REPORT No. 25.

NOMENCLATURE FOR AERONAUTICS.

By the National Advisory Committee for Aeronautics.

INTRODUCTION.

The following nomenclature was adopted by the National Advisory Committee for Aeronautics at its annual meeting October 10, 1918.

The purpose of its adoption and publication is to help secure uniformity in the official documents of the Government as well as in the technical journals.

AERONAUTICAL NOMENCLATURE.

AEROFOIL: A winglike structure, flat or curved, designed to obtain reaction upon its surfaces from the air through which it moves.

AEROFOIL SECTION: A section of an aerofoil made by a plane parallel to the plane of symmetry of the aerofoil.

AEROPLANE: See Airplane.

AILERON: A movable auxiliary surface, usually part of the trailing edge of a wing, the function of which is to control the lateral attitude of an airplane by rotating it about its longitudinal axis.

AIRCRAFT: Any form of craft designed for the navigation of the air—airplanes, airships, balloons, helicopters, kites, kite balloons, ornithopters, gliders, etc.

AIRPLANE: A form of aircraft heavier than air which has wing surfaces for support in the air, with stabilizing surfaces, rudders for steering, and power plant for propulsion through the air. This term is commonly used in a more restricted sense to refer to airplanes fitted with landing gear suited to operation from the land. If the landing gear is suited to operation from the water, the term "seaplane" is used. (See definition.)

Pusher.—A type of airplane with the propeller in the rear of the engine.

Tractor.—A type of airplane with the propeller in front of the engine.

AIRSHIP: A form of balloon, the outer envelope of which is of elongated form, provided with a propelling system, car, rudders, and stabilizing surfaces.

Nonrigid.—An airship whose form is maintained by the pressure of the contained gas assisted by the car-suspension system.

Rigid.—An airship whose form is maintained by a rigid structure contained within the envelope.

Semirigid.—An airship whose form is maintained by means of a rigid keel and by gas pressure.

AIR-SPEED METER: An instrument designed to measure the speed of an aircraft with reference to the air.

ALTIMETER: An aneroid mounted on an aircraft to indicate continuously its height above the surface of the earth. Its dial is marked in feet, yards, or meters.

ANEMOMETER: Any instrument for measuring the velocity of the wind.

ANGLE:

Of attack (or *of incidence*) *of an aerofoil.*—The acute angle between the direction of the relative wind and the chord of an aerofoil; i. e., the angle between the chord of an aerofoil and its motion relative to the air. (This definition may be extended to any body having an axis.)

Critical.—The angle of attack at which the lift-curve has its first maximum; sometimes referred to as the "burble point."

Gliding.—The angle the flight path makes with the horizontal when descending in still air under the influence of gravity alone; i. e., without power from the engine.

ANGLE OF INCIDENCE (*in directions for rigging*): In the process of rigging an airplane some arbitrary definite line in the airplane is kept horizontal; the angle of incidence of a wing, or of any aerofoil, is the angle between its chord and this horizontal line, which usually is the line of the upper longitudinals of the fuselage or nacelle.

APPENDIX: The hose at the bottom of a balloon used for inflation. In the case of a spherical balloon it also serves for equalization of pressure.

ASPECT RATIO: The ratio of span to chord of an aerofoil.

ATTITUDE: The attitude of an aircraft is determined by the inclination of its axes to the "frame of reference"; e. g., the earth, or the relative wind.

AVIATOR: The operator or pilot of heavier-than-air craft. This term is applied regardless of of the sex of the operator.

AXES OF AN AIRCRAFT: Three fixed lines of reference; usually centroidal and mutually rectangular.

The principal longitudinal axis in the plane of symmetry, usually parallel to the axis of the propeller, is called the *longitudinal* axis; the axis perpendicular to this in the plane of symmetry is called the *normal* axis; and the third axis, perpendicular to the other two, is called the *lateral* axis. In mathematical discussions the first of these axes, drawn from front to rear, is called the X axis; the second, drawn upward, the Z axis; and the third, running from right to left, the Y axis.

BALANCING FLAPS: See Aileron.

BALLONET: A small balloon within the interior of a balloon or airship for the purpose of controlling the ascent or descent and for maintaining pressure on the outer envelope so as to prevent deformation. The ballonet is kept inflated with air at the required pressure, under the control of valves by a blower or by the action of the wind caught in an air-scoop.

