

## CHAPTER IV.—NON-FACTOR REQUIREMENTS

**1. Tabular summary**

The requirements given in this Chapter are summarized in Table I. All of these requirements are to be complied with unless specifically waived in the aeroplane specification.

TABLE I

Requirement	See Chapter IV, para.
Prevention of wing aileron flutter .. .. .	2
Prevention of undue control circuit stretch and of aileron instability ..	3
Prevention of tail flutter .. .. .	4
Identification markings on control surfaces .. .. .	5
Duplication of control circuits .. .. .	6
Cables in control systems .. .. .	7
Chains in control systems .. .. .	8
Bearings in control systems .. .. .	9
Locking of controls .. .. .	10
Stability and control of aeroplanes in which automatic controls may be used .. .. .	11
Tail unit control surfaces :	
(i) Divided elevators .. .. .	12
(ii) Clearance between fin and rudder .. .. .	12
Rudder power .. .. .	13
Wheel brakes .. .. .	14
Undercarriage wheels and tail wheels .. .. .	15
Castings .. .. .	16
Welding of steel parts .. .. .	17
Streamline wires and tie rods .. .. .	18
Flattening of ends of tubes for the purposes of attachment .. .. .	19
Sweating and drilling steel tubing to B.S. Specification T.2 .. .. .	20
Use of 4 B.A. bolts .. .. .	21
Use of even sizes of B.A. screws .. .. .	22
Use of tab washers .. .. .	23
Design of wiring lugs .. .. .	24
Lugs for external wire bracing .. .. .	25
Sections of aeroplane metal parts (produced from hot-formed sections or forgings) .. .. .	26
High-tensile steel fittings .. .. .	27
Bending of aluminium alloy sheets and strips (applicable to material to B.S. Specification 4 L.3 and L.38 and to D.T.D.270 and 275) .. .. .	28
Permissible bow in light alloy tubing for use in aeroplane structures ..	29
Corrosion of S.61 and S.62 bolts in wooden members subject to wetting in service .. .. .	30
Collars for high-tensile steel pins .. .. .	31
Provision of longitudinal datum marks .. .. .	32
Safe limit of deterioration of shock absorber legs .. .. .	33
Securing of windscreens.. .. .	34

**CHAPTER IV.—PARA. 2**

*Amended by A.L. No. 3*

TABLE I—*contd.*

Requirement	See Chapter IV, para.
Fasteners for cowling and inspection doors .. .. .	35
Compression shakes in spruce rib flanges .. .. .	36
Use of duralumin tubes and sheet thinner than 22 gauge .. .. .	37
Provision for ballast .. .. .	38
Use of parallel pins .. .. .	39
Attachment of wireless aerials (fixed and trailing) .. .. .	40
Retractable undercarriages .. .. .	41
Undercarriage springing characteristics .. .. .	42
Torsional stiffness of ailerons .. .. .	43
Torsional stiffness of elevators .. .. .	44
Repairs to mass-balanced surfaces .. .. .	45
Ground clearance .. .. .	46
Hand and foot holes in airframes .. .. .	47
Buoyancy of engines in estimating buoyancy of aeroplanes .. .. .	48
Protection of aeroplane cowlings and structure from gun blast .. .. .	49
"Closed" structures (provision for internal inspection and removal of riveting pin or mandrel heads) .. .. .	50
Emergency exits in aeroplanes .. .. .	51

**2. Prevention of wing aileron flutter** (*see also Chapter V, Section V*)

(i) Careful consideration is to be given to the feasibility of complying with the anti-flutter recommendations of R. & M. 1155, articles 9 and 9a and 1255, articles 51 and 52. In particular, all ailerons must be mass-balanced.

(ii) For an aileron on a given wing, mass-balance is defined as follows.—Let  $m$  be an element of aileron mass at a perpendicular distance  $x$ , measured in the plane of the wing, from the aileron hinge axis and a perpendicular distance  $y$  from a longitudinal axis in the plane of the wing parallel to, and usually\* coincident with, the chord at the wing root. Let  $x$  be positive when  $m$  is behind the hinge axis and  $y$  positive when  $m$  is outboard of the longitudinal axis. Then the aileron should be regarded as mass-balanced when the following conditions are each separately fulfilled:—

(a) The product of inertia  $\Sigma mxy$  of the mass-balanced aileron in its "C.G. back" condition is zero or negative both when the aileron is neutral and when it is displaced  $\pm 10^\circ$ .

(b) The centre of gravity of the mass-balanced aileron in its "C.G. forward" condition is not forward of the hinge line, measured parallel to the wing chord, by more than  $0.06c_a$ , where  $c_a$  is the mean chord of the aileron behind the hinge line, both when the aileron is neutral and when it is displaced  $\pm 10^\circ$ .

In the above the C.G. back condition of an aileron is to be taken as that obtaining when the aileron is in a condition as regards fabric and doping weights, trimming strips, repairs, etc. corresponding to a most rearward position of the aileron C.G.; and the C.G. forward condition corresponds to the opposite practicable extreme. For biplanes, the weight of

\* When the inboard portion of the wing can be shown to be abnormally stiff, either inherently or by virtue of exceptionally stiff external supports, it may be permissible to locate the longitudinal axis elsewhere than at the wing root.

any inter-aileron member should, for the purpose of calculating  $\Sigma mxy$  for the ailerons, be halved and the halves treated as two isolated masses fixed to the upper and lower ailerons respectively at the points of attachment of the inter-aileron member. The finished covering of a control surface supplies an important contribution to the total mass. It is important, therefore, in the above C.G. back case to arrange mass-balance to be adequate when the weight of the finished covering is a maximum. The aileron to be mass-balanced should be weighed both covered and uncovered, and the weight of the finished covering obtained. This latter should then be corrected up to the maximum likely to be encountered during the life of the aircraft and this value used in the above C.G. back case. If the surface is covered with doped fabric a weight of at least 10 ounces per square yard of fabric (i.e. a total of 20 ounces per square yard of control surface area) is to be taken. Ailerons should not be painted (*see* para. 5). If mass-balancing is effected by means of a bob-weight this should be placed well outboard of any point of external support to the wing.

(iii) In exceptional cases compliance with the above obligatory requirement may not be a sufficient safeguard. When this appears probable, compliance with one or more of the other recommendations of R. and Ms. 1155 and 1255 may be required.

\* **3. Prevention of undue control circuit stretch and of aileron instability**

(i) *Stiffness of aileron control circuits.*—Unless the control and/or circuit is of unconventional type, the aileron control circuit of an aeroplane must be such that the hinge stiffness,  $h$ , in lb. ft./radian, is not less than the values given in fig. 1, Chap. V, Sect. VI,

(a) by the upper curve for upward movement of the aileron,

(b) by the lower curve for downward movement of the aileron, for the

value of the control circuit factor,  $\frac{S_a C_a V^2}{10^6}$  appropriate to the particular aileron. These

requirements are to be met when measurements are made as in Chapter V, Section VI, and are irrespective of any tendency of the aileron to blow up or down under normal flight conditions. In the above.—

$S_a$  = aileron area aft of hinge line (sq. ft.),

$C_a$  = mean aileron chord aft of hinge line (ft.) both  $S_a$  and  $C_a$  being measured in the plane of the undersurface of the particular aileron, and

$V$  = maximum speed (ft./sec.) to which the aeroplane is required to be dived during contractor's and official flight trials.

For a monoplane, only one aileron need be considered. For a biplane one upper and, if present, one lower aileron must be considered and each must individually satisfy (a) and (b) above. If the lateral control and/or the circuit is of unconventional type—as, for example, a circuit with irreversible units—reference should be made to the Airworthiness Department so that the case may be dealt with on its merits.

(ii) *Stiffness of elevator and rudder control circuits.*—The elevator and rudder control circuits must—unless the circuit is of unconventional type—be such that the percentage stretch for each of the circuits ( $S_3$  for elevator,  $S_4$  for rudder), when measured as described in Chapter V does not exceed 20 per cent. If an elevator or rudder control circuit is of unconventional type—as, for example, a circuit with an irreversible unit—reference should be made to the Airworthiness Department so that the case may be dealt with on its merits.

\* Previously A.D.M. 343.

## CHAPTER IV.—PARA. 4

*Amended by A.L. No. 3*

(iii) *Slack and friction in control circuits.*—Attention is drawn to the need for minimizing slack and friction in control circuits. The fit of all control bearings should be as close as possible consistent with ease of manipulation of the controls, and the areas of the bearings should be adequate to prevent rapid wear leading to the development of slackness. A control circuit should be designed so that its operation when unloaded does not involve stretch, deformation or slackness in any part of the system.

