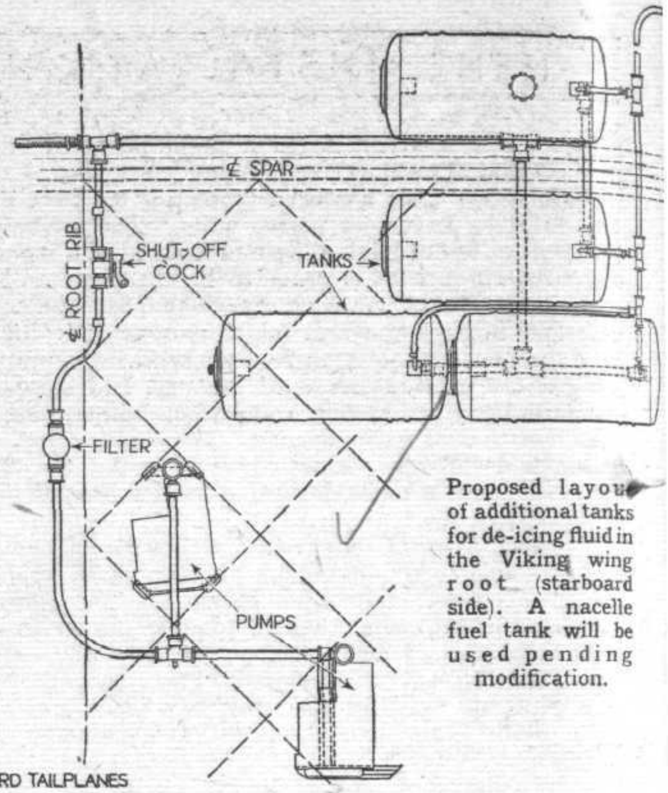
ICE on the VIKING

Important Flying Tests : Results and Remedies : Resumption of Services

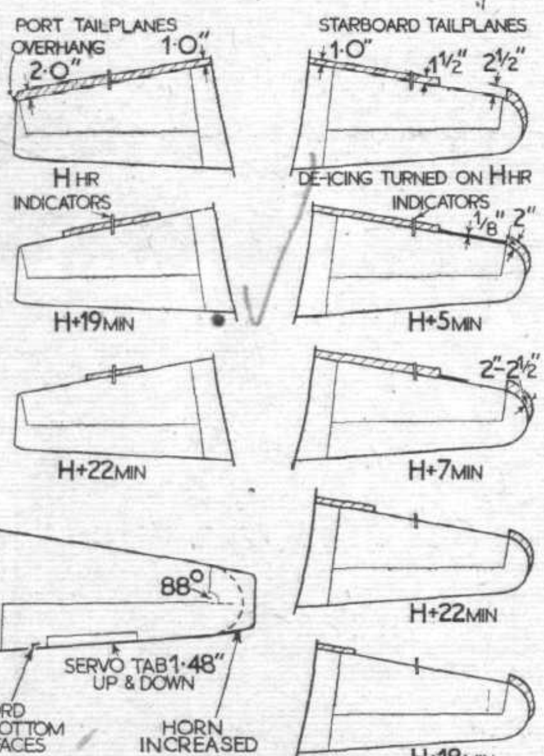
AFTER four months of inactivity Vikings have now, as we briefly recorded last week, regained. A.R.B. approval for operation in icing conditions on all B.E.A.'s routes. Their precautionary withdrawal from service was a severe blow, but it may also well prove indirectly to have been of great advantage to the British aircraft industry. The findings of what must be the most extensive series of flying tests in severe icing conditions, which have been conducted as a result of their withdrawal, are to be made available to all manufacturers by the Vickers-Armstrong company.

Three things are required of a modern aircraft should icing be encountered; the ability to fly and be handled normally—perhaps with some increase of power—with ice on surfaces; the ability, with the aid of its de-icing equipment, to get rid of any ice which has formed and, in anticipation, the power again through the de-icing equipment, to prevent ice from forming at all.

Being the most important problem the aerodynamic one was tackled first. It had been known for some time that the elevators of the Viking, though satisfactory in effect, left something to be desired in their feel. The woolliness had been assumed to be a matter concerning the fore and aft stability of the whole airframe; icing problems have shown that it was caused by too closely balanced elevators. It centres around the B_2 coefficient—the rate of change of hinge moment with elevator angle—and was to a great extent cured as soon as the negative value of B_2 was increased. Should the B_2 coefficient, through icing or other causes, become positive, the elevators would be overbalanced; there must, therefore, be sufficient negative margin to prevent this occurring.