BALLOON: A form of aircraft comprising a gas bag, rigging and a basket. The support in the air results from the buoyancy of the air displaced by the gas bag, the form of which is maintained by the pressure of a contained gas lighter than air.

Barrage.—A small spherical captive balloon, raised as a protection against attacks by airplanes.

Captive.—A balloon restrained from free flight by means of a cable attaching it to the earth.

Kite.—An elongated form of captive balloon, fitted with tail appendages to keep it headed into the wind, and deriving increased lift due to its axis being inclined to the wind.

Pilot. –A small spherical balloon sent up to show the direction of the wind.

Sounding.—A small spherical balloon sent aloft without passengers but with registering meteorological instruments.

BALLOON BED: A mooring place on the ground for a captive balloon.

BALLOON CLOTH: The cloth, usually cotton, of which balloon fabrics are made.

BALLOON FABRIC: The finished material, usually rubberized, of which balloon envelopes are made.

BANK: To incline an airplane laterally—i. e., to roll it about the longitudinal axis. Right bank is to incline the airplane with the right wing down. Also used as a noun to describe the position of an airplane when its lateral axis is inclined to the horizontal.

BANK, ANGLE OF: The angle through which an aircraft must be rotated about its longitudinal axis in order to bring its lateral axis into the horizontal plane.

BAROGRAPH: An instrument used to record variations in barometric pressure. In aeronautics the charts on which the records are made indicate altitudes directly instead of barometric pressures.

BASKET: The car suspended beneath a balloon, for passengers, ballast, etc.

BIPLANE: A form of airplane in which the main supporting surface is divided into two parts, one above the other.

BODY OF AN AIRPLANE: See Fuselage and Nacelle.

BONNET: The appliance, having the form of a parasol, which protects the valve of a spherical balloon against rain.

BRIDLE: The system of attachment of cable to a balloon, including lines to the suspension band.

BULL'S-EYES: Small rings of wood, metal, etc., forming part of balloon rigging, used for connection or adjustment of ropes.

BURBLE POINT: See Angle, critical.

CABANE: A pyramidal framework upon the wing of an airplane, to which stays, etc., are secured.

CAMBER: The convexity or rise of the curve of an aerofoil from its chord, usually expressed as the ratio of the maximum departure of the curve from the chord to the length of the chord. "Top camber" refers to the top surface of an aerofoil, and "bottom camber" to the bottom surface; "mean camber" is the mean of these two.

CAPACITY: See Load. The cubic contents of a balloon.

CEILING: *Service.*—The height above sea level at which a given aircraft ceases to rise at a rate higher than a small specified one, say 100 feet per minute. This specified rate may be different in the services of different countries.

Absolute.—The maximum height above sea level to which a given aircraft can rise.

Theoretical.—The limiting height to which a given aircraft can rise determined by computations of performance, based upon the drawings and wind tunnel data.

CENTER OF PRESSURE OF AN AEROFOIL: The point in the plane of the chords of an aerofoil, prolonged if necessary, through which at any given attitude the line of action of the resultant air force passes. (This definition may be extended to any body.)

CHORD OF AN AEROFOIL SECTION:

For theoretical purposes.—The zero lift line, i. e., the limiting position, in the section, of the line of action of the resultant air force when the position of the section is such that the lift is zero.

Practical.—The line of a straightedge brought into contact with the lower surface of the section at points near its edges. In the case of an aerofoil having double convex camber, the straight line joining the entering and trailing edges.

Length.—The length of the chord is the length of the projection of the aerofoil section on its chord.

CLINOMETER: See Inclinometer.

CONCENTRATION RING: A hoop to which are attached the ropes suspending the basket of a spherical balloon.

CONTROLS: A general term applying to the means provided for operating the devices used to control speed, direction of flight, and attitude of an aircraft.

CONTROL COLUMN: The vertical lever by means of which certain of the principal controls are operated, usually those for pitching and rolling.

CROSS-WIND FORCE: The component perpendicular to the lift and to the drag of the total force on an aircraft due to the air through which it moves.

CROW'S-FOOT: A system of diverging short ropes for distributing the pull of a single rope.

DECALAGE: The angle between the chords of the principal and the tail planes of a monoplane. The same term may be applied to the corresponding angle between the direction of the chord or chords of a biplane and the direction of a tail plane. (This angle is also sometimes known as the longitudinal V of the two planes.)

