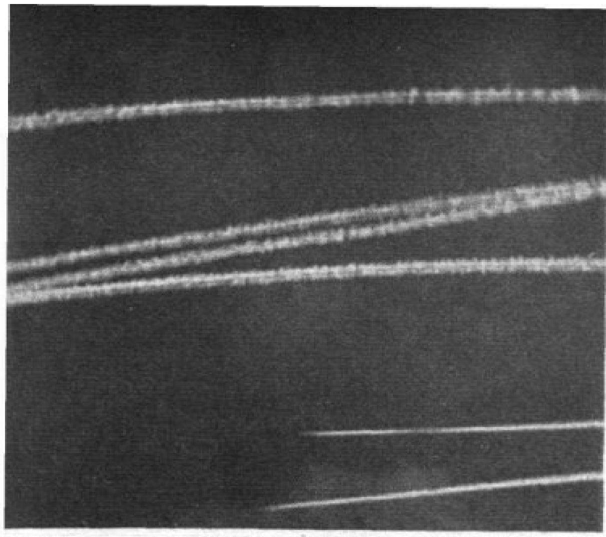


Hunter contrails, showing dark centre in developed stream.

IDENTIFICATION BY CONTRAILS

Possibilities Investigated by the Aircraft Recognition Society

IN a broadcast interview following the All-England Aircraft Recognition Contest in January 1954, Mr. Nigel Price, a member of the winning team, referred to the value of contrail study as an aid to the correct identification of high-flying aircraft. Among aircraft recognition enthusiasts his remarks aroused a good deal of interest and some controversy, and in the 2½ years that have elapsed since the broadcast much useful investigation has been undertaken by members of the Aircraft Recognition Society with the object of establishing the limits within which information gathered from contrails could be considered seriously as an aid to recognition, and, if possible, some accurate system of classification which could act as a guide to further study of the subject. For a variety of reasons, of which the most obvious and the most important is the absolute necessity of establishing beyond all possibility of doubt by visual or other means the identity of the aircraft making the trail, reports admissible as evidence are hard to come by, and research by the Society will continue over a long period. However, a stage has been reached where an interim report is possible, and Mr. L. Anderton, a past chairman of the Society, recently published some conclusions which are of considerable interest.

His report begins with a note on the way in which contrails are usually formed: the exhaust gases from an aero engine contain a considerable amount of water vapour. The amount varies, but may be taken to average about 1¼ lb for every 1 lb of fuel consumed. Free air also contains water vapour, but at the very low temperatures at high altitudes the amount which can be held as invisible vapour is extremely small. Any in excess of this amount condenses out as cloud. The addition of water vapour from the exhaust gases may result in the critical point being reached and passed, the result being the formation of a contrail. [The density of the trail is a function of the weight of fuel burned per mile, and the use of afterburning greatly increases this—a point that was readily apparent during the record runs of the Fairey F.D.2—Ed.]

The amount of water the air can hold depends upon the temperature: the lower the temperature, the smaller the quantity. The heights at which contrails can form will therefore vary in accordance with the prevailing weather. In cold weather they will form at lower altitudes than when conditions are warm. Fig. 1 shows the approximate variation of heights under various weather conditions.

As an aircraft nears the height at which a persistent contrail will be made, it is usual for a short or faint one to appear first, and this gradually develops into the persistent type as the aircraft climbs into colder air. The process continues until the tropopause is reached, i.e., the point where the temperature ceases to decrease with height. At this level, where the aircraft enters the stratosphere, the contrail usually begins to decrease in length, until eventually it is of the short, re-absorbed type once again.*

Factors Influencing Apparent Shape of Contrails. It should be remembered that the cross-section of the contrail of a single-engined aircraft is symmetrical, whereas that of a multi-engined type is not. Because of this, the attitude which a multi-engined aircraft presents to the observer modifies the shape of the contrail-head. For instance, a Canberra, which makes a contrail with a twin-stream head, would appear to be producing a single stream if it were some distance away and flying at right angles to the observer's line of sight. The possibility of recognizing an aircraft

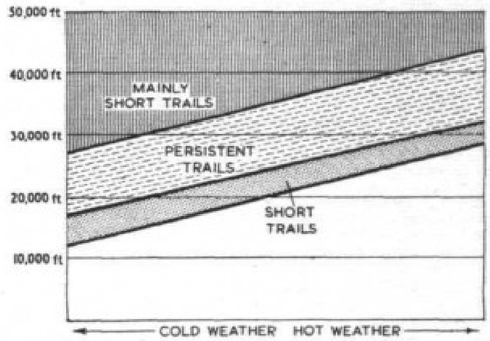


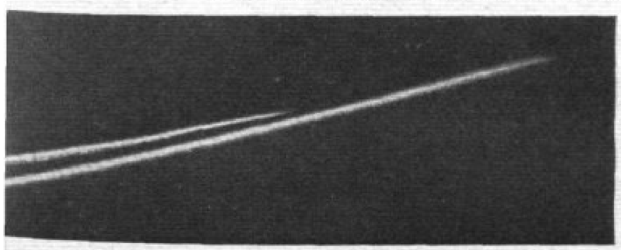
Fig. 1. Variation of trail height with weather.

