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Defence Against Dive Bombing Attacks. (B. di San Secondo, Rivista Maritima, Dec., 1938. Luftwehr, Vol. 6, No. 3, March, 1939, pp. 121-124.) (74/1 Italy.)

Dive bombing attack can be divided into five phases:—

(1) Spiral from 10,000 m. distance to 2,000 m., with gradual loss of height from 5,000 m. to 1,500 m.
Time taken 90 secs., if speed is assumed at 120 m./sec.

(2) Horizontal speed reduced to 40 m./sec. whilst getting into position for attack. The course during this phase is usually at 30—40° with the direction of the dive (10 seconds).

(3) Actual dive at about 70° on to target (7 seconds).
Target distance at beginning of dive ~ 1,500 m.
Target distance at end of dive ~ 600 m.

(4) Release of bomb and pull out (2 seconds).

(5) Spiral get away with gradual climb (90 seconds).

During phases (1) and (5) the attacking aircraft has complete manœuvrability and therefore is difficult to hit by A.A. fire. The sudden reduction in speed in phase (2) is also very disconcerting to the artillery. The chances of hitting the aircraft should be greatest during phase (3) when the flight path of the aircraft must necessarily almost coincide with the trajectory of the bullets. Phase (4) is too short to be considered from the point of view of the A.A. artillery. Unfortunately phase (3) is also very short (of the order of 7 seconds), and unless the explosive shells can be relied on to furnish high-speed fragments in sufficient quantity and in the direction of the aircraft, the effectiveness of the fire is very doubtful.

For this reason the author follows Rougeron and recommends the use of shrapnel, each 10 cm. shell containing about 240 bullets. The bullets are expelled inside a relatively small cone, and at a distance of 100 m. from the burst we may roughly expect one bullet per sq. m., whilst at 600 m. the proportion is one bullet per 39 sq. m.

Even should the bullets be met at an appreciable distance from the point of burst, the impact velocity due to the high speed of the aircraft will accentuate the damage.

Fighter versus Bomber—Italian Experiences in Spain. (Rev. de l'Arm. de l'Air, No. 116, May-June, 1939, pp. 313-319.) (74/2 Italy.)

An interesting discussion on this subject has been published in the Vie dell'Aria towards the end of 1938. The French reviewer calls attention to the value of

publications of this kind based on actual war experience, and points out that many of the early mistakes in the 1914 war could have been avoided if the experiences gained in the Balkan War of 1912 had been published instead of being pigeon-holed.

Main claims for the fighter (put forward by M. Fucini) :—

(1) Greater stability of gun mounting and therefore increased accuracy of fire.
(2) Advantage of fire and aircraft being under control of one man.
(3) Small vulnerable surface.
(4) Although difference in top speed and ceiling may not be very great between the two types of aircraft, the fighter can gain considerable speed by diving on its objective. The bomber is forced to fly low in order to obtain bombing accuracy.
(5) Mutual fire support is seriously interfered with by A.A. artillery, which will force the bomber formation to break up and this facilitates fighter attack.
(6) Vulnerability of bomber is generally recognised by the provision of fighter escorts whenever possible. This was the universal practice of the Government forces.

The case for the bomber (Bruno Montanari) :—

(1) Since the ceilings of the two types are comparable, there is little chance of fighter contact if the bomber operates at high altitude.
(2) Bombing accuracy does not necessarily suffer as altitude increases. The Italians are able to place sixty heavy bombs in a space of 100—200 m. from 6,500 m.
(3) Concentrated fire of S79 bombers prove very effective against attacks by Rata fighters. Heavier guns can be carried by the bomber and thus outrange the fighter.
(4) Co-operation between fighter and A.A. artillery when attacking bombers was not successful in Spain. Many fighters were shot down by their own ground artillery.
(5) Although the bomber has the bigger surface, the vital parts are more dispersed and this makes for safety.
(6) Unescorted bombers (S79) proved very successful against Barcelona.
If escorts are required, the bomber is being utilised for duties, such as participation in ground fighting, which would be better carried out by special machines.
(7) The rôle of the fighter is to obtain mastery of the air over certain restricted zones (defence of vital objectives) or at certain times for the purpose of army co-operation.
(8) The main purpose of an air force is, however, long-distance bombing, and it must be the object of the bomber to reach his target at all costs. If intercepted by fighters, losses will naturally arise, but they will be on both sides equally and should not prevent the bomber from carrying out his mission.