DIHEDRAL IN AN AIRPLANE: The angle included at the intersection of the imaginary surfaces containing the chords of the right and left planes (continued to the plane of symmetry if necessary). This angle is measured in a plane perpendicular to that intersection. The measure of the dihedral is taken as 90° minus one-half of this angle as defined.

The dihedral of the upper planes may and frequently does differ from that of the lower planes in a biplane.

DIRIGIBLE: See Airship.

DIVING RUDDER: See Elevator.

DOPE: A general term applied to the material used in treating the cloth surface of airplane members and balloons to increase strength, produce tautness, and act as a filler to maintain air-tightness; it usually has a cellulose base.

DRAG: The component parallel to the relative wind of the total force on an aerofoil or aircraft due to the air through which it moves.

In the case of an airplane, that part of the drag due to the wings is called "wing resistance"; that due to the rest of the airplane is called "parasite resistance."

DRIFT: See Drag. Also used as synonymous with "leeway," q. v.

DRIFT METER: An instrument for the measurement of the angular deviation of an aircraft from a set course, due to cross winds.

DRIP CLOTH: A curtain around the equator of a balloon, which prevents rain from dripping into the basket.

DROOP: A permanent warp of an aerofoil such that the angle of attack increases toward the wing tips. (The opposite of "wash out".)

ELEVATOR: A movable auxiliary surface, usually attached to the tail, the function of which is to control the longitudinal attitude of an aircraft by rotating it about its lateral axis.

EMPENNAGE: The tail surfaces of an aircraft. Sometimes the word is limited to the fixed stabilizing portion of the tail—usually comprising the tail plane and vertical fin, to which are attached the elevator and rudders.

ENTERING EDGE: The foremost edge of an aerofoil or propeller blade.

ENVELOPE: The outer covering of a rigid airship; or, in the case of a balloon or a nonrigid airship, the gas bag which contains the gas.

EQUATOR: The largest horizontal circle of a spherical balloon.

FINS: Small fixed aerofoils attached to different parts of aircraft, in order to promote stability; for example, tail fins, skid fins, etc. Fins are often adjustable. They may be either horizontal or vertical.

FLIGHT PATH: The path of the center of gravity of an aircraft with reference to the earth.

FLOAT: That portion of the landing gear of an aircraft which provides buoyancy when it is resting on the surface of the water.

FUSELAGE: The elongated structure to which are attached the landing gear, wings and tail. A fuselage is rarely used with pushers; and in general it is designed to hold the passengers.

GAP: The shortest distance between the planes of the chords of the upper and lower planes of a biplane, measured along a line perpendicular to the chord of the lower plane at its entering edge.

GAS BAG: See Envelope.

GLIDE: To fly without engine power.

GLIDER: A form of aircraft similar to an airplane, but without any power plant.

When utilized in variable winds it makes use of the soaring principles of flight and is sometimes called a soaring machine.

GLIDING ANGLE: See Angle, gliding.

GORE: One of the segments of fabric composing the envelope.

GROUND CLOTH: Canvas placed on the ground to protect a balloon.

GUIDE ROPE: The long trailing rope attached to a spherical balloon or airship, to serve as a brake and as a variable ballast.

GUY: A rope, chain, wire or rod attached to an object to guide or steady it, such as guys to wing, tail, or landing gear.

HANGAR: A shed for housing airships or airplanes.

HELICOPTER: A form of aircraft whose support in the air is derived from the vertical thrust of propellers.

HORN: A short arm fastened to a movable part of an airplane, serving as a lever arm, e. g., aileron horn, rudder horn, elevator horn.

HULL OF AN AIRSHIP: The main structure of a rigid airship, consisting of a covered elongated framework which incloses the gas bags and which supports the nacelles and equipment.

INCLINOMETER: An instrument for measuring the angle made by any axis of an aircraft with the horizontal, often called a clinometer.

INSPECTION WINDOW: A small transparent window in the envelope of a balloon or in the wing of an airplane to allow inspection of the interior.

KITE: A form of aircraft without other propelling means than the towline pull, whose support is derived from the force of the wind moving past its surface.

LANDING GEAR: The understructure of an aircraft designed to carry the load when resting on or running on the surface of the land or water.