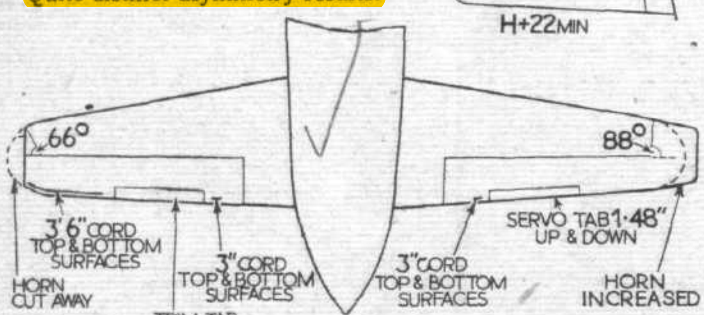


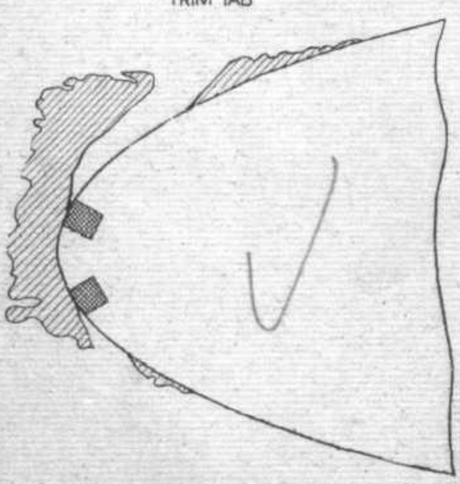
Proposed layout of additional tanks for de-icing fluid in the Viking wing root (starboard side). A nacelle fuel tank will be used pending modification.



Stages in the removal of ice from tailplanes by the T.K.S. system with increased rates of flow.

(Below) Elevator modifications. Quite distinct asymmetry results.





Possible effect of insufficient flow of de-icing fluid. The next stage may be a build-up of upper and lower ice sections to a three-pronged formation.

A second factor which bears on the aerodynamic problem is the asymmetry of slipstream resulting from airscrews rotating in the same direction. Handed airscrews are not a practical proposition, chiefly because of the duplication of spare engines and components which would be entailed. The port horn balance on the Viking has from the start been smaller than the starboard one because the destabilizing effect of the slipstream acts on the port side only. On the modified Vikings, which will go back into service with B.E.A., a quite pronounced asymmetry will exist. This is the first time that the slipstream problem has been countered in this way, but the Vickers-Armstrong Company regard it as a simple and logical step, which may well be adopted by others.

In attacking the Viking elevator overbalance condition several measures were considered:

(1) Spring tab modification.
(2) Cusped trailing edges.
(3) Built-up trailing edges.
(4) Modified horn balances

Longer-term preparation was also made to increase the size of tailplane and to set back the elevator hinges, but other measures have proved successful and this will not now be necessary.

Chief modifications at once adopted for the elevators were:

(1) A reduction in size of port elevator horn to 62 per cent of the original. It is now shielded and is, in effect, only a mass balance.

(2) Addition of 3ft 6in lengths of $\frac{3}{16}$in tube above and below the trailing edges. (See diagram.)

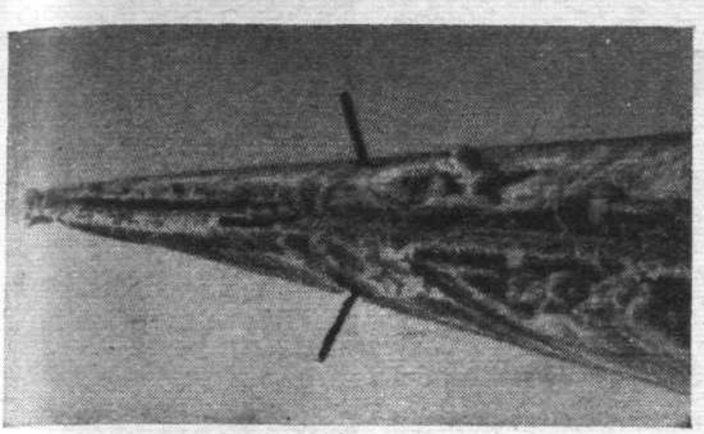
(3) Gearing-up of servo tabs to 1.5in each way instead of 1in.