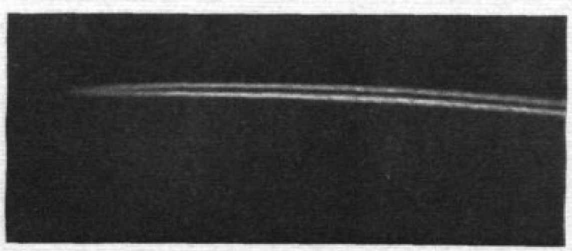
by its contrail is limited to some extent by this factor, and the machine must be in a suitable position, relatively to the observer, before a valid opinion can be formed.

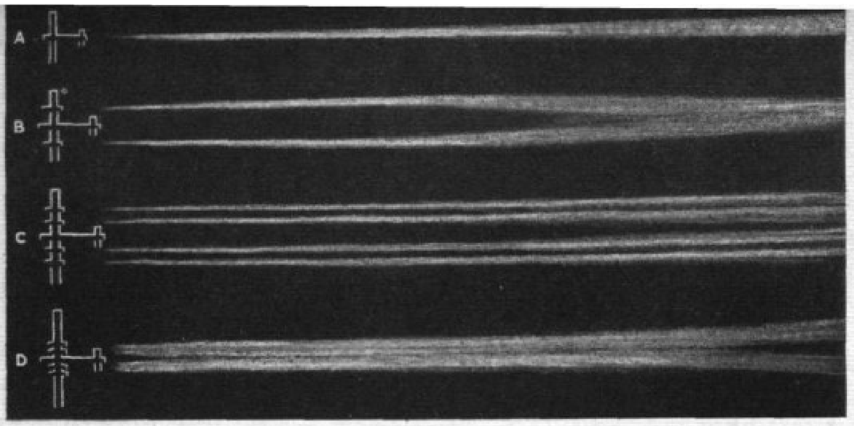
Besides the attitude, there are a number of other factors which may mislead. Because of the variation of trail-forming height with temperature it is possible for trails to be as low as 12,000ft, or as high as 40,000ft, or even more. When by reason of haze the aircraft itself cannot be seen no judgment of scale is possible; and in these circumstances the distance apart of the head-streams in a multi-engined contrail may easily mislead. For example, the Tornado, when hidden by haze, and making a contrail at 14,000ft, is quite likely to be mistaken for an altogether larger aircraft. Another consideration is the length of the contrail: it may persist, and

**Fuller details are given in Air Ministry Publication M.O. 480 (A.P. 3315) "Condensation Trails," price 9d, H.M. Stationery Office.*

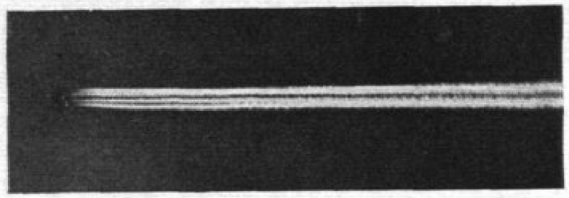
(Left) Hunter—the more pointed—and Canberra trails. The latter is at a greater distance and presenting a side view, hence the illusion of a single-engined aircraft. (Right) Valiant trail, illustrating the characteristic division of the streams.

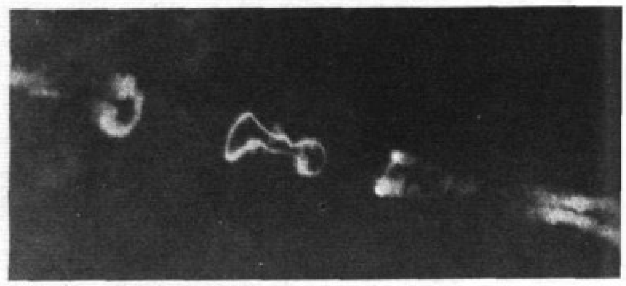






An artist's impression of the four broad types of trail discussed below.





(Below) B-47 trail and (lower picture) typical decay into curved eddies or closed loops.

IDENTIFICATION BY CONTRAILS . . .

stretch from horizon to horizon; or it may be quickly re-absorbed, giving the effect simply of a short plume. This may prevent the contrail from developing sufficiently to show its characteristic form.

Variations in the distance at which the contrail first appears behind the engine can also take place. Where the streams of a multi-engine contrail are divergent, and the aircraft is obscured by haze, delay in forming will lead to the conclusion that the engines are more widely spaced than they actually are.