LEADING EDGE: See Entering edge.

LEEWAY: The angular deviation from a set course over the earth, due to cross currents of wind, also called drift; hence, "drift meter."

LIFT: The component of the total force due to the air resolved perpendicular to the relative wind and in the plane of symmetry.

LIFT OF AN AIRSHIP:

Dynamic.—The component of the total force on an airship due to the air through which it moves, resolved perpendicular to the relative wind and in the plane including the direction of the relative wind and the longitudinal axis.

Static.—The vertical upward force on an airship when at rest in the air, due to buoyancy.

LIFT BRACING: See Stay.

LOAD:

Dead.—The structure, power plant, and essential accessories of an aircraft. Included in this are the water in the radiator, tachometer, thermometer, gauges, air-speed indicator, levels, altimeter, compass, watch, and hand starter.

Full.—The total weight of an aircraft when loaded to the maximum authorized loading of that particular type.

Useful.—The excess of the full load over the dead-weight of the aircraft itself. Therefore useful load includes the crew and passengers, oil and fuel, electric-light installation, chart board, gun mounts, bomb storage and releasing gear, wireless apparatus, etc.

LOADING: See Wing loading.

LOBES: Bags at the stern of an elongated balloon designed to give it directional stability.

LONGERON: See Longitudinal.

LONGITUDINAL: A fore-and-aft member of the framing of an airplane body or of the floats, usually continuous across a number of points of support.

LOOP, A: An aerial maneuver in which the airplane describes an approximately circular path in the plane of the longitudinal and normal axes, the lateral axis remaining horizontal, and the upper side of the airplane remaining on the inside of the circle.

MAROUFLAGE. The process of wrapping and winding wooden parts in cloth.

MONOPLANE: A form of airplane which has but one main supporting surface extending equally on each side of the body.

MOORING BAND: The band of tape over the top of a balloon to which are attached the mooring ropes.

NACELLE: The inclosed shelter for passengers or for an engine. Usually in the case of a single-engine pusher it is the central structure to which the wings and landing gear are attached.

NET: A rigging made of ropes and twine on spherical balloons which supports the entire load carried.

ORNITHOPTER: A form of aircraft deriving its support and propelling force from flapping wings.

OVERHANG: One-half the difference in the span of the upper and lower planes of a biplane.

PANCAKE: To "level off" an airplane, just before landing, at too great an altitude, thus stalling it and causing it to descend with the wings at a very large angle of incidence.

PANEL: The unit piece of fabric of which the envelope is made.

PARACHUTE: An apparatus, made like an umbrella, used to retard the descent of a falling body.

PATCH SYSTEM: A system of construction in which patches (or adhesive flaps) are used in place of the suspension band.

PERMEABILITY: The measure of the loss of gas by diffusion through the intact balloon fabric.

PITCH OF A PROPELLER:

(*a*) *Pitch, effective.*—The distance an aircraft advances along its flight path for one revolution of the propeller.

(*b*) *Pitch, geometrical.*—The distance an element of a propeller would advance in one revolution if it were turning in a solid nut—i. e., if it were moving along a helix of slope equal to the angle between the chord of the element and a plane perpendicular to the propeller axis. The mean geometrical pitch of a propeller, which is a quantity commonly used in specifications, is the mean of the geometrical pitches of the several elements.

(*c*) *Pitch, virtual.*—The distance a propeller would have to advance in one revolution in order that there might be no thrust.

(*d*) *Pitch speed.*—The product of the mean geometrical pitch by the number of revolutions of the propeller in unit time—i. e., the speed the aircraft would make if there were no slip.

(*e*) *Slip.*—The difference between the effective pitch and the mean geometrical pitch. Slip is usually expressed as a percentage of the mean geometrical pitch.

PITCH, ANGLE OF: The angle between two planes, defined as follows: One plane includes the lateral axis of the aircraft and the direction of the relative wind; the other plane includes the lateral axis and the longitudinal axis. (In horizontal normal flight this angle of pitch is, then, the angle between the longitudinal axis and the direction of the relative wind.)

PITOT TUBE: A tube with an end open square to the fluid stream, used as a detector of an impact pressure. It is usually associated with a coaxial tube surrounding it, having perforations normal to the axis for indicating static pressure; or there is such a tube placed near it and parallel to it, with a closed conical end and having perforations in its side. The velocity of the fluid can be determined from the difference between the impact pressure and the static pressure, as read by a suitable gauge. This instrument is often used to determine the velocity of an aircraft through the air.

