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ADDRESS ALL COMMUNICATIONS TO "THE AIR OFFICER COMMANDING"

FILE No. 800/2/Eng./13356.

13th July, 1943.

The Secretary,
Department of Air,
MELBOURNE.

Attention : D.T.S.

AIRFRAME MAINTENANCE.

DMS. 17/8/43

Forwarded herewith is a copy of Headquarters, Fighter Command pamphlet "Improvement in Airframe Maintenance in the interests of Aircraft Performance". Attention to such details as are mentioned in the pamphlet has increased the performance of certain Spitfires by up to 10 miles per hour.

2. It is also of interest to note that removal of the stone guard adds approximately 1500 feet to the full throttle height of the Spitfire V. It is therefore suggested that the design of a retractable stone guard may be worth while.

(W. M. HIGGINS) S/Ldr,
for Air Vice Marshal,
Air Officer Commanding.

Encl.

Improvement in Airframe Maintenance in the interests of aircraft performance.

The attached Special Instruction dealing with the procedure to be adopted in order to maintain the maximum possible performance of Fighter Aircraft in service is forwarded for information and necessary action.

2. These instructions are to be brought into effect immediately and Station and Squadron Engineer Officers are to ensure that all aircraft held by their respective Units are systematically examined, rectified and maintained in accordance with these instructions.

3. The materials quoted can be obtained through normal service channels ref: A.P.1086 with the exception of the Filler. This is to be demanded in 3-lb. tins (price 1/2d. per lb.) on Local Purchase Order from Messrs. Cellon Ltd., Richmond Road, Kingston-on-Thames, quoting Cellon Red Brown Stopper 38792/85095, until such times as the necessary service supply can be arranged.

Group Captain,
Chief Technical Officer,
FIGHTER COMMAND.

IMPROVEMENT IN AIRFRAME MAINTENANCE IN THE INTERESTS OF AIRCRAFT PERFORMANCE

THE NEED FOR IMPROVEMENT

1. If our fighter aircraft are to be supreme in the air they must possess, among other qualities, speed. In search for this essential we look primarily to aircraft manufacture to give us cleaner and more efficient shapes and to the engine manufacturers to give us more power in a unit of given size and weight.

2. The necessity for maintaining a high standard of engine performance is obvious to all maintenance personnel, since an inefficient engine usually shows signs of unreliability, e.g. an engine which is misfiring will loose power and will be attended to primarily because it is unreliable. The lost power (and lost speed) is thus regained automatically.

3. With the airframe a different state of affairs exists. Provided that it is airworthy, i.e. parts are not badly worn or damaged, and the aircraft is clean, a fall off in performance is not immediately apparent. Thus, in the past, too little attention has been given to defects which may seriously affect its performance. Aircraft are now operating at speeds in the region of 400 miles per hour. A drop in <u>top</u> speed performance of 10 miles per hour means that the engine is giving approximately 100 horse power less than it should do or alternatively, and more likely, the aircraft is wasting this amount of horse power due to its inefficient shape and condition.

4. The ideal aircraft has a perfectly smooth surface, free from excrescences, holes or leaks. Excrescences and holes are a direct cause of disturbed air flow. Leaks allow circulation of the air between the outer and inner surfaces of the aircraft as a result of pressure differences at various points, and reduce performance by a more subtle means, since their effect is not obvious. It is not possible to seal the aircraft completely, so that drag of this type must, and does, occur. It is, however, possible to reduce this undesirable circulation to a minimum, and eliminate the more obvious undesirable features referred to above.

5. The production of perfect aeroplanes, i.e. those with the minimum performance loss due to the above troubles, is possible only by intricate jigging and much hand work. Thus, the standard of finish of aircraft delivered to Service squadrons is a function of the amount of time and labour which can be given to detail, which in turn is dictated by the number of aircraft required in a given time.

Production methods are continually being improved, so that the best possible aeroplanes can be made in the minimum of time. The amount of time and care which will be devoted to this particular aspect of aircraft manufacture is, to some extent, dictated by knowledge of the treatment which the aircraft will receive in service, e.g. it is waste of time for manufacturers to produce a smooth surface finish if air and maintenance crews have insufficient pride in the aircraft to keep it clean.

6. A badly maintained aircraft is inefficient, wasteful and dangerous. It uses more horse power than is necessary under all conditions of flight and so wastes fuel and has a reduced range. It is tactically dangerous because its top speed is low.

It is, therefore, essential that all concerned are aware of the factors which affect aircraft performance, and of the remedies for the defects which now exist. The following instructions are published as a guide.

PRACTICAL METHOD OF OBTAINING INCREASED PERFORMANCE

The aircraft has been treated in the following notes both generally and in sections, giving the common defects which may be found and suggesting the remedy.

It should be noted that the most pronounced aerodynamic losses are caused by defects on or near the leading portion of the shape, e.g. leading sections of the main and tail planes, nose cowlings, etc. It is for this reason that flush riveting is adopted on these portions of the aircraft whilst snap riveting may be considered suitable over other surfaces.

2. General Defects and their Remedies.

The most obvious defects found on aircraft are illustrated in Figures 1 to 14 attached, and the remedy is given in the following notes.

(i) Bulged or Dented Panels. These should be dressed into shape by normal metal working methods. Ensure that the work is properly supported and periodically check the panel against the aircraft during the process. Avoid skin stretch when working on a ridged dent. Always check the area worked on for the development of cracks due to work hardening.

(ii) Distorted Cowlings or Cover Plates. Bent cowlings should be re-shaped and checked against their supports during the process to ensure that the metal is being worked correctly. Panels should lie flush with the supporting surfaces and must not protrude. Check for spreading between the panel edges and the stiffening strips. Gaps must not be allowed.

(iii) Faulty Butt Joints, Gaps or Overlapping Skin. Overlapping joints should be faired in with fillers, and when dry the latter should be rubbed down with an abrasive paper and lubricant before re-doping. Gaps should be similarly filled.

(iv) Turned up Edges of Metal or Fabric. Metal edges should be dressed to suit the contours of the surface. Fabric edges must be removed. The re-doping of turned up fabric edges is not always satisfactory, and it is preferable that new fabric should be applied.