(iv) *Aileron and trimming strip settings.*—Standard settings for the ailerons and their trimming strips (if any) are to be stated in Volume I of the Air Publication relevant to the particular aeroplane. For each aileron the standard setting stated is to correspond to the upper limit of permissible positions for the trailing edge of the unloaded aileron relative to the wing, any unavoidable slack in the control circuit being assumed taken up by gently raising the aileron trailing edge, the controls being centralized. For each trimming strip the standard setting stated is to correspond to the lower limit of permissible positions for its trailing edge relative to the ailerons.

It must be demonstrated during the contractor's and official flight trials of the type aeroplane, that the ailerons and trimming strip (if any) are such that, when in their standard setting positions, no overbalance or other instability is observable in the aileron system for all conditions of flight to which the type aeroplane may be subjected. This applies to aeroplanes with no trimming strips, to aeroplanes with trimming strips on the ailerons on both sides of the aeroplane and to aeroplanes with trimming strips on the ailerons on one side of the aeroplane only. In the last case the contractor must make any special provisions that may be necessary for correcting the lateral trim during the flying trials.

It is further required that no adjustment of a trimming strip to a position below its standard setting shall be possible. For this purpose a positive stop must be fitted.

(v) *Construction and adjustment of aileron trimming devices.*—All trimming devices are to be constructed so that they are sufficiently stiff and securely held to withstand the loads occurring in flight and during normal handling and maintenance operations.

It is required that the aeroplane drawings and Volume I of the Air Publication relevant to the particular aeroplane shall include as much information as is practicable concerning the method of adjustment of aileron and trimming strip settings. The information given in Volume I of the relevant Air Publication should include the guidance necessary for the satisfactory replacement of a damaged aileron by a new or repaired one.

### 4. Prevention of tail flutter (see also para. 12 (i))

(i) *Rudder.*—Careful consideration is to be given to the feasibility of complying with the anti-flutter recommendations of R. & M. 1255, articles 85 and 85a. In particular the rudders of all aeroplanes with the possible exception of rudders incorporating auxiliary surfaces, are to be mass-balanced.

(ii) For the purpose of this requirement rudder mass balance is defined as follows :  
Let  $m$  be an element of rudder mass whose perpendicular distances from the rudder hinge axis and above the fuselage axis of torsion are  $x$  and  $z$  respectively. Then the rudder is mass-balanced if  $\sum mxz$  for the complete rudder is small (i.e. between about  $\frac{1}{3}$ th and  $\frac{1}{12}$ th of the magnitude of the product of inertia of that part of the rudder aft of the hinge axis) and negative (see Chapter V, Section V).

(iii)  $x$  is to be considered positive for elements of mass aft of the rudder hinge axis. On conventional types of rudder, i.e. rudders the greater part of which is above the fuselage axis of torsion,  $z$  is to be considered positive for elements of mass above the fuselage

axis of torsion. Other types of rudders will be dealt with individually, and particulars of such rudders for which approval is desired should be forwarded to the Airworthiness Department.

(iv) Present evidence indicates that if rudders incorporating auxiliary surfaces are mass-balanced in the following way they will be free from flutter. Hence this method of mass-balancing main and auxiliary surfaces is to be adopted unless permission is obtained to waive the requirement or to adopt a different method.

(a) Arrange for  $\Sigma m_a x_a z$  for the auxiliary surface alone to be small and negative, where  $x_a$  is the distance of an element  $m_a$  of auxiliary surface mass aft of the auxiliary surface hinge line ;

(b) Arrange for  $\Sigma m_a x_a (d + x_a)$  to be small and negative, where  $d$  is the distance between the hinge axes of main and auxiliary surfaces ;

(c) Arrange for  $\Sigma m_a x_a^2$  to be as small as possible ;

(d) Arrange for  $\Sigma m x z$  of the main and auxiliary surfaces combined to be small and negative,  $x$  being measured aft of the main rudder hinge ;

(e) Arrange for  $\Sigma m x^2$  for the main and auxiliary surfaces combined to be as small as practicable.

(v) In fulfilling the above requirement all masses present in the finished rudder system, such as tail lamps and their fittings, fabric covering, dope and paint, are to be taken into account. The weight of dope and paint is variable and it is important that the maximum probable weight of the covering should be assumed in each case. For unpainted rudders the lowest weight of doped fabric to be assumed in complying with the above requirement is 10 ounces per square yard (i.e. a total of 20 ounces per square yard of control surface area). For a painted surface 25 ounces per square yard (50 ounces per square yard of control surface area) is the minimum. If the figure appropriate to the doped surface is used steps must be taken to ensure that the rudder will not subsequently be painted (see para. 5).

(vi) *Tail structure.*—It is important that the tail plane and fin should be very stiff. In particular the tail plane should be very stiff in torsion and flexure and its attachment to the fuselage, through the trimming gear or otherwise, should be as rigid as possible.

(vii) In order to prevent tail flutter due to relative movement between an elevator and its trimming tab, the following conditions must be fulfilled.—

(a) The trimming tab control circuit must be irreversible ; the irreversible unit or units in the circuit should be placed as close to the tabs as possible.

(b) The trimming tab control circuit, particularly those parts of it between the irreversible units and the tabs, must be stiff and as free from backlash as possible. On the latter point special care should be taken in the design of the tab hinges.

(c) Each trimming tab must be stiff in torsion and flexure and the number of hinges ample to prevent any material bending of the tab between the hinges under air loads.

(d) The design of the trimming tab control circuit must be such as to prevent the development of any differential motion between the tabs on the port and starboard elevators.

(viii) Consideration should be given to the mass-balancing of elevator trimming tabs as an addition to the preventive measures enumerated above. Such mass-balancing would appear particularly desirable when any doubt is felt as to the adequacy with which

## CHAPTER IV.—PARAS. 5-7

Amended by A.L. No. 3

these other measures may have been met. Where mass-balancing is decided upon, this should be arranged so that the C.G. of the trimming tab is on, or slightly ahead of, its hinge line when the tab is in its neutral position.

### 5. Identification markings on control surfaces

(i) It has been the practice hitherto to paint identification markings on the rudders of aeroplanes and on the wings in accordance with S.I.S. No. 4. The "targets" on the wings have been painted in such a manner that an appreciable proportion of them lies on the ailerons.

(ii) The weight of paint thus carried on control surfaces is in some instances of material importance when the mass-balancing of these control surfaces is under consideration.

(iii) It has therefore been decided that the identification marks on rudders are to be entirely eliminated, and the identification marks on the wings are to be of smaller diameter, so that the ailerons and slats are no longer involved. Other identification markings will remain as before.

(iv) Action is being taken to ensure that the spaces so left vacant are not employed for squadron markings after the aeroplanes are delivered.

(v) In designing control surfaces for mass-balance, therefore, it is to be assumed that the weight of paint hitherto involved by identification markings and for squadron markings need no longer be taken into consideration.

(vi) It is pointed out that the aeroplane number will still be painted on the rudder in the location given in S.I.S. No. 4.

### \* 6. Duplication of control circuits

When a servo control surface is fitted the control system must be arranged so that in the event of failure of the servo surface or its attachments, it will be possible to retain some measure of control over the aeroplane by direct operation of the control surface concerned.

### 7. Cables in control systems

(i) Cables in control systems are to be so arranged that they are easy to adjust and easy to replace. Turnbuckles, other adjustment points, fairleads and other points in the circuit which might give difficulty when replacing a cable should be placed in positions where they are readily accessible and visible, an inspection panel being fitted if necessary.

(ii) Where a cable is led round a pulley, joints in the run of the cable may be inserted to facilitate replacement of the portion which travels over the pulley.

(iii) Cables should run as straight as possible. If fairleads have to be used these should be of dry red fibre type.

(iv) The layout of the control system should not involve the splicing of cables in position.

(v) All flying control cables should be proof loaded, after all splicing operations are completed to 50 per cent. of the nominal strength of the cable. Save in exceptional circumstances this should be done before the assembly of the cable in the control system. Where a splice *in situ* cannot be avoided the proof load test must still be applied if practicable.

---

\* Previously A.D.M. 368.

(vi) The effective length of cables should not change during the operation of controls.

(vii) The standard approved method of splicing cables is as shown in S.I.S. No. 3. Alternative methods of splicing may be approved provided that the alternative type of splice is found to be of equal strength.

(viii) Provision is to be made to render mechanically impossible the assembly of control systems with reversed connections. Any suitable and effective method may be used. The following are possible methods.—

- (a) Attachment fittings provided with different sizes of pins.
- (b) Attachment fittings designed to assemble in one position only.
- (c) Lengths of cable and positions of fairleads arranged to make incorrect assembly impossible.
- (d) Use of levers and rods instead of cables.