Some Italian and Russian Opinions on the Aerial War in Spain. (Rev. de l'Arm. de l'Air, No. 116, May and June, 1939, pp. 319-322.) (74/3 France.)

Some of the principal conclusions are given below :—

Italian.

(1) The Spanish aerodromes are very rough and generally devoid of buildings. The aircraft is kept in the open at a distance (camouflaged) and can generally only be detected from a low altitude. A.A. artillery has proved very effective against such a form of attack.
(2) The high landing speeds of modern fighters has led to numerous accidents.
(3) The increased flying speed of the modern bomber is proving a severe handicap to the attacking fighter.

(4) The most suitable targets for ground attack are troops in improvised defensive positions. Troops or mechanised units can only be rarely surprised when on the march unless the leadership makes mistakes.

(5) The Italian method of ground attack in chains has proved very effective. Usually six to nine aircraft participate and dive on to the objective in succession. The low altitude flight is carried out at very high speed and losses are surprisingly small (40 casualties in 587 attacks involving 3,554 aircraft over the period 1st January, 1938, to 31st April, 1938, covering the important engagements at Teruel and on the Ebro). Only small-calibre A.A. guns can be employed, and hits, if registered at all, are very rarely serious.

(6) The Italians employed Breda 65, C.R. 32 and RO 37 machines for work of this kind. The ideal ground attack machine has yet to be designed. It must be armoured and possess exceptional visibility for the pilot.

Some Russian Opinions.

(1) The Y Rata fighter is praised for its good manœuvrability and general fighting capacity. A serious fault is its low ceiling, which made contact with Italian fighters (patrolling habitually at 7,000—7,500 m.) very difficult.

(2) The effect of ground attack is moral rather than material. With existing types, such attacks can only be carried out if supported by fighters which assure a temporary command of the sky. If unsupported by fighters, such units (of the order of ten aircraft) fall an easy prey to the fighter. Only mass attacks (50—100 aircraft) have any chance of success.

(3) Effective co-operation between the troops and the aircraft carrying out ground attack in front of the line is very difficult. Without such co-operation, the attack loses most of its value.

(4) It is agreed that aircraft flying low at high speed have little to fear from A.A. fire. The ideal machine for ground attack is not yet available. The Russian author suggests that it should be a three-seater so as to obviate the need of fighter support. 500 kg. of bomb should be carried.

In conclusion, the French reviewer calls attention to the apparent failure of aircraft reconnaissance in predicting the imminence of large-scale offensives by the enemy. A classical example is Ebro attack, which apparently took Franco by surprise in spite of his superiority in long-range reconnaissance aircraft.

Factory Hands Required for the Equipment of a Modern Air Force. (D. Leonhardt, Luftwehr, Vol. 6, No. 7, July, 1939, pp. 280-281.) (74/4 Germany.)

According to the French expert Rougeron, the proportion of flying personnel, ground troops and workpeople required for maintaining an air force at a given size is in the ratio 1 : 4 : 12.5. Italian calculations, based on front-line strength only, give 1 : 5 : 33. The two sets are in reasonable agreement if the front-line strength is of the order of one-third of the total.