(v) Heavy or Rough Dope. The treatment of surface finish is given in detail in para. 8.

3. Treatment of Major Components and Assemblies.

Engine Cowlings and Nacelles.

Damage, which should not occur, may be caused by ladders, trestles, etc., being leaned against these parts. Similar damage may result from rough handling of removable cowlings which are levered off with screwdrivers, etc., and may be damaged at the edges or distorted by being carelessly stowed whilst off the aircraft.

Inspect for signs of movement of the cowlings during flight. "Panting" may result from bad fitting and cause drag.

Refitting of the cowlings may necessitate repositioning of the

/female halves.....

female halves of the fasteners. Ensure that all tape padding on the cowling supports is continuous, and in good condition, and that the cowling beds securely. Screws which are used to secure cowlings or panels should not be replaced by Hexagon headed bolts which cause more drag. (See Fig.4). With air cooled installations it is important to ensure that the cooling gills can be brought to the closed position.

Main Planes.

Pay particular care to the leading edge (See Fig.6). A fabric strip along the leading edge joint interrupts air flow. If fitted it should be removed and the joint faired with fillers.

Gun blast appertures should be covered with a doped fabric patch in preference to the use of "gun patch". The latter is flexible and more likely to break the smooth contour of the loading edge during flight than is the taut patch.

Examine the aileron and wing flap shrouds for distortion. These should be dressed to the correct contour. (Fig.3). "Walk-way strips should be undamaged and firmly secured to the wing surface.

Undercarriage.

Trestle up the aircraft and retract the undercarriage. Check the legs in the "up" position and ensure that the fairings lie flush with the wing surfaces and are properly secure.

On twin engined types ensure that the undercarriage doors close correctly and that they are not likely to hang down in flight. Check the rubber sealing strips for continuity and security.

Fuselage and Tail Wheel.

Ensure that all inspection doors are of flush fit, particularly access doors, which are in frequent use and likely to be mal-treated. Where a retractable enclosed tail wheel is fitted ensure that the doors are of good fit.

Tail Unit.

Examine the elevator shrouds and if distorted remove the elevator and dress the shrouds into line using a hard wood block correctly shaped as a packing. Ensure that the fillets are not damaged. Bring the screw holes into line to prevent distortion during assembly.

Surface Finish.

Although a shiny surface is usually smooth, it does not follow that a high polish is a criterion of smoothness. From a light reflection and camouflage point of view it is undesirable that the aircraft should shine more than can be avoided. The best all-round results will be achieved by paying strict attention to removing all irregularities on the surface by rubbing down with a fine, well lubricated, abrasive and sealing all gaps between fixed skin surfaces with fillers. Filler is used to smooth out irregularities after initial assembly and before final doping.

An aircraft which has had many coats of dope applied and the surfaces of which are undulating, will not necessarily

/perform any better.....

perform any better as a result of a further coat of shiny paint or varnish. It may appear more pleasing to the eye but not be more efficient in flight. The thickness of dope should be the minimum possible consistent with covering the surface to be protected. Unnecessary dope adds weight and reduces performance. (See Fig.11). Instances have been known where the recognition letters of an aircraft have been changed four times. The old ones have been painted out at each change and the new ones superimposed. This has added 4 lbs. of dope to the weight of the aircraft, and, owing to irregularities in the surface still further detracted from its performance.

9. Materials for use in obtaining a Smooth Surface Finish.

(i) Abrasive Paper, rubbing, waterproof, grade 280, Ref: 330/674 for use in smoothing down surfaces before and after final doping. It is essential that the coat of Primer is rubbed down smooth before the dope is applied.

(ii) Primer. Ref: 330/213, for covering all bare metal surfaces before applying dope.

(iii) Filler, Red Brown, to be used for filling all gaps between fixed skin plates. The success of its application is entirely dependent on the cleanliness of surfaces upon which it is to be applied.

(iv) Knives, filler, to be made as per attached Fig.15, from local resources, or by local purchase, to ensure even application of the filler.

DON'TS FOR GROUND CREWS

1. Don't lean ladders and trestles against any part of the aircraft. It may not damage, but it will distort.

2. Don't wear boots when walking on aircraft, they tear and damage the finish. Rubber shoes are issued, use them.

3. Don't lay cowlings and panels on the ground, they may be walked on, or rest them insecurely so that they may be blown over or knocked down. Damage or distortion must be rectified and will add to your work.

4. Don't lay detachable items of aircraft external equipment on the ground with the doped face downwards. The surfaces become torn and ragged.

5. Don't use bolts when rivets are called for.

6. Don't brush on dope as though you were "white washing". Use a spray gun when possible. If you must use a brush, use it correctly.

7. Don't throw chocks in front of the wheels. They must be positioned carefully to avoid damaging leg shields and fairings.

8. Don't place engine and cockpit covers etc. on wet or muddy ground. Mud and foreign matter picked up by the covers scratches the surface of the aircraft.

9. Don't sit on the tail plane when engines are being ground tested. Tail planes are not designed to take such loads and become distorted through any form of mis-use. "Jack-knife" your body over the leading edge of the tail plane if the extra weight is necessary to hold the tail down.

10. Don't use a metal hammer where a hide or rubber hammer is the obvious tool.

11. Don't throw your tools on mainplanes and cowlings etc. Use a strip of felt or cloth to prevent the surface finish becoming chipped and scratched.