Classification of Contrail Types. When it is considered that various combinations of the above factors are not only possible, but indeed probable, it is apparent that the question of recognition by contrails is very complex, and unlikely to have a simple solution. Nevertheless, careful analysis reveals certain classifiable dissimilarities which seem to suggest grouping of contrail types into four easily recognizable categories as a basis for further study:—

(A) Single-engined aircraft—Hunter, Seahawk, etc.

(B) Twin-engined aircraft with the engines well spaced—Meteor, Tornado, etc. (the four-engined Tornado has the trail-effect of a twin).

(C) Multi-engined aircraft with the engines disposed across the span —B-47, Shackleton, etc.

(D) Aircraft with four or more engines close to the fuselage—Comet, Victor, etc.

(Note that in these groupings engines paired in pods are considered as one engine, e.g., the inboard pods of the B-47.)

A fifth group would appear possible, comprising those aircraft which have two engines mounted very close to the fuselage. Coming within this group would presumably be such types as the CF-100 and the Badger. However, it has not so far been possible to make sufficient observations to report with certainty on these aircraft.

Within each of the above classifications many small variations have been noted, giving rise to the hope that with further patient research much progress might be made towards the identification of individual types. In the remainder of this report each category is separately considered and some pointers are given to the direction in which such investigations might profitably proceed.

Group A—Single-engined Aircraft. Thin, single-stream contrail-head. The speed of the aircraft appears to influence the shape of the head. The greater the speed, the more pointed the head. This is particularly noticeable with the Hunter, the head being drawn out to a very fine point. A further feature of the Hunter contrail is a narrow, dark band, which forms along the centre of the trail, starting where the taper of the head reaches its final expansion. The dark band continues to run along the tail of the contrail and is sometimes apparent when the contrail starts to decay. It is remarkable that a single-engined aircraft should produce such an effect. No other variations have been noted in this group.

Group B—Twin-engined Aircraft with Engines Spaced Well Apart. A twin-stream contrail head. The two streams when first leaving the aircraft are slightly divergent. The angle of divergence and the distance for which they continue to diverge varies for different aircraft. The twin stream, after diverging, runs parallel for some distance, and then usually merges into a single stream. The distance behind the aircraft at which this occurs varies for different aircraft. Three types have been noted: Canberra, Tornado and Meteor.

Taking divergence of stream first, the aircraft with the greatest angle is the Canberra, followed by the Meteor and Tornado, in that order. The distance for which the streams continue to diverge comes in the following order: Tornado, Meteor, Canberra. Nevertheless the two streams of the Meteor tend to unite quite a short distance behind the aircraft, whereas those of the Tornado remain separated for a longer distance, and those of the Canberra sometimes do not join up at all but frequently form a narrowly spaced twin contrail which often breaks up into eddies similar to those formed by the contrail of the B-47 when it is decaying (see below).

Group C—Multi-engined Aircraft with Engines Disposed along the Wing. A four- six- or eight-stream contrail head. Separate streams come from each engine, indicating the number of engines. The pattern formed by the beginning of the streams conforms to the wing sweep as a general rule, and reveals if the wing is well swept, or straight. Some streams came out straight, some converge in pairs, and the tail can form into various shapes. Three types have been observed: Lincoln, B-36 and B-47 Stratojet:—

