense of the word, can be established.

Firstly, there are two phenomena: the wing tip trail, and the trail formed of air which has passed through the airscrew and is therefore helical in shape. These two types should be thought of separately. Considering first the wing tip trail, it is evident that numerous examples of this have been seen both by pilots and ground observers, and that the trails occur under conditions of high speed or heavy wing loading (dives, pull-outs and steep turns). That is to say, they occur when the wing tip vortex is strong. Some evidence exists that the condensation starts at the centre of the vortex.

The trails exist as short plumes behind the wing tips and disappear in a few seconds, suggesting fairly conclusively that they are water vapour temporarily condensed by low pressure. Two accounts give them as occurring at altitudes of only a few thousand feet at which the temperature was probably above freezing. So it is unlikely that they are finely divided ice particles.

It seems, then, a fair conclusion to say that these wing tip trails are real visible vortices. Whether they would be permanent (in the sense of lasting for an hour or so) if made at a higher altitude with the temperature below freezing, is not established, but perhaps this theory may be tested later by some enterprising pilot. (There is one instance in the letters of a permanent double trail from a single-engined machine at a high altitude, but a single example cannot be regarded as conclusive.)

One isolated instance is recorded of a flat trail being left, corresponding in width to the wing span. This is most

VISIBLE VORTICES

*Their Formation Established : Wing
Tip and Slipstream Trails : The
Evidence Summarised*

interesting, particularly as the aeroplane concerned was a Spitfire. The more nearly the wing loading corresponds to an elliptical curve, the less does the vortex tend to be concentrated at the wing tip, and the more does it approach to an evenly distributed vortex sheet across the whole span. Due to its wing plan form, the Spitfire wing loading must be nearly elliptical, hence the flat trail.

The other type of trail has several other characteristics. It does not immediately disappear, and seems to be as permanent as the meteorological conditions into which it has been born. It is invariably white and has not been reported at low altitudes, being usually above 15,000 feet. Another important characteristic is that when low enough for its structure to be seen it is clearly of helical shape. For this reason this type of trail might well be called a "slipstream trail." Such a name avoids any controversy about whether the condensed vapour comes from the exhaust or from

the air itself—although this point will be dealt with later. It has also been reported that double trails have been made by twin-engined aircraft, which is an additional reason for using the name "slipstream trail."

Such trails are intermittent. That point has been clearly established by photographs and statements. The slipstream trail will extend for some distance behind an aeroplane and then for no apparent reason will fail to form. After some distance, either short or long, it will start again. This does not necessarily occur when the aeroplane is climbing; it may occur during level flight. It is thought that this piece of evidence is particularly significant, and that a deduction may be made from this to give an indication as to the source of the water which is condensed to vapour or frozen to ice particles.

Super-cooled Water Vapour

Since the flight is level, exhaust gases are being produced all the time. Perhaps in varying quantity, if the throttle opening is varied, but unless the aeroplane glides with engine off there is always some exhaust. In general, it is likely that engine conditions would not be varied very much. Nor is it likely that there would be much variation of temperature at the same altitude when that altitude is of the order of 15,000 to 25,000 feet. It therefore seems reasonable to say that if it were only the condensation of exhaust gas which caused the trail, the trail would be continuous, since the conditions for its formation seem to exist everywhere along its track, if that track is level. But all agree that breaks occur.

The other view seems to be the more likely, that the trail is due to the freezing of super-cooled water vapour through which the aeroplane passes. That this can exist in "patches" in the atmosphere has been stated by correspondents and the phenomena of super-cooling and super-saturation is well known in any laboratory. (Super-cooled rain which became the most slippery ice as soon as it hit the roadway was seen—and felt—at Brighton in the unusually bad weather of last January.)

As the trails have only been reported under conditions of calm with cumulus or cirrus clouds, there would be little mixing of the different patches. The effect of mixing is very clearly described by one correspondent who was