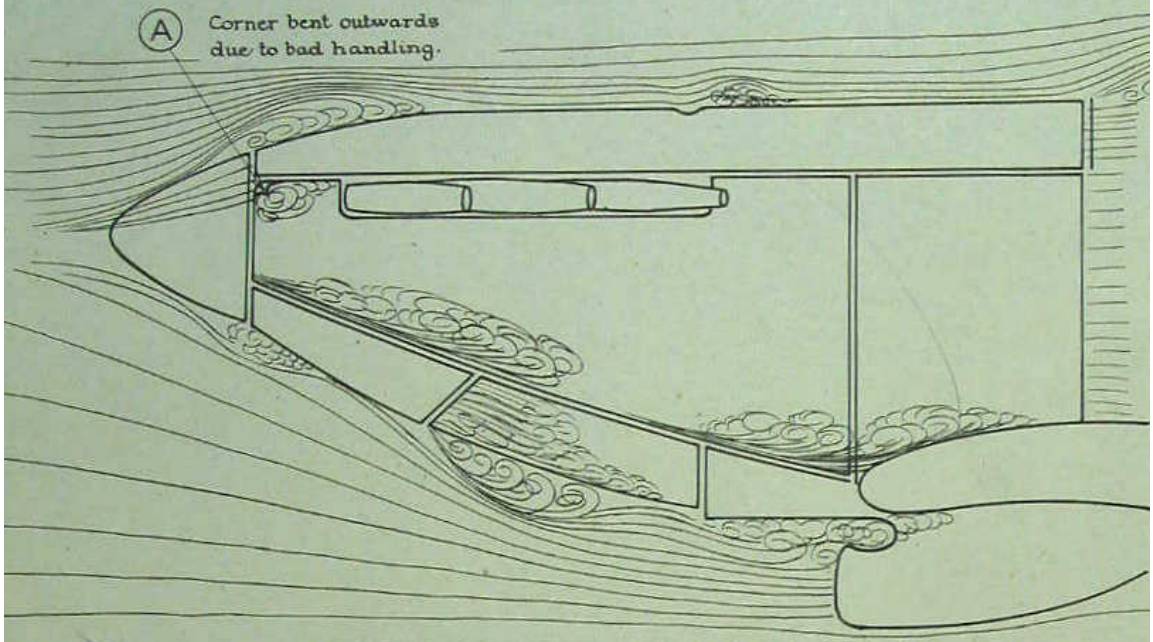
12. Don't leave your aircraft dirty at any time. Congealed oil and dry mud will strip the dope from the metal when you are eventually forced to clean it down.

13. Don't use a hammer to assist the screwdriver in locking or unlocking cowling fasteners. Damage may not be apparent externally but the support formers and female half of the fasteners become badly distorted.

14. Don't be impatient and use a screwdriver to assist in the removal of aircraft parts. Exercise even greater care as difficulties increase.

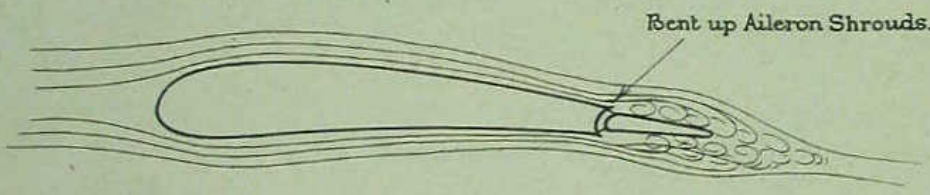
Headquarters, Fighter Command.
18th August, 1942.

FIG. 2



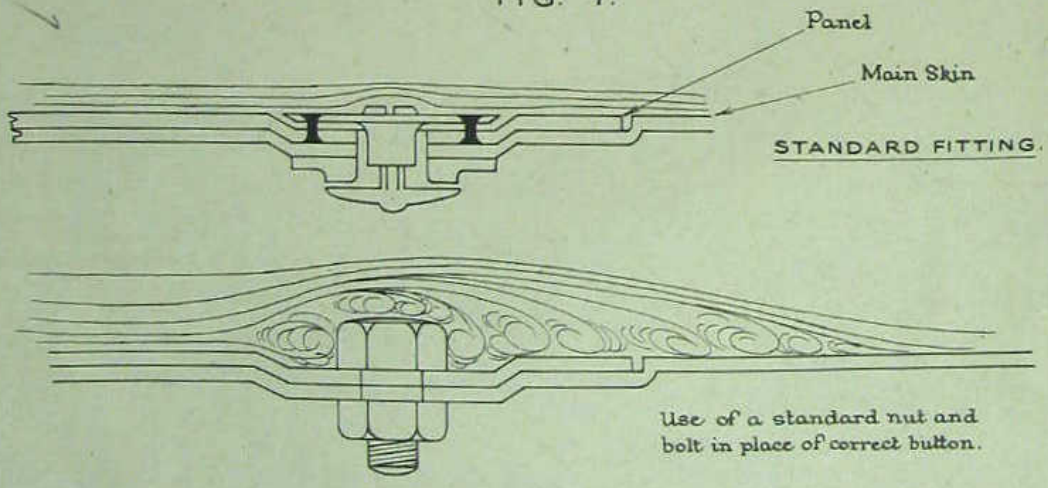
EFFECT OF LEAK DRAG ON AIRFLOW.

FIG. 3.