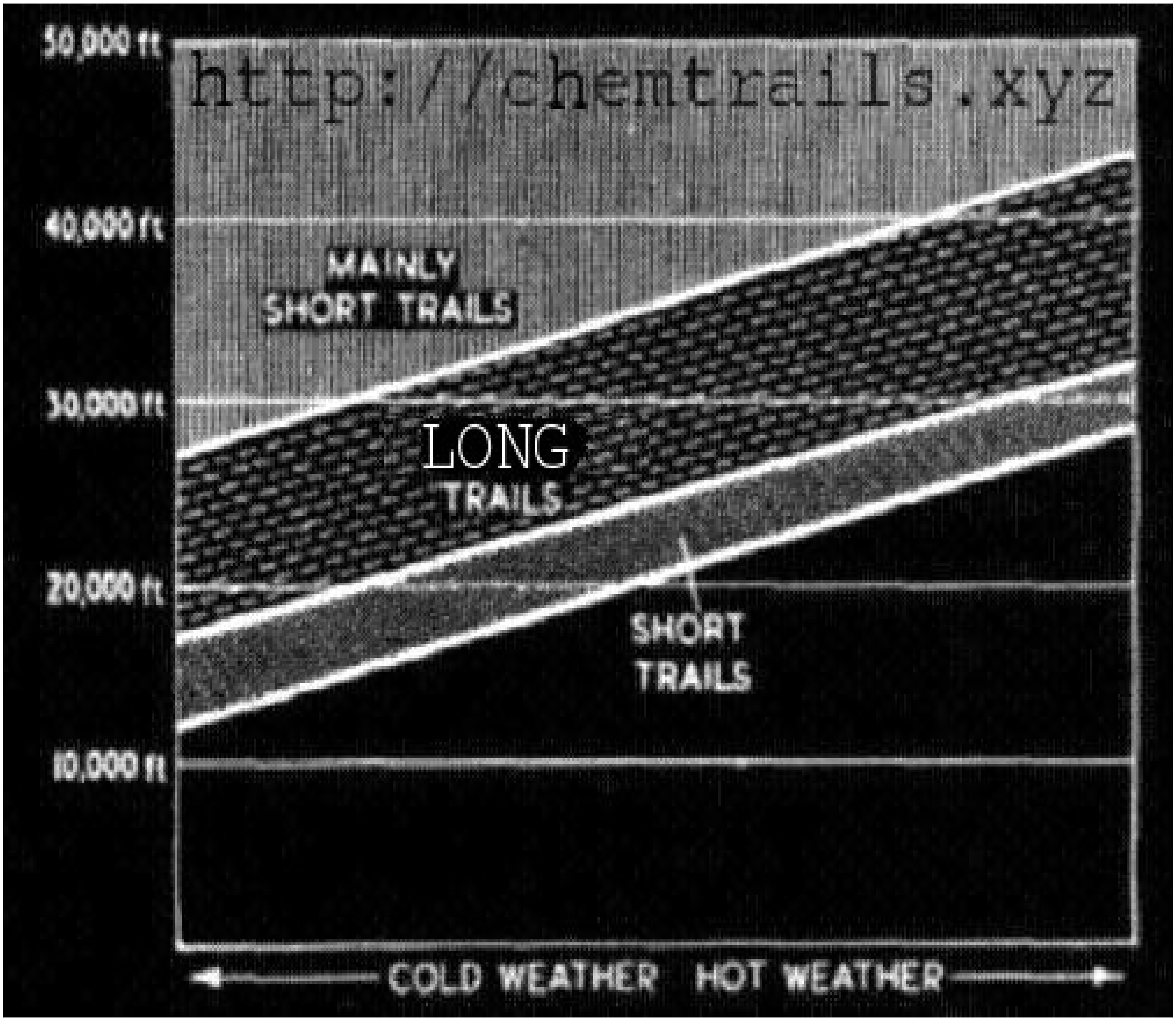
Lincoln: Four parallel streams starting in a straight line. The streams are almost equally spaced except for a slightly wider space between the two centre ones. At some distance behind the head the four streams merge into a rough, broad band.

B-36: Two groups of three parallel streams, with a space between the groups. The streams in each group come together well behind the aircraft, to form two parallel, widely spaced streams, which eventually merge into a broad strip. If the wing-tip jet engines are in use, the groups consist of four streams each, instead of three. The streams of the jet engines diverge slightly from the outer piston engine streams, but eventually join the streams in each group to form the two parallel, widely spaced streams. The sight is very spectacular, giving the impression that the aircraft is throwing out a tremendous amount of cloud.

B-47: The head has two pairs of streams, the inner streams of each pair starting to form slightly ahead of the outer ones, i.e., conforming to the sweep-back of the wings. The streams in each pair quickly join up, to form two parallel streams. Sometimes these break up into curved eddies. The way these eddies form is interesting. The twin contrail breaks up into short sections and the ends of the opposite streams of the sections curve inwards and join together, to form shapes similar to an hour-glass. They sometimes break through at the neck, to form rough circles. The eddies become rapidly reabsorbed, and disappear. The B-47 contrail does not always decay in this manner. It may become persistent, and spread out by the action of the wind into a rough cloud strip, in which case the twin contrail becomes obliterated.

Group D—Aircraft with Four or More Engines Close to Fuselage. The width of the single stream indicates the over-all distance across the engines. If examined closely with binoculars the first beginning of the stream may be seen to have a small vee space, with the point of the vee facing backward. This gives the effect of the streams converging very rapidly to form one broad stream. In the case of the Valiant, *after the short, broad head the contrail divides into two parallel streams,* which stay apart for quite a long distance but finally merge together as the stream becomes diffused. In a turn, the two streams are thrown apart and do not join up. The stream on the inner side of the turn looks much denser than the one on the outside.

It will be seen from the foregoing brief remarks that thorough and patient analysis can bring to light a great many useful pointers out of which a really practical system of aircraft recognition by contrail may develop. It is hoped, with the help of observers all over the country, to build up a body of information.



The words 'PERSISTENT TRAILS' have been replaced by LONG TRAILS in Figure 1 above, to clarify the original meaning intended by the article in 1956. This change of wording was done to avoid confusion, because today's chemtrails persist for hours, whereas back then, the word persistent was applied to long condensation trails that disappeared within two minutes.

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