(4) Addition of a spring compensator (bungee) to give a 25 lb down-load at the controls.

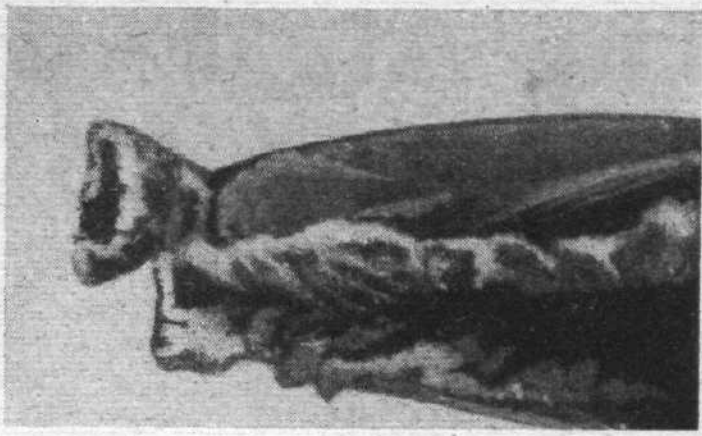
Tests with an increase in size of the starboard horn of 20 per cent were tried and found successful, and a 40 per cent increase is to be adopted. When the large horn is added the interim spring compensator will be discarded.

The effect of the $\frac{3}{16}$in tube on the handling of the elevator controls is to make them heavier, while the increased gearing of the tabs has rather the reverse effect under normal conditions. The aim, successfully achieved, has been to obtain less balance but the same stability under all conditions.

One effect of the modifications to the tail units has been to the stick load in the event of an overshoot. From a powered approach to a balked landing the load is rather less than 30 lb, and from the glide at 90 to 95 kt it may be as high as 60 to 70 lb. This last case would be exceptional, and in that the trimmers are very accessible the



Ice on the leading edge of the starboard tailplane. The upper indicator is free but the horn balance is heavily coated.



A large "cabbage" has formed on the starboard elevator horn.

momentary high load is considered acceptable.

There is no doubt that a thorough practical research into icing should have been carried out some years ago by one of the national establishments. Figures have hitherto been mainly theoretical; A.R.B. estimated flow requirements, now to be modified, are an example which may be compared with T.K.S. recommended fluid flows and the quantities recently found to be necessary for the Viking in practice. Various calculated and tested flow figures are given below. All are expressed in pt/hr/sq ft (or in the case of airscrews pt/hr/ft run), and the two columns, recommended low and high rates of flow.

(1) **Flow estimated by A.R.B.** (to prevent severe icing at −5 deg C and −20 deg C).

Wing and tail	0.18	0.9
Airscrew	0.33	0.83

(2) **Calculated Fluid Required** (R.A.E. Theory).

Wing	1.53	4.00
Tail	1.6	3.0

(3) **Fluid Rates and Duration** (Original System, Normal and Emergency flow).

Wings	0.2	1.0
Tailplane and fin	0.2	1.0
Airscrew	0.33	1.65

Tank capacity 15.4 gal. Duration 2hr 50min or 34min. One pump and T.K.S. Controller giving "normal" or "emergency," (5×normal) flow. One tank (15.4 gal) in starboard inner wing.

(4) **Fluid Rates and Duration** (System as Flight Tested).

Wings	1.0
Tailplane and fin	2.0
Airscrew	0.83

Tank capacity 73.8 gal. Duration 3hr 18min. One pump and T.K.S. Controller. Two tanks, Original (15.4 gal) and nacelle tank (starboard, originally used for fuel) 58 gal=73 gal.

(5) **Fluid Rates and Duration** (Final Scheme, European Aircraft).

Wings	1.0	2.0
Tailplane and fin	2.0	4.0
Horns	8.0	16.0
Airscrew	0.83	1.66

Elements in each horn gap and on leading edge of fin horn and starboard horn. Tank capacity 73.8 gal. Duration 2hr 54min or 1hr 27min. (Duration with 30.8 gal, 1hr 15min or 0hr 37min.) Two pumps and special controller giving full flow from either or both pumps. Not coupled to ice detector. Pump failure warning device.

It must be stressed that in the Viking tests icing conditions were carefully searched out, and the aircraft was then flown around in the area for long periods to collect ice. Only under exceptional circumstances would an aircraft remain in icing conditions for as long as an hour when operating over European routes.