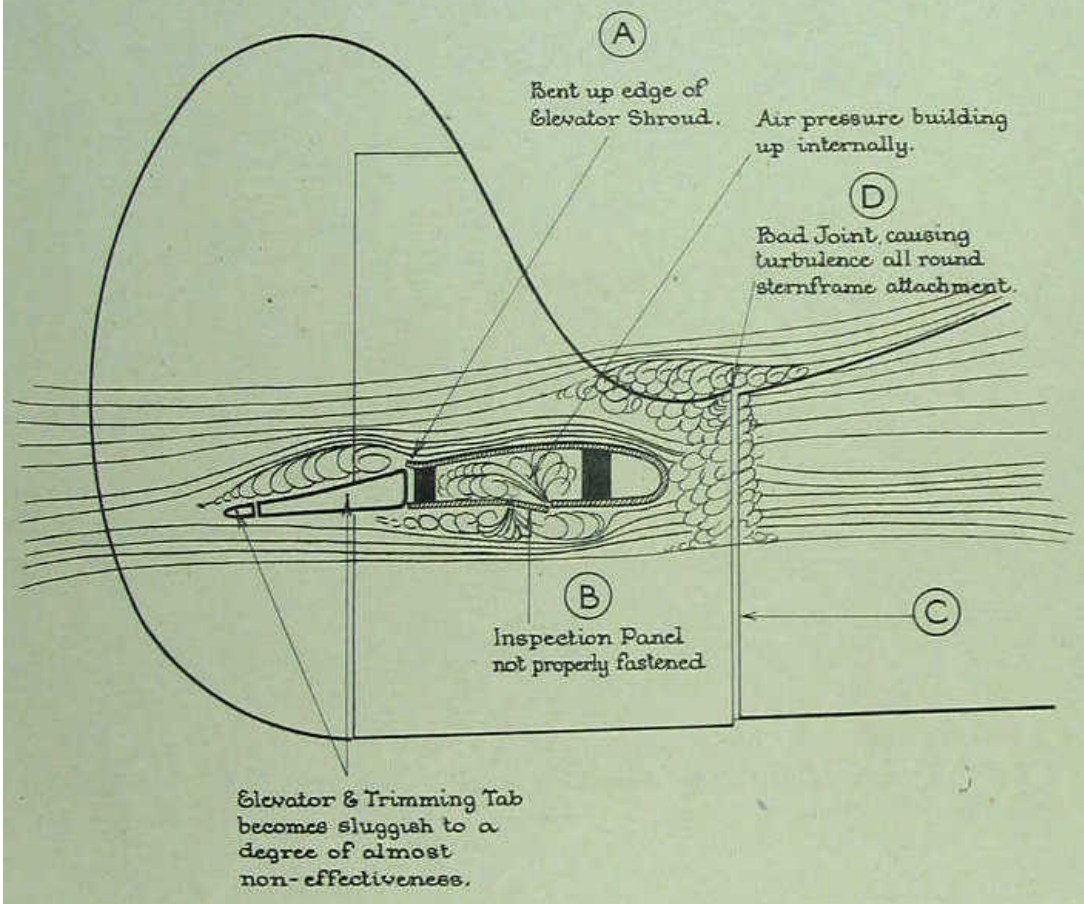
ONE OF THE MAIN REASONS WHY CONTROLS BECOME INEFFECTIVE

FIG. 4.



USE OF NON-STANDARD PARTS OFTEN CAUSES DRAG.

FIG. I.


A
Bent up edge of Elevator Shroud.
Air pressure building up internally.
D
Bad Joint, causing turbulence all round sternframe attachment.
B
Inspection Panel not properly fastened
C
Elevator & Trimming Tab becomes sluggish to a degree of almost non-effectiveness.

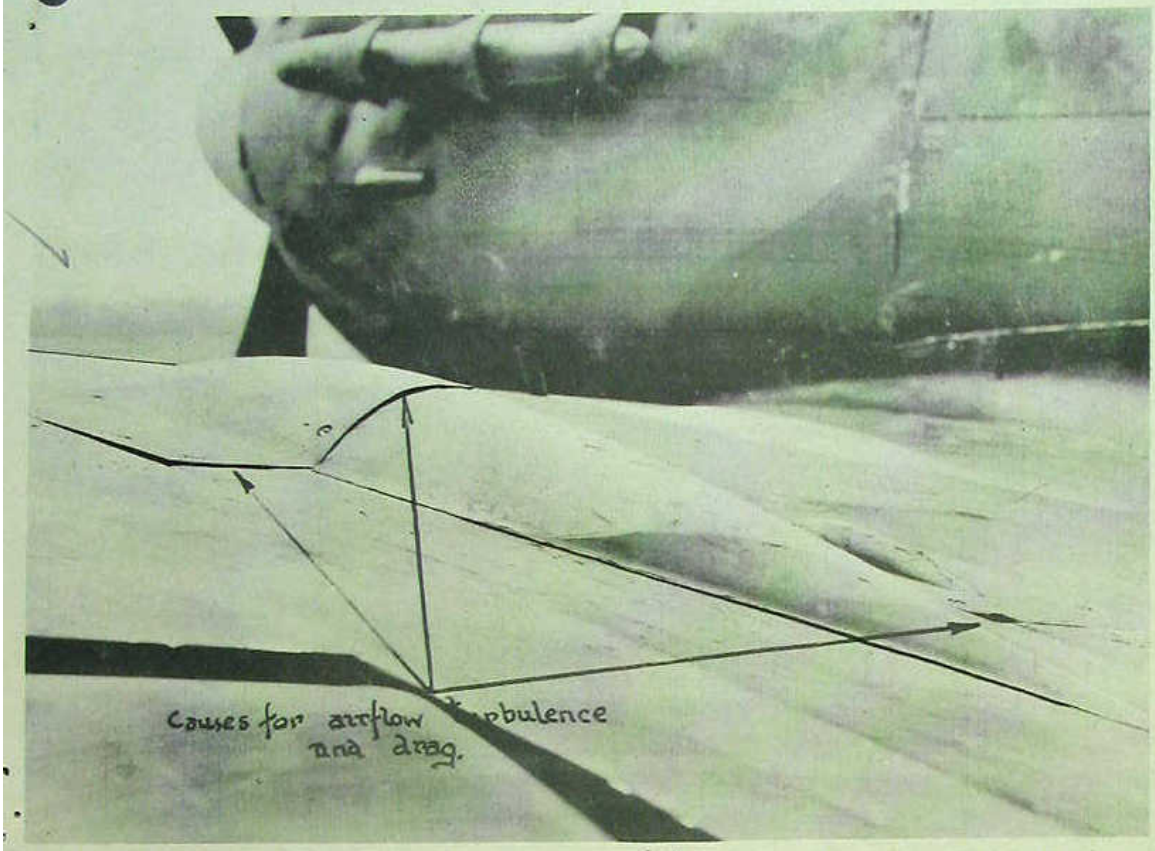

Causes for airflow turbulence
and drag.