A more detailed examination of the problem shows, however, that the non-combatant strength in relation to the flying personnel is likely to exceed the proportions given above. Let us assume that the total strength of an air force amounts to 10,000 aircraft, of which 3,000 are front-line machines. The monthly losses to be expected amount to 50 per cent. for front line and 25 per cent. for the rest. This requires a yearly output of 40,000 aircraft, plus an estimated output of 60,000 engines. An all-metal fighter requires about 14-18,000 man-hours for completion, each engine (1,000 h.p.) 8-9,000 man-hours. Taking 2,700 hours as the work output per man per year, the yearly requirements in aircraft and engines amount to the employment of $40{,}000 \times 6 + 60{,}000 \times 3 = 420{,}000$ men. Aircraft accessories (at 33 per cent.) and engine accessories (at 66 per cent.) account for another 200,000 men. But even this grand total of over 600,000 does not show the full requirements, since labour spent on repairs and the necessary

development work has not been included, nor has an allowance been made for armament and equipment of the combatants, ground organisation and fuel supply. The author estimates the grand total labour requirements for maintaining an air force at 10,000 aircraft under war conditions as being well over one million men.

A Russian Pilot's Opinion on the German Fighter in Spain. With Some Reference to Italian and French Aircraft. (*From the Russian.*) Riv. Aeron., Vol. 15, No. 9, September, 1939, pp. 501-2.) (74/5 U.S.S.R.)

The German fighters generally operate in three groups, of which the first two attack in turn.

The third group is fitted with cannons and remains in reserve at a greater altitude. These machines will dive at great speed on any suitable target below them.

The German pilot is trained to make the most of sun and clouds, and the camouflage paint is adjusted to the type of country in which the operation takes place.

The great art in air fighting is to know the blind spot of the adversary. Junkers fuel tanks are vulnerable to incendiary bullets if the machine is attacked from the rear and above.

On the other hand, the Fiat 32 is more vulnerable to attack from below.

The French Multi-seat Potez 54 (liquid-cooled bomber) is so vulnerable that each machine had to be protected by half-a-dozen fighters.

World's Aircraft Production, with Special Reference to the U.S.A. (Inter. Avia., No. 687, 5/12/39, pp. 1-4.) (74/6 Switzerland.)

U.S.A.

The Wall Street Journal estimates the 1940 capacity of the American aviation industry at 674 million dollars. This figure is considered unduly optimistic, seeing that the total November, 1939 sales (a record for the year) amounted to less than twenty million dollars.

The present back log of the industry amounts to no less than 534 million dollars.

Germany.

The German aviation industry has become most reticent, and the monthly trade journal " Luftwehr " has ceased publication. The following points should, however, be noted:—

(1) Even prior to September, 1939, at least 300,000 persons were employed in the German aviation industry.
(2) Advertisements for extra staff and published figures concerning increase in capital of a number of firms clearly indicate further expansion.
(3) The possibilities of the Czechoslovak and Polish aircraft industries are bound to become utilised to the fullest extent.

Great Britain and France.

Production figures are not available, but it clearly indicates the intention of the Allies (and more especially of France) to look to America as a source of supply.

In view of the position of the American industry, and the large demands of the U.S. Army Air Corps, the Swiss reviewer is doubtful whether any considerable help can be expected from that quarter during 1940.

New Driving Band for Projectiles (to Replace Copper Ring). (La Technique Moderne, Vol. 31, No. 21-22, 15/11/39, p. 18.) (74/7 Germany.)

The band consists of a mixture of asbestos fibre, paper and cotton reinforced by metal wires.

A mixture of graphite, talc, rubber and resin is used as a filler, adhesion being assured by high compression.

German War Time Labour Regulation. (Inter. Avia., No. 689, 19/12/39, p. 9.) (74/8 Germany.)

Upon the outbreak of war some of the regulations protecting labour were necessarily relaxed, but these modifications are now speedily to be removed again. An order issued on December 12th re-enforces the regulations previously promulgated. The daily working time is not to exceed eight hours without special sanction unless, of course, war orders are involved, necessitating accelerated execution. Even in the latter cases the daily working hours must not exceed ten, and, in exceptional cases, twelve. Wages are increased by 25 per cent. for overtime work beginning with the eleventh working hour. It is unlawful to employ women and minors on night shifts. A new set of regulations covering labour in Germany will come into force on January 1st, 1940.