### 8. Chains in control systems (see also Chapter II, para. 20 A (v))

When chains and sprockets are used in the control system, steps are to be taken to ensure that the chain is guided on to the sprocket and guarded in such manner that it is impossible for the chain to jam or over-ride its sprocket, even when the chain is completely slack. The guards must be so arranged that loose articles such as screws and small nuts inadvertently left in the neighbourhood of the sprocket cannot enter the guard or cause the chain to jam. The guards must be readily detachable for inspection purposes.

### 9. Bearings in control systems

Precautions are to be taken to eliminate slack in control systems. To this end the fit of all bearings must be as close as possible consistent with ease of manipulation of the controls, and the bearing surfaces must be large enough to prevent rapid wear.

### 10. Locking of controls

\* If provision is made for locking the controls of an aeroplane to prevent the control surfaces flapping when the aeroplane is unattended on an aerodrome or at moorings, the locking device is to be arranged so that the pilot cannot sit in his seat and attempt to take off so long as the elevator, rudder and aileron controls are locked. (This requirement does not apply to aeroplanes of the Fleet Air Arm type on which the control surfaces must be locked in accordance with S.I.S.369 when the aeroplane is stowed on deck or on a catapult.) Locking devices must be capable of being stowed away when not in use so that they do not restrict the pilot in any way, and so that they cannot accidentally obstruct the use of the controls. Should it be found necessary to introduce locking devices in the control system to prevent the control surfaces from flapping about during taxiing, it is essential that such locking devices should be kept in operation only by continuous physical effort on the part of the pilot, e.g. by means of a push button on the control column.

### 11. Stability and control of aeroplanes in which automatic controls may be used

(i) In the specifications of certain types of aeroplane provision for fitting automatic controls is called for. In what follows an attempt is made to define as generally as possible the characteristics required of an aeroplane in order to obtain the best results under automatic control compatible with satisfactory manual control. Any such definition must of necessity be tentative until further experience has been obtained of automatic controls in various aeroplanes.

\* Previously A.D.M. 368.

(ii) The requirements may be summarized as.—

(a) an approximation to neutral stability both longitudinally and laterally with controls fixed ;

(b) the dominance of self-centring moments over the friction of the control system.

With regard to (a), an aeroplane possessing these characteristics will be subjected to a minimum initial angular disturbance when the direction of the relative wind is altered either by bumps or by the use of the controls, for example, in turning "flat." Thus the displacement acquired before the automatic controls can apply the necessary corrections will be reduced to a minimum. As regards (b), when an automatic control is working satisfactorily in calm air, minute movements of the servo-motors are taking place. These movements could be accommodated by the stretch of the control cables and the slack in the system without any corresponding movement of the control surfaces if the friction of the system were sufficient to cause the control surfaces to "stick" when displaced. The result would be that the deviation of the aeroplane would increase until the servo-motor movement were sufficient to take up the slack and strain, when the control movement would be excessively large. In this way the aeroplane would be caused to "hunt" instead of settling down in equilibrium with the automatic controls. Satisfactory working depends upon a minute movement of the servo-motor being sufficient to cause a minute movement of the control surface.

#### DESIGN REQUIREMENTS

(iii) The aeroplane should be so designed as to obtain the maximum advantage from the use of automatic controls consistent with safe and easy manual control.

(iv) *Feel*.—All controls should be self-centring when disturbed in flight. This requires that the hinge moment resulting from a displacement of the control surface from its trimming position by not more than  $\frac{1}{4}^\circ$  should be sufficient to overcome the friction in the control system when the normal amount of vibration is present. If this condition is satisfied, the control will have satisfactory "feel" for small movements under manual control. For large control movements the amount of balance required will be determined by the consideration that the aeroplane must be controllable by manual effort.

(v) *Longitudinal stability*.—The aeroplane should be as nearly "neutral" as possible for a condition of normal loading but should not be longitudinally unstable when the C.G. is on the aft permissible limit. These conditions refer to the state of the aeroplane when the elevator control is held fixed. Stability with controls free is not required for automatic control, but the fact that the aeroplane must also be flown under manual control makes it essential that the aeroplane should not be dangerously unstable with the elevators free.

(vi) *Lateral stability*.—The rolling moment due to side-slip should be as small as possible consistent with the consideration that the aeroplane may have to be landed at night under manual control. (Of course from general considerations the aeroplane must not be actually unstable in this respect.) The characteristic is desirable for precision stabilization whether the control is manual or automatic. It is to be expected that reduction of rolling moment due to side-slip will require closer limits to the permissible value of yawing moment due to side-slip with rudder fixed. As for manual control, the yawing moment due to side-slip should be slightly stable (i.e.  $N_V$  positive and small). For automatic control this condition is required only when the rudder is fixed. For manual control it is desirable either that it should hold with the rudder free or alternatively that some means of applying a spring constraint to keep the rudder in the trimming position should be available when the automatic control is not in use. This device must not produce any interference with the smooth operation of the rudder when precision flying is required.

**12. Tail unit control surfaces**

(i) *Divided elevators.*—Sections of elevators in the same plane must be rigidly connected together. No form of indirect linking will be accepted (*see* also para. 4 (vi)).

(ii) *Clearance between rudder and fin.*—The clearance between the rudder and the fin should be sufficient to preclude fouling even though the structure becomes slightly distorted under Service conditions, or as the result of delayed tautening effect of the dope used.

**13. Rudder power**

The rudder power of all landplanes must be at least 10 unless spinning model tests have shown that a particular design is satisfactory with a rudder power smaller than this. Rudder power is defined as.—

$$\text{Rudder power} = \frac{1000 N}{0.002378 S s V^2}$$

where  $N$  = maximum yawing moment (lb. ft.) about  $Z$  (body) axis due to the rudder at aircraft incidence of  $25^\circ$  and at speed  $V$  (lb. ft.).  $N$  is to be measured on a complete model at  $25^\circ$  incidence from zero lift, at zero yaw.

$S$  = area of the wings (sq. ft.).

$s$  = semi-span of the wings (ft.).

$V$  = wind tunnel speed at which  $N$  is measured (ft./sec.).

Certain features of design may make it necessary to provide a greater rudder power than 10. Such features are.—

*Wings.*—Thick section ; monoplane ; stagger less than  $15^\circ$  forward ; gap abnormally small.

*Rudder.*—Where liable to excessive shielding when the aeroplane is stalled.

**14. Wheel brakes** (*see* Chapter III, para. 4)

Wheel brake installations are to comply as far as possible with the following requirements :—

(i) The controls for operating the brakes are to be so designed as to enable the pilot to apply the brakes on the port and starboard sides of the aeroplane in unison and with equal power, or independently of one another for the purpose of steering.

(ii) In cases where aeroplanes are fitted with a tail wheel it is essential that some form of " parking " brake be provided of sufficient strength to hold the aeroplane without the use of wheel chocks for the purpose of running up the engine. On aeroplanes provided with a tail skid a " parking " brake is not regarded as absolutely essential, but it is considered very desirable that it should be provided. The use of tail wheels in lieu of tail skids is generally desirable from the point of view of minimizing damage to aerodrome surfaces, and it is hoped that the general introduction of wheel brakes will enable the use of tail wheels to become more general.

(iii) The action of the brakes must be progressive, that is to say, must increase and decrease in proportion to the force applied by the pilot to the brake control. In particular, the brakes must cease to act instantly with removal of force from the brake control. The sensitivity of the brake control should be such that the pilot is enabled to judge by the force which he is applying how much braking effect he is using, and he should be enabled to arrive at this judgment before the wheel actually touches the ground during the landing manoeuvre.

## CHAPTER IV.—PARAS. 15-16

(iv) The system employed for operating the brakes must be easy to adjust and maintain and must not require frequent attention. Appropriate access must be provided to all parts which require adjustment, maintenance and inspection. From the maintenance point of view the order of preference ascertained in the course of comparative trials was as follows :—

- (a) Oil operation ;
- (b) Pneumatic operation ;
- (c) Cable operation.

(v) The operation of both brakes acting in unison may be controlled by hand or by the feet. If the lay-out is such that operation is by hand, then the time during which the hand has to be removed from the throttle and/or control column to apply or release the brakes must be the minimum possible. In the case of aeroplanes whose aerodynamic controls are so heavy that both hands are needed normally to hold the control column back after landing, any form of hand control used for applying the brakes in unison on landing must be fitted on the control column or wheel. Hand levers used for the purpose of the " parking " brake may be separate from the normal braking control, and the above comments in regard to hand operation need not apply to the control for the " parking " brake.