FIG. 7. 6

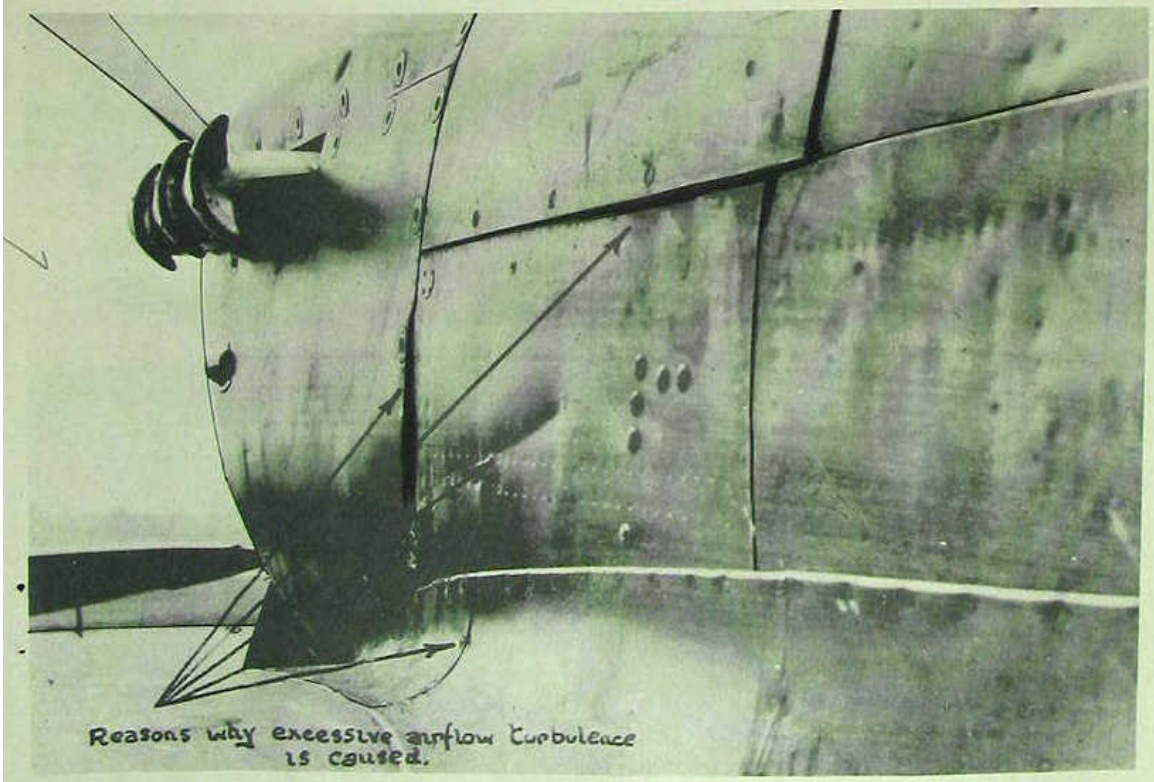

Reasons why excessive airflow turbulence
is caused.

FIG. 8. 7

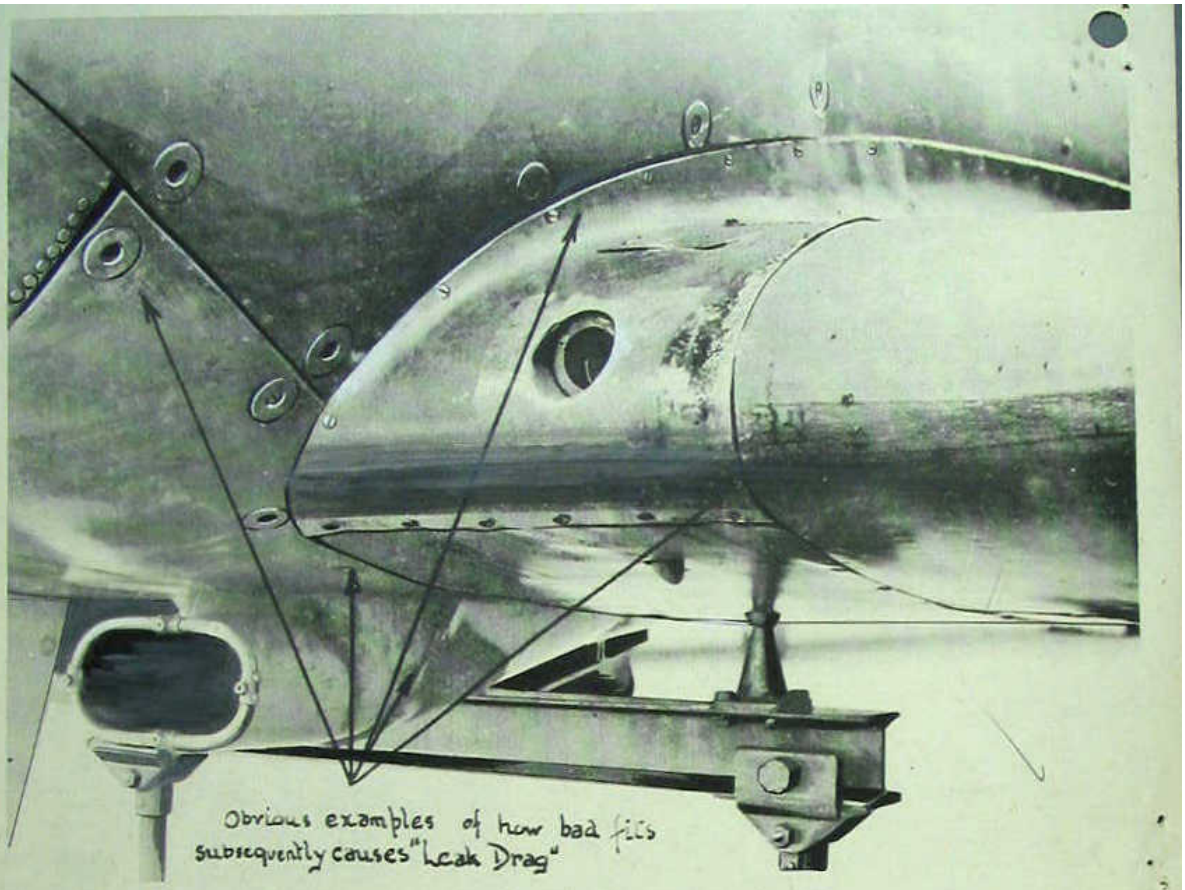

Obvious examples of how bad fits
subsequently causes "Leak Drag"

FIG. 5.