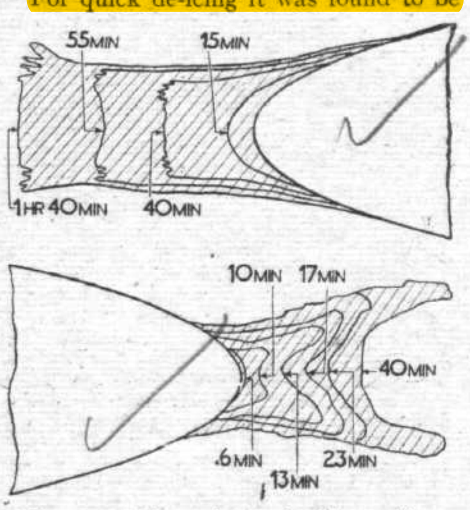
In that the normal flow of de-icing fluid was found to be inadequate, various measures were tried. These were:

(a) An increased average flow over the whole aircraft.

(b) Recalibration of delivery pumps to intensify local flow over tailplanes.

(c) Addition of a second fluid pump as a standby and for emergency delivery increase.

For quick de-icing it was found to be



Stages and times for the build-up of ice formations on tailplane leading edges in medium icing conditions.

essential to prime the system before the flight, and it then took about 30 seconds for the fluid to begin to appear on clear elements, and about 1 minute from under ice. Within five minutes of the system being started the last nodules were disappearing. Stages are illustrated.

Most of the tests were conducted in normal icing conditions, and an average rate of build-up was one inch in 20 minutes, although on one occasion of severe icing one inch formed in 3 minutes.

The extraordinary cabbage formation on the elevator horn has been drawn in its various stages of formation. Being entirely stalled, the iced horn had no effect on the elevators except as a mass balance.

Broad conclusions formed from test results were: (1) The Viking as tested was safe even if the de-icing system failed. The increased T.K.S. flow rates are not, therefore, particular to the Viking. (2) The prescribed flow rates were not adequate for European conditions. (3) When modified as indicated, de-icing was satisfactory, and there were no adverse aerodynamic effects.

Additional conclusions were that the original "normal" flow (2×T.K.S. recommended rate) did not remove substantial ice formations, but that it would prevent some icing in mild ice conditions. The aircraft was also found to fly safely on one engine (starboard engine cut) when carrying ice, and on test climbed at 120 ft/min at about 32,000 lb A.U.W.

It should be mentioned that no trouble was at any time experienced with the fin or rudder. However, in keeping with other tail surfaces, their flow will be doubled. For ice prevention the modified T.K.S. system is now satisfactory.

Temporary measures to increase the de-icing fluid capacity on the European Vikings have necessitated the use of one nacelle fuel tank of 58 gallons capacity. As soon as new de-icing fluid tanks can be made and fitted, the nacelle fuel tank will revert to its original purpose. Vikings for non-European services will probably carry 31 gal of fluid.

Airscrew icing gave no trouble at any time, and no ice was seen on newly feathered blades. That ice did form on the blades, however, was proved by dents in the fuselage opposite their tips, and by the considerable hammering noise it made on impact.

Engine icing also gave no trouble, and the internal hot-air intake worked well. Use of hot air for landing has, however, been incorporated in Viking landing drill. This has little effect on power output.

Resumption of Operation

Speaking at a recent conference, Mr. G. d'Erlanger, managing director of B.E.A., said that numbers of Vikings would be back in service by April 20th. The modifications had to be incorporated in all B.E.A.'s Vikings, the production line had to be got going again, B.E.A.'s pilots had to be checked-out again after four months off Vikings, more proving flights would be made as a precaution, and, finally, agents and the public had to be notified of time-table changes.

It is chiefly due to the excellent combined team work on the part of Vickers and B.E.A. that the problems have been satisfactorily solved in a few months. Many pessimists predicted a year's work for solution.

On the first two test flights, made on January 25th and 26th with short-nosed Viking G-AHPG, Capt. James and Capt. Summers, chief pilots of B.E.A. and Vickers respectively, Mr. Edwards, chief designer, Mr. Black of the Air Registration Board, and Radio Officer Cox of B.E.A. flew. Capt. James and his radio officer flew on every subsequent occasion, but were, on occasions, accompanied by W/C. Lowdell, Vickers test pilot, Mr. Richards, also of Vickers, and 1st Officer Crawford of B.E.A.