(vi) For the differential operation of the brakes for the purpose of steering, it is preferred that control should be by the use of the feet direct on the rudder bar. If the controls for the brakes move with the rudder bar, they must be adjustable with it on the general lines in which rudder bars are adjustable to suit pilots of different stature. The use of pedals for controlling the brakes is regarded as generally undesirable, but if they are used it is essential that they should be of ample size and provided with a form of surface which will prevent pilots' feet from slipping. The use of pedals operated by the heel is to be avoided.

(vii) The above guidance relates to the system of control employed for operating the brakes. In addition to this attention is drawn to the fact that arrangements are now in hand for the standardization of brake drums, both as regards diameter and location relative to the centre plane of the wheel. It is, therefore, essential that where standards have already been fixed for brake drums they should be adhered to, and where sizes of wheel are being used for which standard brake drums do not yet exist, consultation with the Air Ministry should be arranged with a view to ascertaining whether a standard is about to be fixed.

### 15. Undercarriage wheels and tail wheels (see also Chapter III, para. 3)

(i) *Main undercarriage wheels.*—Lists of approved wheels together with allowable loads are to be obtained on application to the Airworthiness Department. The lists of approved wheels include tail wheels. The operational load is defined as the weight of the aeroplane fully loaded divided by the number of main undercarriage wheels.

(ii) *Tail wheels.*—The operational load is defined as the load on the tail wheel when the fully loaded aeroplane is at rest on a level surface with the C.G. at the aft limit.

### 16. Castings

Castings may be used in aeroplanes subject to compliance with the following conditions.—

(i) *Class 1 castings.*—Castings used in such a position that a single failure might cause collapse of the structure or loss of control, either in flight or when landing or taking off. The specified ultimate factor for such castings is twice the ultimate factor specified

for the aeroplane as a whole, and every casting must be radiologically examined, as laid down in A.I.D. Inspection Instruction No. M.429 except as may be agreed under paragraph (vi) below.

(Note.—To avoid confusion, a casting which exactly fulfils these conditions should be referred to as having a reserve factor of 1 not 2. See definitions of reserve factor in Chapter I, para. 5.)

(ii) *Class 2 castings.*—Stressed castings used in such a position that a single failure would not cause collapse of the structure or loss of control, either in flight or when landing or taking off. The first castings of a given part from each source of supply are to be radiologically examined, as laid down in A.I.D. Inspection Instruction No. M.429, to prove the suitability of the foundry methods, pattern and alloy. If this radiological examination shows all the castings to be satisfactory, thereafter only 2 per cent. of the castings need be radiologically examined, the balance being subjected to individual visual examination for general condition, as laid down in the Inspection Instruction.

(iii) *Class 3 castings.*—Castings, the strength of which does not contribute to the strength of the primary structure or control system. Such castings will be subjected to individual visual examination only.

(iv) Drawings of castings are to be endorsed to indicate the classification of each casting and the method of inspection agreed, so as to enable the appropriate inspection procedure to be followed.

(v) Subject to the agreement of the Director of Aeronautical Inspection first being obtained, when the castings are such that complete radiological examination presents great difficulty, the "break up" procedure, as detailed in A.I.D. Inspection Instruction No. M.429 may be adopted as an alternative to radiological examination under Class 1 or Class 2 above.

## 17. Welding of steel parts

The following requirements refer to oxy-acetylene welding but proposals to use electric welding will be considered if they are put forward.

### (i) *General requirements*

(a) The welding processes will be carried out to the satisfaction of the Director of Aeronautical Inspection, in accordance with the methods laid down by him.

(b) Welded joints will be permitted only in positions where failure of any one welded joint will not involve the collapse of the structure or cause the pilot to lose control of the aeroplane. This requirement may, subject to the concurrence of the Director of Technical Development, be waived in certain cases of repairs to damaged members, when the nature of the repair provides a considerable margin of strength over the strength of the original undamaged member. Special consideration will also be given to cases in which the area of the weld is large in relation to the load to be carried and the form of the joint is such as to ensure a good weld.

(c) Strength calculations on welded joints are to be based on the minimum strength in the welded and (if applicable) heat-treated condition. If this strength is not given in the specification it must be obtained from material tests. In no case, however, must the strength taken for calculation exceed the minimum specified strength in the unwelded condition.

---

\* Previously A.D.M. 336, issue 2.

## CHAPTER IV.—PARA. 18

(d) Local application of heat is not permissible for heat-treatment purposes. All structures and fittings, etc., shall be heat-treated after welding except in the following three cases.—

*Case 1.*—Where the drawings state that heat-treatment can be omitted, provided that the drawings have been approved by the Director of Technical Development. Such approval will only be granted when both.

1. It is considered that the design of the part renders heat-treatment impracticable, and

2. The part is made from steel to one of the following specifications.—

Sheets and strips ..	S.3, D.T.D.12, D.T.D.124, D.T.D.141.
Tubes .. .. .	T.26, T.35, T.45, D.T.D.41, D.T.D.178.
Bars .. .. .	S.21, D.T.D.126.

*Case 2.*—Where the parts have been made from non-corrodible steels to Specifications D.T.D.171, 176 and 207.

*Case 3.*—Parts made from non-corrodible steel to Specification D.T.D.166 which have been edge or spot-welded (the strength of the steel in the vicinity of the weld will be reduced to that of steel to Specification D.T.D.171).

(e) Where the part is to be heat-treated after welding, any aircraft steel to a British Standard or D.T.D. Specification may be used, provided that the approval of the Director of Technical Development is obtained if the steel is not to one of the specifications quoted in sub-para. (d) above.

(ii) *Welding rods, etc.*

(a) All the steels mentioned in sub-para. (ii) (d) *Case 1* must be welded with iron or mild steel wire to Specification D.T.D.82 or with a rod or strip of approximately the same composition as the material being welded.

(b) Non-corrodible steels must be welded with rods or strips of approximately the same composition as the material being welded, or with rods to Specification No. D.T.D.61.

### 18. Streamline wires and tie rods

(i) *Precautions to minimize breakage.*—Compliance with the following recommendations, which will reduce the probability of these wires breaking in extended service, is to be satisfied.—

(a) Avoid values of length/diameter ratios in streamline wires greater than 400. Length is defined as the "A" length in B.S. specifications, irrespective of intermediate support such as by means of an acorn. Diameter is the diameter of the rod used for making the streamline wire, referred to in B.S. Specification 5.W.3 as "size of wire" or "size".

(b) Provide centre anchorages for streamline wires wherever possible. The anchorage should be such as to prevent both torsional and flexural movement.

(c) Avoid designs of end fitting which give fixation greater than that of the standard fork end.

(d) Avoid structural arrangements in which normal deformations may impose bending loads near the ends of a streamline wire or tie rod, e.g., ample clearance should be provided if the wire passes through a hole in a bulkhead near the end of the wire.

(ii) In order to reduce the number of different sizes of fork ends which have to be stocked, only the following sizes of streamline wires and tie rods to B.S. Specifications 5.W.3 and 5.W.8 are to be used in future in new aeroplane designs.—

4 B.A., 2 B.A., 8/32, 10/32, 12/32.....

(even sizes expressed as thirty-seconds).

(iii) *Lock-nuts*

(a) For streamline wires and tie rods not made of stainless steel, brass or cast-iron lock-nuts only are to be used. On seaplanes, ship-planes and amphibians brass lock-nuts only (A.G.S. 672 and 673) are to be used.

(b) For stainless steel streamline wires and tie rods stainless steel standard thin lock-nuts to B.S.I. Specification 4 A.1 are to be used.

### 19. Flattening of ends of tubes for the purpose of attachment

When the ends of tubes are flattened a liner tube must first be inserted, the liner having a serrated inner end and a length of three diameters of the containing tube. The gauge of the liner must be less than that of the original tube. The complete flattened end should be made solid by approved methods (brazing, sweating, etc.).

### 20. Sweating and drilling steel tubing to B.S. Specification T.2

The strength of tubes to this specification is considerably reduced by sweating and by drilling. If sweated-on fittings cannot be avoided the temperature during sweating operations is to be controlled pyrometrically, and must not be allowed to exceed 220° C. This requirement is to be complied with both when the tubes are used as received and when they are heat-treated to give a lower tensile strength.

### 21. Use of 4 B.A. bolts

(i) Attention is drawn to the risk involved by the use of 4 B.A. bolts where the removal of the nuts is likely to be necessary for maintenance operations, in that they are liable to be stripped or over-strained in tightening up.