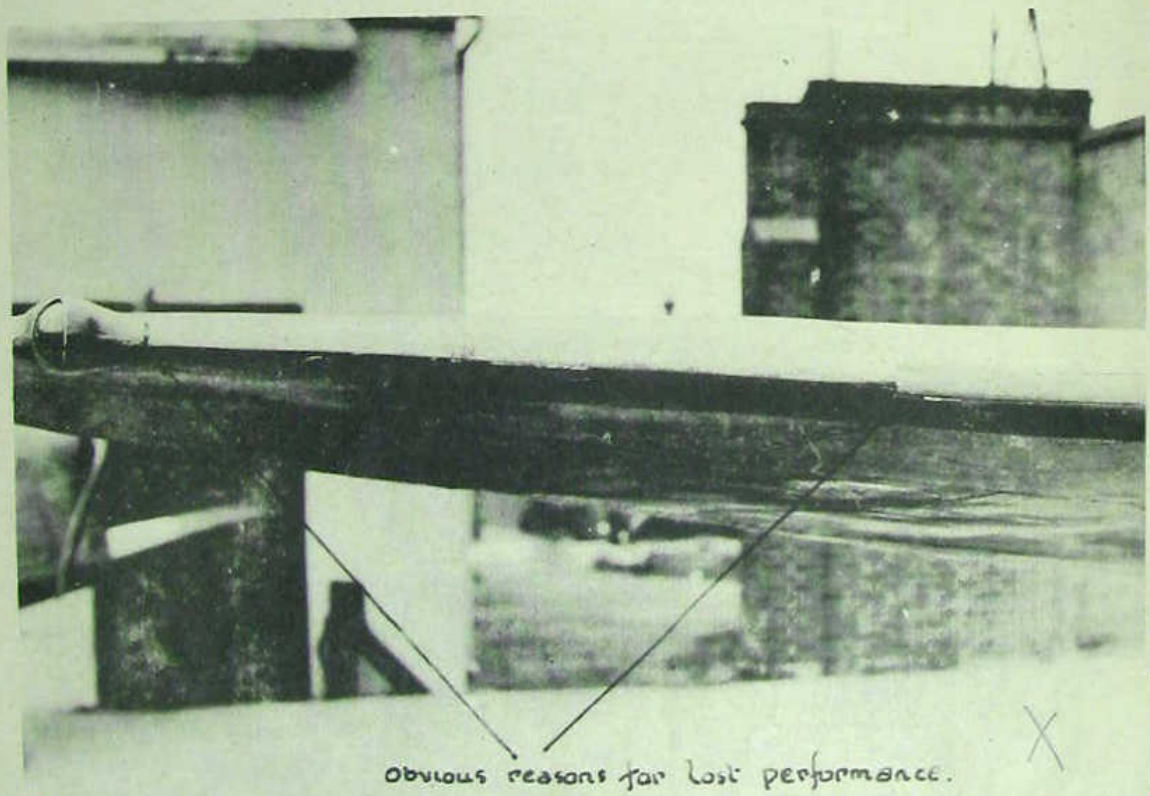
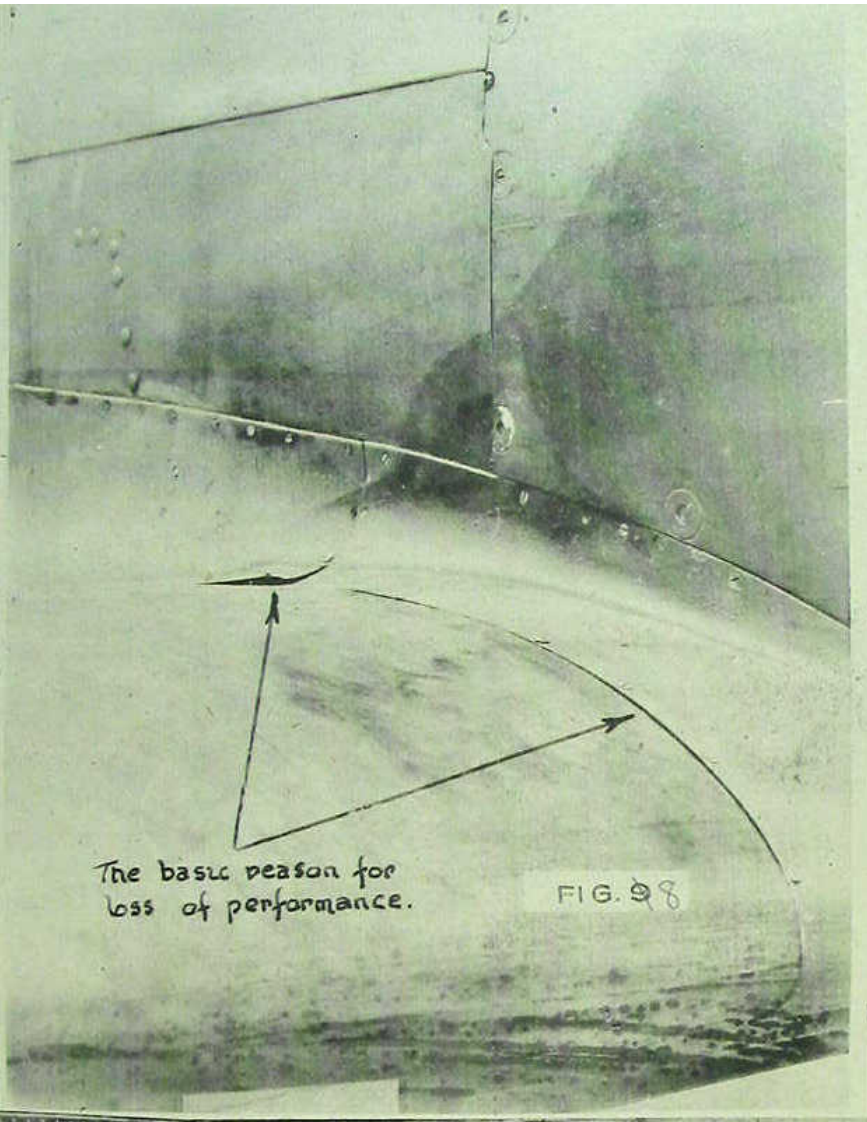
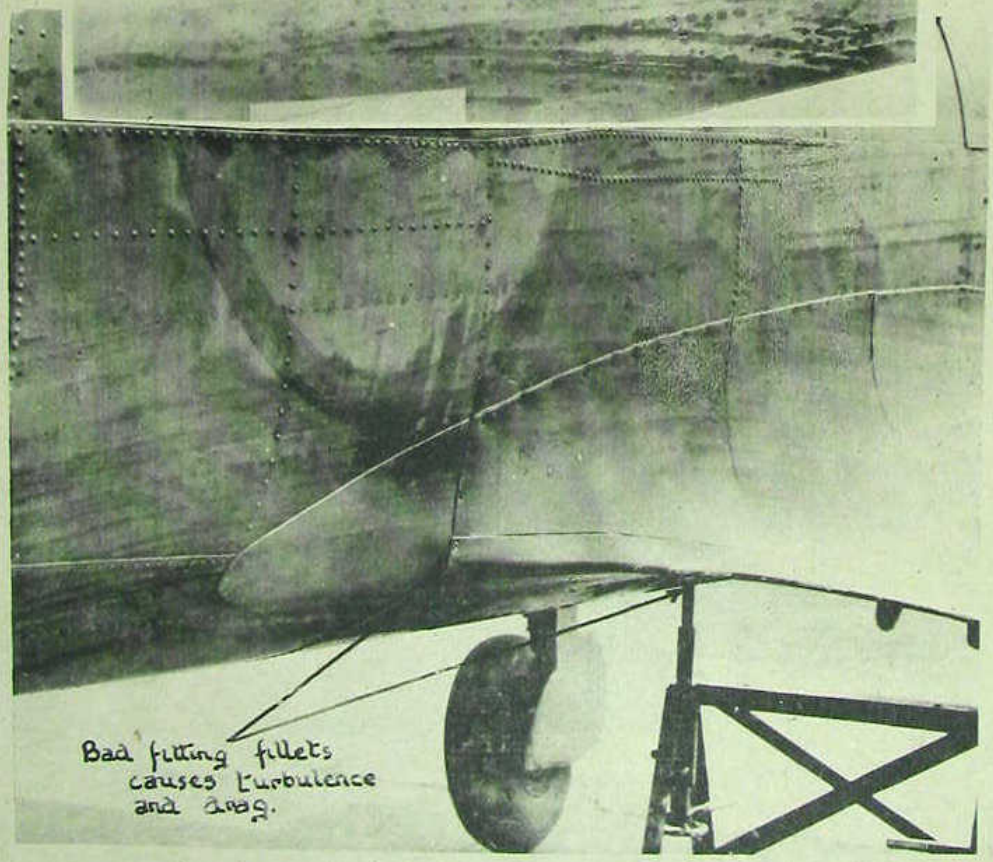