PLANE: One of the main supporting surfaces of an airplane or of a wing. (Thus the upper or lower plane of an airplane or the upper right plane or lower right plane of the right wing.)

PONTOONS: See Float.

PRESSURE NOZZLE: The apparatus which, in combination with a gauge, is used to measure speed through the air.

PUSHER: See Airplane.

PYLON: A mast or pillar serving as a marker of a course.

RACE OF A PROPELLER: See Slip stream.

RATE OF CLIMB: The vertical component of the flight speed of an aircraft—i. e., its vertical velocity with reference to the air.

RELATIVE WIND: The motion of the air with reference to a moving body. Its direction and velocity, therefore, are found by adding two vectors, one being the velocity of the air with reference to the earth, the other being equal and opposite to the velocity of the body with reference to the earth.

RIGHT-HAND ENGINE: An engine designed to drive a right-hand tractor screw.

RIGHTING MOMENT: A moment which tends to restore an aircraft to its previous attitude after any rotational disturbance.

RIP CORD: The rope running from the rip panel of a balloon to the basket, the pulling of which causes immediate deflation.

RIP PANEL: A strip in the upper part of a balloon which is torn off when immediate deflation is desired.

ROLL, A: An aerial maneuver in which a complete revolution about the longitudinal axis is made, the direction of flight being maintained.

RUDDER: A hinged or pivoted surface, usually more or less flat or stream lined, used for the purpose of controlling the attitude of an aircraft about its normal axis—i. e., for controlling its lateral movement.

Balanced.—A rudder having part of its surface in front of its pivot.

RUDDER BAR: The foot bar by means of which the rudder is operated.

SEAPLANE: A particular form of airplane in which the landing gear is suited to operation from the water.

(*a*) *Boat seaplane* (or *flying boat*).—A form of seaplane having for its central portion a boat which provides flotation. It is often provided with auxiliary floats or pontoons.

(*b*) *Float seaplane.*—A form of seaplane in which the landing gear consists of one or more floats or pontoons.

SERPENT: A short, heavy guide rope.

SIDE SLIPPING: Sliding downward and inward when making a turn; due to excessive banking. It is the opposite of skidding.

SKIDDING: Sliding sidewise away from the center of the turn in flight. It is usually caused by insufficient banking in a turn and is the opposite of side slipping.

SKIDS: Long wooden or metal runners designed to prevent nosing of a land machine when landing or to prevent dropping into holes or ditches in rough ground. Generally designed to function should the landing gear collapse or fail to act.

SLIP STREAM (or *propeller race*): The stream of air driven aft by the propeller and with a velocity relative to the airplane greater than that of the surrounding body of still air.

SOARING MACHINE: See Glider.

SPAN (or *spread*): The maximum distance laterally from tip to tip of an airplane or the lateral dimension of an aerofoil.

SPEED: *Air.*—The speed of an aircraft relative to the air.

Ground.—The horizontal component of the velocity of an aircraft relative to the earth.

SPIN: An aerial maneuver consisting of a combination of roll and yaw, with the longitudinal axis of the airplane inclined steeply downward. The machine descends in a helix of large pitch and very small radius, the upper side of the machine being on the inside of the helix, and the angle of attack being maintained at a large value.

STABILITY: A body in any attitude has stability about an axis if, after a slight displacement about that axis, it tends to regain its initial attitude.

Directional.—Stability with reference to the normal axis.

Dynamical.—The quality of an aircraft in flight which causes it to return to a condition of equilibrium after its attitude has been changed by meeting some disturbance—e. g., a gust. This return to equilibrium is due to two factors: First, the inherent righting moments of the structure; second, the damping of the oscillations by the tail, etc.

Inherent.—Stability of an aircraft due to the disposition and arrangement of its fixed parts, i. e., that property which causes it to return to its normal attitude of flight without the use of the controls.

Lateral.—Stability with reference to displacements involving rolling or yawing, i. e., displacements in which the plane of symmetry of the airplane is rotated.

Longitudinal.—Stability with reference to displacements involving pitching, i. e., displacements in which the plane of symmetry of the airplane is not rotated.