(ii) In this connection it should be borne in mind that maintenance work must often be done by the service in unfavourable conditions, particularly when on active service.

(iii) The use of 4 B.A. bolts and nuts must therefore be avoided where failure due to stripping or overstraining would lead to serious results.

### 22. Use of even sizes of B.A. screws

With a view to keeping down superfluous stocks as much as possible, only even sizes of B.A. screws, as listed in the relevant A.G.S. sheets should be employed.

### † 23. Use of tab washers

The use of tab washers is to be avoided in the construction of aeroplanes in any place where their failure to lock a bolt securely would lead to the development of structural failure, or to the controls failing to function in the air.

### 24. Design of wiring lugs

(i) Experience has shown that wiring lugs as in fig. 1 are unsatisfactory. The thickness of the sheet and the stiffness of the bolt are generally insufficient to prevent concentration of the load at the ends of the lug as at *aa*, with the result that a crack is

\* Previously A.D.M. 334.

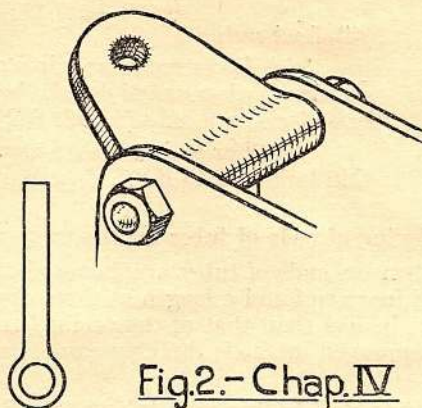
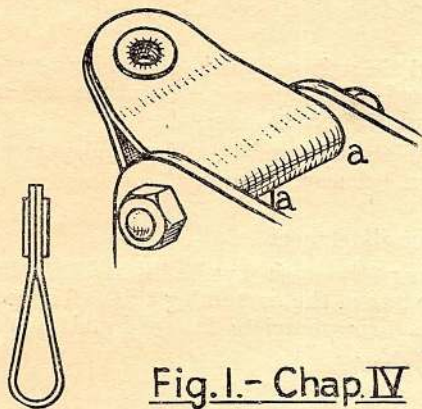
† Previously A.D.M. 237.

**PTER IV.—PARAS. 25-27**

*Amended by A.L. No. 3*

started which gradually travels from end to end. It is preferable that such lugs should be made from forgings as in fig. 2.

(ii) It is also important in all fittings that sharp corners and rough tool marks should be avoided, as cracks are likely to start from stress concentration at such places.



**\* 25. Lugs for external wire bracing**

To reduce the risk of fatigue failures of external bracing wires or attachments which are under tension during the greater proportion of the time in flight, the thickness of the wiring lug is to be such that there is a clearance between the lug and the jaws of the fork-end fitting and the hole in the lug is to provide a loose fit for the pin.

It is not possible to state the minimum clearances necessary to eliminate such failures but, in general, the requisite slight freedom of the lug in the fork will be obtained if the clearance in the jaws is not less than 2 per cent. of the width between them and if the clearance for the pin in the hole is not less than 2 per cent. of the pin diameter.

For external bracing wires which are slack during the greater proportion of the time in flight, serious elongation of the hole in the wiring lug may occur if too much clearance is provided for the pin. The hole, therefore, is to be no larger than that required for assembly purposes and excessive vibration of these wires is to be prevented by the use of spreaders or by other suitable means.

**† 26. Sections of aeroplane metal parts (produced from hot-formed sections or forgings)**

Sharp-cornered sections are unsuitable in aeroplane structural parts (whether rolled, drawn extruded or machined) which have to carry any appreciable bending or torsional stress. All such parts should have fillets of a reasonable size. In general, the inner radius of a fillet should not be less than one-fifth of the thickness of the flange or web (whichever is the thicker) at the corner.

**27. High-tensile steel fittings**

(i) The edges of all holes should be given a small radius, and buffing all over is recommended as a final finish.

(ii) Although certain high-tensile steels may be welded, great care is required and complicated fittings involving difficult welds should be avoided in these steels.

(iii) The position for identification markings and inspector's stamps must be indicated in the drawings of structural parts.

\* **28. Bending of aluminium alloy sheets and strips** (applicable to material to B.S. Specifications 4.L.3. and L.38 and D.T.D.270 and 275)

Attention is directed to the necessity for the employment of suitable radii in bending and forming operations on aluminium alloy sheets and strips, and it is notified that the radii specified below are the minima that can be accepted for the manufacture of aeroplane parts and fittings.

Condition	Minimum radius			
	Angle of bend. 18 s.w.g. and thinner		Angle of bend. Thicker than 18 s.w.g.	
	Through 120° or less	Over 120°	Through 120° or less	Over 120°
Fully annealed .. ..	0.5T	1T	0.5T	1T
Finally heat treated and within one hour of quenching	0.5T	1.5T	1.5T	2T
Finally heat treated and aged	2T	3T	2.5T	3T

In the above table T = thickness of sheet or strip.

(Note.—The minimum radii specified above apply to the tools over which the light alloy strips or sheets are bent, and not to the dimensions of the finished plating.)

† **29. Permissible bow in light alloy tubing for use in aeroplane structures**

(i) When light alloy tubing is used in compression in the primary structure or control system of aeroplanes the departure from straightness is not to exceed  $\frac{L}{600}$ .

(ii) Two classes of straightness will be included in future issues of specifications for light alloy tubing of  $\frac{3}{4}$  in. outside diameter and over. These will be.—

Class "A" with a departure from straightness not exceeding  $\frac{L}{600}$  and

Class "B" with limits of straightness to be agreed between the purchaser and the manufacturer.

(iii) For parts under para. (i) above, made of tubing of  $\frac{3}{4}$  in. outside diameter or over, the drawing schedule should call for material to Class "A" straightness. For parts made of tubing less than  $\frac{3}{4}$  in. outside diameter, the limit of departure from straightness,  $\frac{L}{600}$ , should be given in the detail drawing.

(iv) When Class "A" straightness is required for tubing to existing specifications the order should be marked accordingly until such time as the specifications are revised to include the straightness clause.

\* Previously A.D.M. 338.

† Previously A.D.M. 344.

## CHAPTER IV.—PARAS. 30-35

*Amended by A.L. No. 3*

### \* 30. Corrosion of bolts to B.S. Specifications S.61 and S.62 in wooden members subject to wetting in service

It has been found in practice that bolts made of material to the above Specifications have been seriously weakened by corrosion in places where they pass through wooden members which are liable to become wet in use, as for example, the spars of the lower main plane and the tail plane spars of flying boats and seaplanes. For this reason, S.61 and S.62 material should not be used for bolts and other parts in contact with wood on flying boats and seaplanes. S.80 is a suitable material for such use. A.G.S. parts 868 and 869 (bolts) and A.G.S. parts 863-877 inclusive (nuts) are the current parts which should be called for on aeroplane drawings.

### 31. Collars for high-tensile steel pins

Where high-tensile steel pins (A.G.S. 383 and 384) are used to connect actuating levers and control rods or cables, the rotary movement sometimes causes excessive wear on the small diameter split pin securing the high-tensile pin in position. Provision is to be made to prevent this and an approved method is to fit a small duralumin collar (A.G.S.674) over the end of the high-tensile pin and insert the split pin through the hole already drilled in the collar.

### 32. Provision of longitudinal datum marks

Aeroplanes are to be provided with datum marks complying with S.I.S. No. 36 for checking the longitudinal rigging position.

### 33. Safe limit of deterioration of shock absorber legs

Shock absorber legs are to be provided with a gauge or mark to indicate when the safe limit of low air pressure and/or deterioration of the rubbers has been reached.

### 34. Securing of windscreens (*see* also Chapter II, para. 27)

(i) Adequate precautions are to be taken to secure the glass firmly in windscreen frames by positive locking methods.

(ii) In windows or windscreens of transparent material such as cellastoid, rhodoid, etc., secured by riveting in a metal frame, it is very important to ensure that sufficient clearance is provided to permit the material to contract freely at the low temperatures reached in flight. This clearance should be provided both at the rivet and bolt holes and also between the edges of the transparent panel and its frame, or alternatively between adjacent panels. The provision for securing the edges of the panels should be such that when contraction or expansion due to changes of temperature takes place the panels are free to adjust themselves. The clearance allowed for holes, edges, etc., should be of the order of  $\frac{1}{2}$  per cent. of the linear dimensions of the panel.

(iii) If it is essential that the joints between the panel and its frame should be water-tight, it may be necessary to provide some form of flexible packing at the joints.