Obvious reasons for lost performance.

FIG. 6.



The basic reason for loss of performance.

FIG. 9



Bad fitting fillets causes turbulence and drag.

FIG. 10.

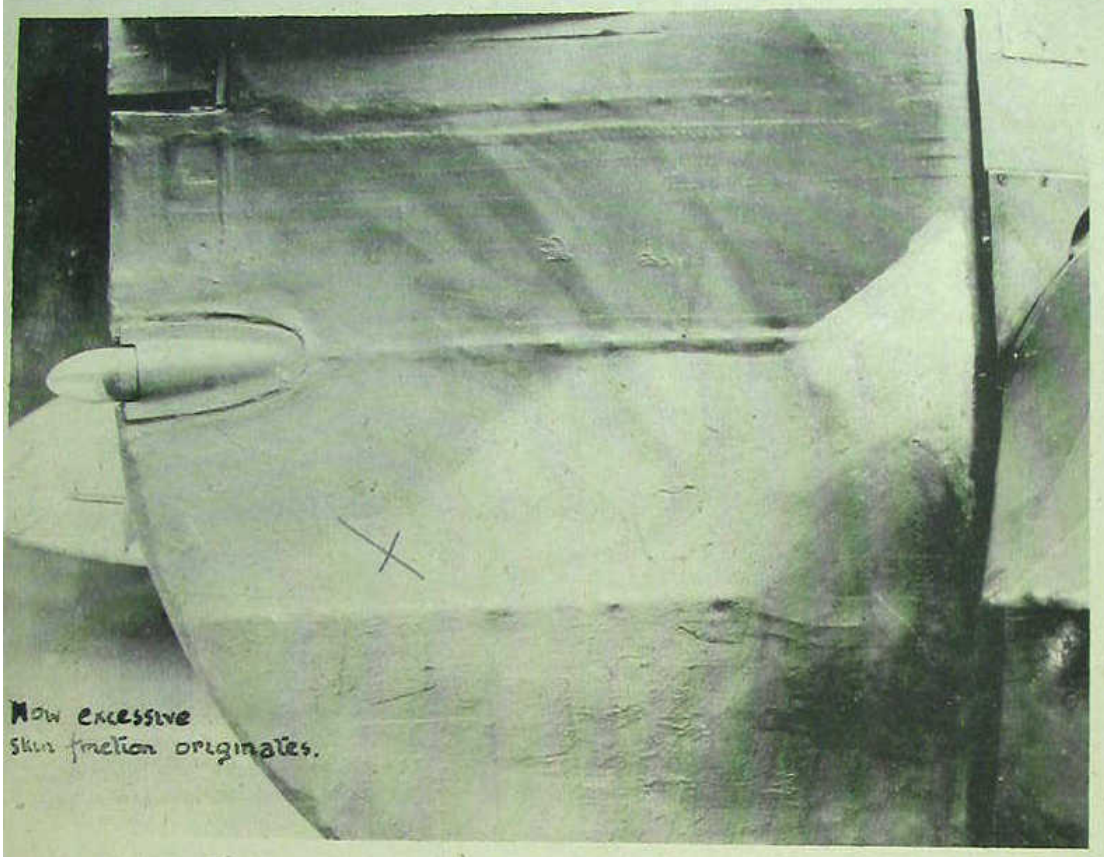


FIG. 11.