On the Deformation of Free Boundary Due to Line Vortices. (I. Imai, Aer. Res. Inst., Tokyo Rept., No. 183, Aug., 1939.) (74/9 Japan.)

In this paper a method is developed for dealing with the two-dimensional irrotational motion of an incompressible perfect fluid bounded by free surfaces as well as by rigid walls, in which a number of line vortices are placed. The method is illustrated by taking several cases of interest, for which approximate solutions have been known for some time. The exact formulæ are obtained, however, for the first time in the present paper. In particular, Riegels's problem (one rigid wall and free surface), which was also attacked by Schmieden, is solved in a simple and exact manner.

Pressure Distribution Investigation of an N.A.C.A. 0009 Aerofoil with a 50 per cent. Chord Plain Flap and Three Tabs. (W. G. Street and M. B. Ames, Jr., N.A.C.A. Tech. Note No. 734, Nov., 1939.) (74/10 U.S.A.)

Pressure-distribution tests of an N.A.C.A. 0009 aerofoil with a 50 per cent. chord plain flap and three plain tabs, having chords 10, 20 and 30 per cent. of the flap chord, were made in the N.A.C.A. 4 × 6-foot vertical tunnel. The tests supplied aerodynamic section data that may be applied to the design of horizontal and vertical tail surfaces.

The results are presented as resultant-pressure diagrams for the aerofoil with the flap and the 20 per cent. chord tab. Plots are also given of increments of normal-force and hinge-moment coefficients for the aerofoil, the flap, and the three tabs. The experimental results and values computed by analytical methods are in good agreement for small flap and tab deflections. The results of the tests indicated that the effectiveness of all three tab sizes in reducing flap hinge moments decreased with increasing flap deflection.

Pressure Distribution Measurements on a Tapered Wing with a Partial-Span Split Flap in Curved Flight. (T. Troller and F. Rokus, N.A.C.A. Tech. Note No. 735, Nov., 1939.) (74/11 U.S.A.)

Pressure-distribution tests were made on the 32-foot whirling arm of the Daniel Guggenheim Airship Institute of a tapered wing to determine the rolling and the yawing moments due to an angular velocity in yaw. The model was tested at 0° and 5° pitch; 0°, 5° and 10° yaw; and with split flaps covering 25, 50, 75 and 100 per cent. of the wing span and deflected 60°. The results are given in the form of load distributions and as calculated moment coefficients.

CONCLUSIONS.

1. The experimental rolling- and yawing-moment coefficients for a wing without flaps are in close agreement with the theoretical values.

2. For a wing with a full-span or a partial-span flap, the experimental rolling-moment coefficients are 10 to 15 per cent. smaller than the theoretical values.

3. The rolling-moment coefficients were little affected by angle of yaw within the range of $\pm 10°$ with a tendency to decrease as the model was yawed in the positive direction. The yawing-moment coefficients were little affected by the angle of yaw for flap lengths up to 50 per cent. of the span, but showed considerable change for the full-span flap with a tendency to increase as the model was yawed in the positive direction.

Wind Tunnel Investigation of N.A.C.A. 23012, 23021 *and* 23030 *Aerofoils with Various Sizes of Split Flap.* (C. J. Wenzinger and T. A. Harris, N.A.C.A. Tech. Report No. 668, 1939.) (74/12 U.S.A.)

An investigation has been made in the N.A.C.A. 7 × 10-foot wind tunnel of large-chord N.A.C.A. 23012, 23021 and 23030 aerofoils with split flaps 10, 20, 30 and 40 per cent. of the wing chord to determine the section aerodynamic characteristics of the aerofoils as affected by aerofoil thickness, flap chord and flap deflection. The complete section aerodynamic characteristics of all the combinations tested are given in the form of graphs of lift, drag and pitching-moment coefficients, and certain applications to aerodynamic design are discussed.