(iv) It is pointed out that failures have occurred during flight due to clearance not being provided at the point of attachment and it is also to be anticipated that failure to allow for temperature effects on the material will result in the surface deforming with consequent impairment of visibility. The drawings of such parts should be dimensioned and noted so as to ensure that the necessary clearances are provided.

### 35. Fasteners for cowling and inspection doors

These fasteners must give clear indication whether they are in the locked or free position. As far as possible all fasteners should be arranged to lock with the slot in the direction of flight.

\* Previously A.D.M. 206.

**36. Compression shakes in spruce rib flanges**

Compression shakes which have not passed the neutral axis of the flange and which occur in that part of the flange in the forward two-thirds of the distance between the leading edge and the front spar, may be allowed in ribs where the flange is reinforced by a three-ply or solid spruce web. In cases where the flange is not suitably supported, compression shakes cannot be allowed.

**37. Use of duralumin tubes and sheet thinner than 22 gauge (.025 in. and .028 in.—see Chapter VIII, Section I, para. 4)**

Main structural members of duralumin such as struts and spars are not to be made of material thinner than 22 gauge. This does not apply to.—

- (a) seamless circular tubes less than  $2\frac{1}{2}$  in. outer diameter used in positions where they are protected from handling loads (e.g. inside a main plane) ;
- (b) stiffeners, diaphragms and webs of spars ;
- (c) the skin and stiffeners of monocoque construction ;
- (d) ribs, trailing edge tubes, etc. ;
- (e) wing slats.

**38. Provision for ballast (see Chapter III, para. 19)**

- (i) Provision for ballast should be made in the early stages of design.
- (ii) Provision is to be made for carrying sufficient ballast to trim the aeroplane if necessary when any items of removable equipment or members of the crew are omitted from the load.
- (iii) On aeroplanes destined primarily for overseas, provision is to be made for carrying ballast in a neutral position where it does not affect the trim so that it may be available for trim if required at a later stage of the flight.
- (iv) If the ballast is carried internally the stowage is to be at the extreme rear of the fuselage or forward of the foremost member of the crew actually carried when the ballast is in position.

**39. Use of parallel pins**

Solid parallel rivets which are unsupported for the major portion of their length, such as through thin tubes, are not to be used where it is possible to use taper pins in reamed holes. When solid parallel pins are essential to the design, then the length/diameter of the unsupported portion should not exceed 4. This restriction is necessary because the strength of the joint depends upon the pin tightly filling the hole and it is not always possible to ensure by inspection that the riveting of parallel pins has produced the required result.

**40. Attachment of wireless aerials (fixed and trailing)**

(i) To determine the necessary strength for those parts of an aeroplane structure which support a fixed or trailing aerial, tensions will be assumed in the aerial wires producing an aerial load of such magnitude that the breaking strength of the weakest part of the aerial system is just reached. Parts of the airframe which are affected by any of the standard stressing cases must be so designed that the superposition of the aerial load upon the full factored aerodynamic load for the relevant stressing case does not bring the structure below the minimum requirements.

(ii) If welding is used for securing aerial attachments to the airframe, the attachments and the form of the weld are to be such as will give an ample margin of safety against vibration fractures.

## CHAPTER IV.—PARA. 41

### 41. Retractable undercarriages

#### A.—GENERAL REQUIREMENTS

##### (i) *Indicators*

(a) A visible indicator is to be provided showing the pilot when the undercarriage is in the safe landing position and when it is in the safe retracted position. It need not indicate intermediate positions.

(b) If the indicator is electrical, the making, not the breaking, of a circuit is to indicate that the undercarriage is in position for landing. Preferably a green light should show all the time the undercarriage is in the safe landing position\*, and a red light when the undercarriage is in the safe retracted position.

(c) The indicator is to show whether the locks (if any) which hold the undercarriage in the safe landing position have gone home. When locks are fitted the indicator must be operated by the locks themselves. The locks must not operate the indicator until they are fully home.

(d) An audible or specially prominent visible indicator must be fitted in addition to and independent of the visible indicator referred to in sub-para. (a), (b) and (c) above. This additional warning device is to be arranged to indicate danger to the pilot if he attempts to land with the undercarriage in an unsafe position for landing. It may be arranged to be brought into action by any of the following—(i) air-speed indicator, (ii) air speed, (iii) incidence, (iv) landing flaps, (v) engine r.p.m. The arrangement should give the maximum possible certainty of the warning device operating in time to prevent a landing with the undercarriage in an unsafe position, while at the same time the device should not be brought into action during ordinary flight manœuvres. The provisions of this sub-para. (d) do not apply to amphibians.

(e) If the indicator of sub-paras. (a), (b) and (c) and the emergency indicator of sub-para. (d) are both electrically operated, the two systems are to have separate and independent fuses, or alternatively some equivalent safeguard is to be provided to minimize the possibility of both warning systems breaking down together.

*Note.*—An earth return through the frame or bonding system is not permitted. Insulated cable must be used for both positive and negative leads.

##### (ii) *Operating gear*

(a) Provision is to be made on hydraulically operated gears for lowering the undercarriage and locking it in the landing position in the event of a burst pipe or failure of a mechanically-operated pump.

(b) Provision is to be made on electrically-operated gears for lowering the undercarriage and locking it in the landing position in the event of a breakdown of the electrical motor or electricity supply.

(c) Precautions are to be taken to prevent damage, due to overwinding at both ends of the travel. If hand operated, it must be impossible for the operator to damage any portion of the mechanism if he exerts his full strength to overwind the gear.

(d) Unequal lowering of the two sides must be capable of being corrected by continuing to operate the lowering gear until both sides are fully down.

---

\* The switch needed to prevent the green light burning all the time the aeroplane is on the ground should be interconnected to the engine switch so that switching *on* the engine also switches on the green light while switching *off* the engine does not break the green light circuit. Equivalent alternative arrangements will be considered.

(iii) *Locking*

(a) Positive locks are to be provided to hold the undercarriage in the landing position. A dead centre mechanism will not, in general, be accepted without locks as an additional safeguard. An irreversible worm gear will in general be accepted as complying with this sub-paragraph.

(b) If locks are provided to fix the undercarriage in the up position, precautions are to be taken to prevent the lock seizing up (e.g. due to mud, rust or flight deflections) and so making it impossible to lower the undercarriage. In addition to the normal means provided for operating such locks, a second emergency method of opening or breaking the locks must be provided. This emergency method must be capable of applying to the lock mechanism a force much greater than is necessary for normal operation of the locks.

(c) The locking mechanisms securing the undercarriage in the up position and in the down position are to be such that effective inspection of their mechanical condition can be carried out by service personnel without a large amount of dismantling.

(iv) *Strength*

(a) When locked ready for landing, a retractable undercarriage is to comply with all the requirements applicable to a fixed undercarriage.

(b) The shock absorber leg must be capable of functioning satisfactorily if lowered quickly immediately before the aeroplane makes contact with the ground.

(c) In both the open and the retracted positions the undercarriage and mechanism are to have the factors specified for the aeroplane under all loads (e.g. acceleration loads) that may arise in flight. In any intermediate position the factors should be at least one-half those specified for flight loads.

B.—TESTS

New designs of retractable undercarriages and/or operating gears fitted on new experimental aeroplanes or on existing types are to be tested as follows.—

(i) *Static tests prior to taxiing trials*

(a) Jack the aeroplane off the ground with the jacks so placed as to deflect that part of the wing affecting the operation of the undercarriage to an extent comparable to the deflection in steady level flight at cruising speed when fully loaded. Raise and lower the undercarriage twenty-five times, locking it in the extended and retracted positions; if locks are fitted in the retracted position these are to be released by the emergency method twice during the course of the test. The emergency device may be reset after each operation.

(b) Repeat test (a) with weight of wheels reduced to 80 per cent. of their normal weight.

(c) Repeat tests (a) with the wheels loaded so that

1. for 90 per cent. of the full movement of the retractable undercarriage (starting from the extended position) the wheels weigh 1.33 times their normal weight and

2. for the last 10 per cent. movement the wheels weigh twice their normal weight.

\* Previously amendment No. 1 to A.D.M. 321.

† Previously corrigendum No. 2 to A.D.M. 322.

## CHAPTER IV.—PARA. 41

(d) Repeat test (a) with a load representing twice the air drag on wheels and undercarriage appropriate to flight at a speed equal to twice the stalling speed with flaps normal. If it is found to be impracticable to arrange the test rig to permit full retraction of the undercarriage with the load in place, partial retraction is permissible, but the loading system should be devised to allow the greatest possible range of retracting movement.