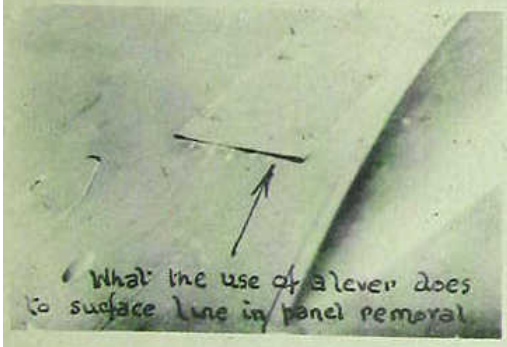


FIG. 12.

FIG. 13.

FIG. 14.

FOR OFFICIAL USE ONLY

AIR FORCE HEAD-QUARTERS

TECHNICAL ORDER

AIRCRAFT GENERAL INSTRUCTION
PART 5 NUMBER 12

APPLICATION: All fighter aircraft

MAINTENANCE OF EXTERNAL SURFACE FINISH OF FIGHTER AIRCRAFT

INTRODUCTION

1. This instruction describes the correct methods to use under service conditions for maintaining the surface finish on high performance aircraft.

It must be realized, that nowadays the surface finish is an essential part of the machine, and influences performance to a surprising degree.

This may be best illustrated by stating that exhaustive tests have shown an increase of 3 per cent in maximum speed on fighter aircraft by carefully rubbing down, smoothing and polishing the existing dull camouflage finish.

Although this may appear a negligible gain for the effort required, it must be realized that careful attention paid to the elimination of any source of drag resistance such as extruding pipes, incorrectly fitting inspection doors, and fairings, and dents in wing skin and/or fuselage covering will each result in a slight increase in performance, the cumulative effect of which will result in a considerable increase in performance.

Cases have been known where an increase of 30 m.p.h. in maximum speed have been obtained by close attention to detailed elimination of minor drag factors.

The following details are worthy of attention during maintenance of fighter aircraft.

DENTS

2. Small dents which are impossible or inconvenient to remove by normal metal working methods to conform with the original surface contour, may be filled with stopper as described in A.G.I. Pt.3, Sec.C. No.11. Where a dent is of such extent that stopping or filler would be appreciable in weight, it is preferable to either, beat out the dent or replace the damaged portion with a flush patch as described in the relevant aircraft handbook of repair methods.

Dents which are easily overlooked as they are not apparent unless careful inspection is made using wing contour boards, are those on the upper surface of mainplanes caused by personnel walking on areas not intended for such loads, also the careless placing of tools and equipment on areas not intended to bear any concentrated load. This type of dent or "oil canning" is caused by heavy weight concentrated on one bay or section of the skin bounded by rivets. The skin and rivets are strained beyond their elastic limit leaving a shallow depression possibly only a small fraction of an inch in depth but ample to upset the designers conception of a smooth air flow over the wing surface.

Such dents of course, are impossible to remove unless the whole section of the affected skin is replaced.

INSPECTION DOORS COWLINGS AND FAIRINGS

3. See Figures 1 to 11.

It is essential that particular attention be paid to the flush, smooth fit of all inspection doors, cowlings and fairings. Apart from the danger of an ill fitting component being torn off, or further distorted by the terrific air pressure at high speed, such items are one of the major causes of parasitic drag, and inattention to neatness of fit can seriously detract from the maximum speed of fighter aircraft.

Inspection panel screw recesses and inspection door fastener recesses which are not normally opened at minor inspections can be smoothed over with stopping as described in A.G.I. Pt.3 Sec.C No.11 to improve the lines of airflow. A tool for this purpose can be made up as shown in Fig.12.

VENT AND DRAIN PIPES

4. Attention should be paid to excessive length of vent and drain pipes protruding through the fuselage and undersurface of the wings. These, in many cases may be cut off flush with the surrounding surface to reduce drag, but discrimination must be observed in which pipes are cut; for instance fuel and oil vent lines must be so cut to create positive air pressure in the pipe orifice, and also drain effluent clear of the wing surface.

RIVET BOLT AND SCREW HEADS

5. See Figure 11.

Where repairs or modifications have been carried out, it is important to replace rivets with countersunk head type to reduce drag.

Where possible, bolt and screw heads should be of the countersunk head type, and if continued removal is not required for minor inspections, these may be smoothed over with stopper to present a smooth airflow surface.

LEADING EDGES OF MAINPLANES

6. See Figure 3.

Conclusive tests have shown that on fighter aircraft, especially Spitfires by rubbing down and polishing the existing matt camouflage finish with a wax polish expecially, over the leading 20% of the wing chord, marked improvement in maximum speed is obtained by preventing breakaway of the airflow in this region.

SURFACE FINISH

7. Although a shiny surface is usually smooth, it does not follow that this is always the case. For instance a dusty, or unprepared surface when freshly sprayed may be shiny, but rough to the touch. From a light reflection and camouflage point of view, it is undesirable that the aircraft should shine more than can be avoided. The best results will be obtained by paying strict attention to all irregularities on the surface by rubbing down with a fine well lubricated abrasive and sealing all gaps between fixed skin surfaces with filler. Filler is to be used

SURFACE FINISH (Contd)

to smooth out irregularities after initial assembly and before final doping.

An aircraft which has had many coats of dope applied and the surfaces of which are undulating, will not necessarily perform any better as a result of a further coat of shiny paint or varnish. It may appear more pleasing to the eye but not be more efficient in flight. The thickness of the dope should be the minimum possible consistent with covering the surface to be protected. Unnecessary dope adds weight and reduces performance.

Instructions on the method of surface filling and preparation for smooth high performance finish will be found in A.G.I. Pt. 3 Section C Number 11.

REFERENCES: Files R.A.A.F. 62/1/318 150/4/
Sketches 1 to 12 inclusive attached.

DATE OF ISSUE: September, 1943