The final maximum lift coefficients for the three aerofoils tested with the 0.20 cw. flap were about equal. For the aerofoils with the 0.10 cw. flap, the maximum lift coefficient decreased with aerofoil thickness; for the aerofoils with the 0.30 cw. or 0.40 cw. flaps, the maximum lift coefficient increased with aerofoil thickness to a maximum value of 2.94. Within the range covered, the increment of maximum lift coefficient due to the split flaps was practically independent of Reynolds Number. The increase in minimum profile-drag coefficient with aerofoil thickness was large, being about twice as great for the N.A.C.A. 23030 as for the 23012 plain aerofoil.

A Theoretical Study of the Moment on a Body in a Compressible Fluid. (C. Kaplan, N.A.C.A. Tech. Report No. 671, 1939.) (74/13 U.S.A.)

The extension to a compressible fluid of Lagally's theorem on the moment on a body in an incompressible fluid and Paggi's method of treating the flow of compressible fluids are employed for the determination of the effect of compressibility on the moment on an arbitrary body. Only the case of the two-dimensional subsonic flow of an ideal compressible fluid is considered. As examples of the application of the general theory, two well-known systems of profiles are treated, namely, the elliptic profile and the symmetrical Joukowski profiles with sharp trailing edges. The effect of compressibility on the position of the centre of pressure is also discussed. In order to determine this effect, it is necessary to calculate the additional circulation induced by the compressibility of the fluid for both the elliptic and the Joukowski profiles. For these two types of profile, the centres of pressure in the compressible and the incompressible fluids are found to coincide for a definite and fairly small angle of attack, which is essentially dependent on the thickness coefficients. For angles of attack less than this neutral angle, the centre of pressure in the compressible fluid is farther from the nose and, for angles of attack greater than the neutral angle, nearer to the nose than the centre of pressure in the incompressible fluid.

Several numerical examples of both the elliptic and the Joukowski profiles are given. The results show that, although the effect of compressibility on the moment and on the lift may be large, the effect on the centre of pressure for conventional profiles is negligible.

The Analogy Between Fluid Friction and Heat Transfer. (Th. von Kármán, Trans. A.S.M.E., Vol. 61, No. 8, November, 1939, pp. 705-710.) (74/14 U.S.A.)

The results of the modern turbulence research on velocity distribution near solid walls are applied to extend Reynolds' analogy between fluid friction and heat transfer to liquids. Discrepancies between the experimental results and the theory of Taylor and Prandtl are explained. A new theoretical formula which fits the experimental results more satisfactorily is suggested and compared with the empirical equations of Dittus and Boelter.

It appears from the results of this paper that the fundamental idea of Reynolds' analogy can be applied with success to the problem of friction and heat transfer between fluid and solid. However, it must be mentioned that recent experiments make it doubtful whether the same idea is applicable to exchange phenomena between fluids flowing with different velocities. It seems that in this case the exchange of heat occurs at a relatively higher rate than the exchange of momentum. At the present time the number of experiments is still too small to draw final conclusions. It is believed that the exchange mechanism of friction and heat transfer for the case " fluid versus fluid " is one of the most important topics for future research.

Wind Tunnel Investigation of an N.A.C.A. 23021 *Aerofoil with Various Arrangements of Slotted Flaps.* (C. J. Wenzinger and T. A. Harris, N.A.C.A. Report 664, 1939.) (74/15 U.S.A.)

The tests were carried out in the 7 × 10-foot wind tunnel and in the variable-density tunnel of the N.A.C.A.

1. The optimum arrangement of the slotted flap tested was superior to the split, the plain, and the external aerofoil types of flap compared on the basis of maximum lift coefficient, low drag at moderate and at high lift coefficients, and high drag at high lift coefficients. The slotted flap, however, gave slightly lower maximum lift coefficients than the Fowler flap.