(e) If the retracting gear is hydraulically or pneumatically operated it is to be proved by test that in the event of a pump or pipe failure the undercarriage may be lowered to the extended position and locked there.

(f) If operated by electric power a similar demonstration to that required under (e) is required to prove satisfactory operation in the event of breakdown in the electrical system.

### (g) Notes

1. During tests (a) to (d) inclusive the operator should ensure that the undercarriage is hard against its stops at the limiting positions, using the full available force to effect this. The locking device in the retracted position should be examined under each test condition to ascertain the adequacy of the locking, taking into account possible structural deflections in accelerated flight.

2. It is of great importance that special care should be taken to support the aeroplane in such a way that excessive loads are not imposed on the aeroplane structure. If the presence of the skin is not essential during the tests, it is preferable that the tests should be made before the covering is applied. This would enable a thorough inspection to be made after the tests.

3. If the prime mover for the undercarriage is the engine, some other prime mover (e.g. an electric motor) is to be provided for the static tests of sub-para. (i) to avoid having to run the engine with the aeroplane jacked up.

(ii) *Taxying trials.*—Taxying trials, as follows, are to be made prior to actual flight.

(a) *Aeroplane at light load* (tare weight plus reasonable fuel, oil, ballast and crew).—

1. Run engine(s) against chocks, brakes off, to full ground r.p.m.
2. Run engine(s) against brakes, no chocks, to full ground r.p.m. or until brakes or wheels slip.
3. Make straight runs tail up and tail down, three in each attitude, to  $\frac{3}{4}$  stalling speed (I.A.S., flaps not in use). Bring aeroplane to rest by progressively harsh use of brakes on successive runs.
4. Turn aeroplane port and starboard with one wheel locked by the brakes, three complete turns, each way, raising the speed in the turn progressively, to a reasonable maximum in the final turn.

(b) *Aeroplane fully loaded.*—

Repeat tests under 3 and 4 above.

*Note.*—Flight trials at light load are permitted between the series of taxying trials under (a) and (b) above.

**\* 42. Undercarriage springing characteristics**

Comparative tests show that undercarriages vary considerably in their landing and taxiing qualities. It is not possible to specify quantitatively all the features which make for a satisfactory undercarriage but tests on service aeroplanes indicate that particular attention should be paid to the following.—

(i) *Track*.—The undercarriage track should be as wide as possible.

(ii) *Taxying*.—To obtain good springing when taxiing the travel of the oleo from the static position (i.e. the position when the aeroplane is at rest on the ground) to that corresponding to  $3W$  should be large. This, however, will make the aeroplane roll badly unless the undercarriage track is wide, hence the importance of (i).

(iii) *Rebound*.—In order to reduce the tendency to rebound on landing, rebound damping must be provided. A good working rule is to provide sufficient damping to reduce the velocity of opening to not more than half the velocity of closing when the oleo is tested under conditions representing the specified vertical velocity of descent.

**43. Torsional stiffness of ailerons**

(i) *Ailerons with distributed mass-balance* (see definition in sub-para. (iii)).—The value of the torsional criterion

$$\frac{1}{VS_a} \sqrt{Ts'}$$

is not to be less than 0.010.

(ii) *All other ailerons*.—The value of the torsional criterion

$$\frac{1}{VS_a} \sqrt{Ts'}$$

is not to be less than 0.018, and in addition special care is to be taken to avoid material changes of aileron torsional stiffness along the aileron span.

**(iii) Definitions**

$T$  = aileron torsional stiffness estimated as described in (iv) or (v) below (pounds-feet per radian twist).

$S_a$  = area of that portion of the aileron which is aft of the hinge line (square feet).

$s'$  = overall span of aileron measured parallel to the aileron hinge line (feet).

$V$  = maximum indicated air speed to which the aeroplane is required to be dived during contractor's trials (feet per second).

The strict theoretical implication of "distributed mass-balance" is that each fore-and-aft cross section of the aileron is mass-balanced in that same cross section. While this is the thing to aim at it will sometimes be inconvenient to provide mass-balance in this way. For the present purpose, therefore, an aileron will be deemed to have distributed mass-balance provided that if the aileron were divided into two parts by a cut through its mid-span at right angles to its hinge line, each half would itself be separately mass-balanced when in its correct relative position on the aeroplane. This approximate rule only applies provided that mass-balance is not effected by means of a concentrated weight at the mid-span of the complete aileron, nor by two concentrated masses each at the inner end of its respective half aileron.

\* Previously A.D.M. 246.

## CHAPTER IV.—PARA. 44

(iv) Let  $aa$  and  $bb$  be two cross sections at right angles to the hinge line of the aileron distant respectively  $0.1 s'$  from the inner and outer ends of the aileron. Hold the aileron rigidly at  $aa$  and apply a couple at  $bb$ . Then  $T$  is the torque required to produce one radian twist, assuming a linear stress-strain relationship. If the aileron is fabric covered,  $T$  is to be measured or estimated with the fabric removed. It will usually be necessary to estimate  $T$  by a mechanical test. For this purpose the aileron should be detached from the aeroplane and wooden frames fitted round its section at positions  $aa$  and  $bb$ . The aileron should then be slung from its hinges in a vertical plane with its hinge line horizontal and one frame fixed whilst the other is left free to rotate with as little restraint as possible from the slinging cables or cords. By applying incrementally increasing twisting couples  $C_1, C_2, \dots$  to the free frame and measuring the resulting twists  $\theta_1, \theta_2, \dots$  between the sections  $aa$  and  $bb$ , and plotting, the average value of  $C/\theta = T$  may be obtained. In applying these couples care should be taken to avoid causing any damage or permanent strain to the aileron. Owing to the presence of a control lever or a mass-balance arm, or for some structural reason, it may not in some cases be practicable to apply the couples and measure the twists at the exact positions  $aa$  and  $bb$ . In such cases the couples should be applied outside rather than inside the ideal sections and an additional twist measurement made at a section near the mid-span of the aileron. The measurements should then be corrected to give the value of  $T$  by plotting twist against aileron span and interpolating for the twist between the ideal sections.

(v) A mechanical test will be unnecessary on an aileron whose torsional stiffness is primarily given by an aileron spar of known torsional properties (e.g. a circular metal tube), provided that  $T$  is taken as the calculated torsional stiffness of this spar itself without any additional allowance for ribs, leading and trailing edges, etc.

### 44. Torsional stiffness of elevators

(i) The overall torsional stiffness of an elevator shall be such that the value of the criterion

$$\frac{1}{V S_e} \sqrt{T s''}$$

is not less than 0.010.

(ii) In the above criterion

$T$  = elevator torsional stiffness (pounds-feet per radian twist).

$S_e$  = area of that portion of the elevator (comprising all sections in the same plane) which is aft of the hinge line (square feet).

$s''$  = overall span of elevator, including all sections in the same plane (feet).

$V$  = maximum indicated air speed to which the aeroplane is required to be dived during contractor's trials (feet per second).

(iii)  $T$  should be obtained in a manner similar to that described for ailerons in para. 43 (iv) above, the two sections  $aa$  and  $bb$  being taken at distances  $0.1 s''$  from the extreme port and starboard tips. Calculation may be used if the conditions of para. 43 (v) apply and if any interconnection fittings present in the elevator unit have well-known torsional properties.

## \* 45. Repairs to mass-balanced surfaces (ailerons and rudders)

(i) In all future designs allowance must be made for the effect of repairs on mass-balance. This will in general necessitate a slight increase of the balance weight above that previously required, but care should be taken to see that repairs are so designed as to involve as little increase of weight as possible.

(ii) On all future designs the aileron and rudder mass-balance requirements of this chapter, paras. 2 and 4 are to be complied with when *three* typical repair patches have been applied to the control surface so placed as to have the most adverse effect upon mass-balance. In fabric covered surfaces the additional weight due to the patched fabric is to be included. Alternatively, a simple means of correcting the mass-balance is to be provided in the repair scheme as a part of the instructions for repair of the control surfaces.

(iii) If provision is made for trimming an aileron by doping cord along its trailing edge, or by some equivalent method, the most adverse arrangement of such trimming device is to be taken into account when complying with the aileron mass-balance requirement.

## † 46. Ground clearance

The ground clearance for airscrews, elevators, fins and rudders must not be less than the following.—

(i) *Airscrews*

(a) Aeroplane resting on the ground (tail down), tyres normally inflated and the undercarriage and tyres compressed corresponding to 3g. . . . . 9 in.