Statical.—In wind-tunnel experiments it is found that there is a definite angle of attack, such that, for a greater angle or a less one, the righting moments are in such a sense as to tend to make the attitude return to this angle. This holds true for a certain range of angles on each side of this definite angle; and the machine is said to possess "statical stability" through this range.

A machine possesses statical stability if, when its attitude is disturbed, moments tending to restore it to this attitude are set up by the action of the air on the machine; e. g., if an aircraft, after an initial disturbance, oscillates with swings of constantly increasing amplitude, it is statically stable but not dynamically stable.

STABILIZER: A fixed horizontal, or nearly horizontal, tail surface, used to steady the longitudinal motion and to damp oscillations in pitch.

Mechanical.—A mechanical device to steady the motion of an aircraft.

STAGGER: The amount of advance of the entering edge of the upper plane of a biplane over that of the lower, expressed as percentage of gap; it is considered positive when the upper surface is forward and is measured from the entering edge of the upper plane along its chord to the point of intersection of this chord with a line drawn perpendicular to the chord of the lower plane at its entering edge, all lines being drawn in a plane parallel to the plane of symmetry.

(*In directions for rigging*).—The horizontal distance between the entering edge of the upper plane and that of the lower when the airplane is in the standard position; i. e., when the arbitrary line of reference in the airplane is horizontal. (This line is usually the axis of the propeller shaft.)

STALLING: A term describing the condition of an airplane which from any cause has lost the relative speed necessary for control.

STATOSCOPE: An instrument to detect the existence of a small rate of ascent or descent, principally used in ballooning.

STAY: A wire, rope, or the like, used as a tie piece to hold parts together, or to contribute stiffness. For example, the stays of the wing and body trussing.

STEP: A break in the form of the bottom of a float.

STREAM-LINE FLOW: The condition of continuous flow of a fluid, as distinguished from eddying flow.

STREAM-LINE SHAPE: A shape intended to avoid eddying and to preserve stream-line flow.

STRUT: A compression member of a truss frame. For instance, the vertical members of the wing truss of a biplane.

SUSPENSION BAND: The band around a balloon to which are attached the basket and the main bridle suspensions.

SUSPENSION BAR: The bar used for the concentration of basket suspension ropes in captive balloons.

SWEEP BACK: The horizontal angle between the lateral axis of an airplane and the entering edge of the main planes.

TAIL: The rear portion of an aircraft, to which are usually attached rudders, elevators, stabilizers, and fins.

TAIL CUPS: The steadying device attached at the rear of certain types of elongated captive balloons.

TANDEM: An airplane whose sets of planes are placed one in front of the other.

TRACTOR: See Airplane.

TRAILING EDGE: The rearmost edge of an aerofoil or propeller blade.

TRIPLANE: A form of airplane whose main supporting surface is divided into three parts, superimposed.

TRUSS: The framing by which the wing loads are transmitted to the body; comprises struts, stays, and spars.

UNDERCARRIAGE: See Landing gear.

VENTURI TUBE: A short tube, flaring at the front end, and constricted approximately midway of its length, so that, when fluid flows through it, there will be a suction produced in a side-tube opening into the constricted throat. This tube, when combined with a Pitot tube or with one giving static pressure, forms a pressure nozzle, which may be used as an instrument to determine the speed of an aircraft through the air.

WARP: To change the form of the wing by twisting it.

WASH IN: See Droop.

WASHOUT: A permanent warp of an aerofoil such that the angle of attack decreases toward the wing tips.

WEIGHT, GROSS: See Load, full.

WING: The aggregate sustaining structure on the right or left side of an airplane, comprising both planes and trussing. (Thus, "detachable wings" and "folding wings.")

WING FLAP: See Aileron.

WING LOADING: The weight carried per unit area of supporting surface.

WING MAST: The mast structure projecting above the wing, to which the top load wires are attached.

WING RIB: A fore-and-aft member of the wing structure used to support the covering and to give the wing section its form.

WING SPAR OR WING BEAM: A transverse member of the wing structure.

YAW: *Yawing.*—Angular motion about the normal axis.

Angle of.—The angle between the direction of the relative wind and the plane of symmetry of an aircraft.

ZERO LIFT LINE: The limiting position in an aerofoil section of the line of action of the resultant air force when the position of the section is such that the lift is zero.