2. The increment of maxium lift due to the slotted flap was found to be practically independent of the Reynolds Number over the range investigated.

3. Openings in the lower surface of the aerofoil for the slotted flaps tested had a measurable effect on the drag for high-speed flight conditions even when the slot was smoothly faired to maintain the contour of the upper surface and there was no air flow through the slot.

4. The slotted flap gave the highest maximum lift coefficients when the nose of the flap was located slightly ahead of, and below, the slot lip, and with a slot lip that directed the air down over the flap.

5. The lowest profile drags at moderate lift coefficients were obtained by using a slotted flap with an aerofoil nose shape and with an easy entrance to the slot.

6. It appears that still further improvement may be obtained in low drag characteristics at moderate and high lift coefficients by the use of multiple flaps or by slotted flaps with greater lip extensions.

Free-Spinning Wind Tunnel Tests of a Low Wing Monoplane with Systematic Changes in Wings and Tails. IV. Effect of Centre of Gravity Location. (O. Seidman and A. I. Neihouse, N.A.C.A. Report No. 672, 1939.) (74/16 U.S.A.)

The tests were carried out in the N.A.C.A. free spinning tunnel.

By analysis of the data presented, the following conclusions may be obtained:—

Effects of centre-of-gravity location:—

1 In nearly every case, moving the centre of gravity forward steepens the

spin, increases $\Omega b/2V$ and improves recovery; whereas moving the centre of gravity back flattens the spin, decreases $\Omega b/2V$, and retards recovery.*

2. Forward movement of the centre-of-gravity position tends to produce more outward sideslip, except for the wing of N.A.C.A. 6718 section, for which the reverse is true.

Effects of wings:—

1. Tip shape.—Rectangular and faired tips give the steepest spins and the most rapid recoveries. The Army tip consistently gives flatter spins and slower recoveries.

2. Plan form.—The wing of 5: 2 taper generally gives slower recoveries than the rectangular wing.

3. Section.—The N.A.C.A. 23012 section consistently exhibits the poorest recovery characteristics. The N.A.C.A. 0009 section gives the most outward sideslip; whereas the N.A.C.A. 6718 section gives inward sideslip.

Wind Tunnel Investigation of an N.A.C.A. 23021 *Aerofoil with Various Arrangements of Slotted Flaps.* (C. J. Wenzinger and T. A. Harris, N.A.C.A. Report No. 677, 1939.) (74/17 U.S.A.)

An investigation has been made in the N.A.C.A. 7 × 10-foot wind tunnel of a large-chord N.A.C.A. 23021 aerofoil with several arrangements of 25.66 per cent. chord slotted flaps to determine the section aerodynamic characteristics as affected by slot shape, flap shape, flap location and flap deflection. The flap positions for maximum lift, the polars for arrangements considered favourable for take-off and climb, and the complete section aerodynamic characteristics for selected optimum arrangements were determined. A discussion is given of the relative merits of the various arrangements for certain selected criteria. A comparison is made of a slotted flap on the N.A.C.A. 23021 aerofoil with a corresponding slotted flap previously developed for the N.A.C.A. 23012 aerofoil.

The best slotted-flap arrangement on the N.A.C.A. 23021 aerofoil gave the same maximum lift coefficient as the best slotted flap on the N.A.C.A. 23012 aerofoil. The drag coefficients were higher with the N.A.C.A. 23021 aerofoil, but the pitching-moment coefficients were about equal for comparable arrangements.

Wind Tunnel Investigaion of an N.A.C.A. 23012 *Aerofoil with a Slotted Flap and Three Types of Auxiliary Flap.* (C. J. Wenzinger and W. E. Gauvain, N.A.C.A. Report No. 679, 1939.) (74/18 U.S.A.)