(b) Aeroplane resting on the ground, tyres normally inflated with the thrust line horizontal and under carriage and tyres compressed corresponding to 3g. . . . . 3½ in.

When the thrust line is abnormally tilted, allowance for this will be made in determining the attitude of the aeroplane at which this airscrew clearance is to be measured.

(ii) *Elevators (fully down), fins and rudders*

(c) Tail at rest on the ground with tail wheel and its shock absorber compressed corresponding to 3g. . . . . 6 in.

## ‡ 47. Hand and foot holes in airframes

In designing hand and foot holes in airframes it is necessary to ensure that the flap or similar device to prevent ingress of foreign matter is arranged to operate in such a way that there is no possibility of the hand or foot being grazed or jammed on withdrawal in any position. Metal flaps with a spring hinge should have sufficient overhang to ensure that the outer edge is never in contact with the fingers, and this edge should be beaded or otherwise arranged so as to run smoothly over a boot.

## § 48. Buoyancy of engines in estimating buoyancy of aeroplanes

In estimating the buoyancy to be provided by emergency flotation gear, the buoyancy of the engine complete with airscrew hub, exhaust system and accessories is to be based on a mean specific gravity of 5·25, no allowance being made for air spaces within the engine, exhaust system or accessories.

\* Previously A.D.M. 305.

† Previously A.D.M. 362.  
‡ Previously A.D.M. 265.

‡ Previously A.D.M. 272.

**\* 49. Protection of aeroplane cowlings and structure from gun blast**

Experience has shown that the blast from fixed guns causes damage of various kinds to those parts of the aeroplane adjacent to the gun muzzle and immediately in front of it. For example, the gun blast tends to lift up the cowling joints in the gun tunnel when these face aft. Damage occurs consequent on the panting of insufficiently supported surfaces, rivets working loose and rivet heads being removed by wads at breaks or joins in the surfaces ahead of the gun muzzle.

**DESIGN RECOMMENDATIONS**

(i) Where guns are mounted in tunnels or grooves, the plating should be sufficiently stiff to avoid panting, and joints should be avoided between a point aft of the muzzle attachment to a point 2 ft. ahead of the muzzle attachment. The top and bottom edges should be lapped over the edges of the adjacent cowling. Grooves and tunnels of 22 s.w.g. steel to B.S. Specification S.3 have in general been found satisfactory.

(ii) If lap joints are used in the cowling joints of the gun tunnel these joints should face forward. Consideration should be given to the use of butt joints.

(iii) Where the gun muzzle is not housed in a tunnel or groove the surface adjacent to and immediately forward of the muzzle should be adequately supported to avoid panting.

(iv) Use of rivets should be avoided as far as possible immediately in front of the gun muzzle. Where rivets are essential they should be flush with the surface exposed to blast.

**† 50. Closed structures (provision for internal inspection and removal of riveting pin or mandrel heads)**

(i) In closed structures such as stressed skin wings, large box spars, etc., in which the form of construction is such that the satisfactory completion of assembly processes cannot be seen by external inspection alone, the design must provide for internal inspection both during manufacture and in the final inspection, and must provide for the removal of dropped rivets, rivet mandrel heads, clips, bolts and nuts, tools and other loose articles which may have been left in the component during assembly.

(ii) In any portion of the structure containing moving mechanism, such as parts of the control system, a means of ensuring the complete absence of loose articles such as those mentioned above is to be provided, and means of inspection for the presence and removal of any items such as rivet mandrel heads, which may become free during subsequent use, must be arranged.

(iii) Any closed part of the structure to which ready access is not provided and which is liable to contain the broken off heads of rivet mandrels used in its construction or final closing, must be sealed to prevent these heads from gaining access to parts containing controls, unless the pin heads are of the type specially formed to remain secure in the rivets, and approved as such by D.T.D.

**† 51. Emergency exits in aeroplanes**

(i) All aeroplanes are to have easy means of exit for all occupants under the following conditions.—

(a) Emergency exit by parachute in the air.

(b) Emergency exit on ground from an overturned aeroplane.

(c) With the aeroplane floating in the water after an emergency landing at sea (this only applies to aeroplanes with flotation gear).

(d) Emergency exit on ground from an aeroplane which has landed with the undercarriage retracted.

\* Previously A.D.M. 179 and 300.

† Previously A.D.M. 348.

‡ Previously A.D.M. 361.

(ii) It is appreciated that standardized requirements cannot be expected to meet every case, but the following detailed requirements should be complied with as far as possible.—

(a) All enclosed aeroplanes are to have one or more easily breakable or opening windows, large enough for a man wearing a parachute to get through easily. Sliding roofs or opening windows which may make satisfactory parachute exits must not be counted as emergency crash exits in the number required by (g) below unless their design is of such a type that, when opened, satisfactory exit is possible from an aeroplane which is overturned on the ground.

In such cases the sliding roof may be assumed to have been opened before the aeroplane overturned, if the roof when opened is secured from sliding forward.

(b) All aeroplanes must be provided with conveniently placed handgrips, supports, etc., to assist the occupants to extricate themselves from the machine whilst experiencing accelerations (e.g. in a spin).

(c) Doors counted as parachute exits, except where they are of the type which can be completely jettisoned, should open inwards.

(d) Exit from enclosed turrets should be either direct or through an exit accessible and adjacent to the turret.

(e) All doors are to be fitted with positive locks and independent safety catches.

(f) Emergency parachute exits must be situated so as to minimize the risk of the persons using them colliding with the tail or other parts of the aeroplane.

(g) Enclosed compartments are to be provided with exits from each compartment at the rate of at least one for every four occupants, to meet all cases of emergency on the ground and water as shown in sub-para. (i) above.

No. of occupants in the compartments	No. of exits to meet each emergency under (a), (b), (c) and (d) of sub-para. (i) above
4 or less .. .. .	1
5 to 8 inclusive .. .. .	2
9 to 12 inclusive .. .. .	3
Over 12 .. .. .	4

(iii) Where hoods, for blind-flying practice, or sunblinds are provided in cabin tops that have exits for use in emergency, the operating mechanism of the blind or hood must be such that, when the cabin top is opened, the sunblind or hood is automatically furled or folded out of the way so that it cannot prevent easy exit with parachute.

The following information was obtained from a review of the records of the Department of Defense concerning the activities of the [redacted] during the period [redacted].

[redacted] was born on [redacted] at [redacted]. He is a [redacted] and has been a resident of [redacted] since [redacted]. He is currently employed as a [redacted] at [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

[redacted] has been a member of the [redacted] since [redacted]. He has also been a member of the [redacted] and the [redacted]. He has been active in the [redacted] and has served as a [redacted] in the [redacted].

6th, September, 1939.

CLASS I CASTINGS.

The following remarks concern the interpretation of the requirements for Class I Castings as given in A.P. 970, Chapter IV, Paragraph 16 (1).

Proof Strength:

The requirement that a Class I Casting must be capable of withstanding twice the fully factored loads applied to the aeroplane as a whole concerns ultimate failure and is not applicable to proof failure.

It is, however, considered essential that a Class I Casting should be capable of withstanding the fully factored loads applied to the aeroplane as a whole (as distinct from three quarters of them), without appreciable yield.

Test Factor:

Subject to the above conditions being satisfied it will not be necessary to increase the loads for test purposes merely to cover variation from standard dimensions and material specification, i.e., the 20% margin for test is not required.

Extended Definition of Class I Castings.

Class I Castings will in future include not only those castings whose failure might lead to collapse of the structure or loss of control, but also those castings whose failure might lead to release of a bomb.

(Please send your copy of A.P. 970 as ~~is~~ above)

23 September 1938

CLASS I CASTINGS

The following remarks concern the interpretation of the requirements for Class I Castings as given in A.P. 270

Proof Strength

The requirement that a Class I Casting must be capable of withstanding twice the fully loaded load applied to the component as a whole concerns directly the casting and not the component to which it is attached.

It is, however, essential that a Class I Casting should be capable of withstanding the fully loaded load applied to the component as a whole (as defined in three quarters of them), without appreciable strain.

Test Factor

Subject to the above conditions being satisfied it will not be necessary to increase the load for test purposes merely to cover variation from standard dimensions and material specifications, i.e. the 20% margin for test is not required.

Excluded Definition of Class I Castings

Class I Castings will in future include not only those castings which fail to meet the above requirements of proof strength or load of control, but also those castings which fail to meet the above requirements of test.

(Please send your copy of A.P. 270 as above)

This file was downloaded  
from the RTFM Library.  
Link: [www.scottbouch.com/rtfm](http://www.scottbouch.com/rtfm)  
Please see site for usage terms,  
and more aircraft documents.