An investigation was made in the N.A.C.A. 7 × 10-foot wind tunnel to determine the aerodynamic section characteristics of an N.A.C.A. 23012 aerofoil with a single main slotted flap equipped successively with auxiliary flaps of the plain, split and slotted types. A test installation was used in which an aerofoil of 7-foot span was mounted vertically between the upper and the lower sides of the closed test section so that two-dimensional flow was approximated.

On the basis of maximum lift coefficient, low drag at moderate and high lift coefficients, and high drag at high lift coefficients, the optimum combination of the arrangements was found to be the double-slotted flap. All the auxiliary flaps tested, however, increased the magnitudes of the pitching moments over those of the main slotted flap alone.

Study of Some Technical Problems Relating to the Wing Theory. Application of the Rheo-Electric Method to Their Solution. (L. Malavard, Pub. Sci. et Tech., No. 153, 1939.) (74/19 France.)

The rheo-electric method of analogy for solution of hydro- and aerodynamic

* $\Omega b/2V$ = spin coefficient where
Ω = resultant angular velocity,
b = span of wing,
V = rate of descent.

problems was described in Pub. Sci. et Tech., No. 57, 1934; it consists in producing electric currents distributed in conductors of two or three dimensions and giving a reproduction of the fluid flow. The method is now applied to the study of lifting wing problems, and an electrical apparatus has been developed known as the "wing calculator." It is applied to calculation of wings, in particular the effect of ailerons, and determination of the effect of the boundaries of the jet in wind tunnels. The solutions obtained are quite general and can be used for jets of any cross-section.

The two final chapters deal with the general problem of the biplane, an entirely new application of the calculator being made to the study of a biplane of finite span. The conditions which define in the electrical device the free vortices of a multiplane cellule do not reduce to the same form as in the case of a monoplane, so that the "multiplane wing calculator" employed has been considerably modified.

[See also Translation No. 837, L. Malavard, "The Application of Electrical Analogies to Some Aerodynamic Problems," E.N.S.A., No. 1, Jan.-Feb., 1937, pp. 62-73; No. 2, Mar.-Apr., 1937, pp. 5-12; No. 7, Jan.-Feb., 1938, pp. 39-50.]

U.S.A. Aircraft Year Book, 1939. (Inter. Avia., No. 686, 27/11/39, p. 17.) (74/20 U.S.A.)

An average of 36,000 employees were hired by the manufacturers of planes and engines in 1938; their export trade gave employment to about 15,000 shop employees, and 44 cents of the average sales dollar was paid to shop labour. The average shop employee in the aeroplane plants received an annual wage of $1,550. A comparatively small figure is given as the expenditure by the National Advisory Committee for Aeronautics: $6,002,480 for the five fiscal years 1935-1939; in approximately the same period of time, during the calendar years 1934-1938, the aeroplane, aeroplane engine and propeller manufacturers of the United States spent $44,000,000 on research and development work to improve American flying machines. During this same period, exports of American flying equipment amounted to $143,000,000, while commercial sales inside the United States aggregated $107,000,000; therefore, commercial, domestic and export sales amounted to $250,000,000. At the beginning of 1939 there were 11,744 non-military aircraft in the United States, 208 gliders, 24,443 aeroplane pilots, 116 licensd glider pilots, 2,374 landing fields of all kinds, 719 of the latter either fully or partially lighted for night flying.

A New Method of Assisted Take-off for Aircraft. (La Technique Moderne, Vol. 31, No. 21-22, 15/11/39, p. 18.) (74/21 France.)

The aircraft is towed by means of a tractor and cable. The cable passes over a special system of pulleys carried on a trailer placed between tractor and aircraft. At the beginning of the run both tractor and trailer advance at the same speed. The trailer is then deceleratd (braked), the tractor continuing to advance. This causes a rapid acceleration of the aircraft due to the pulley system which the rope has to pass.

Analysis of Best Rate of Climb and Ceiling as Affected by Ice Accretions. (A. Gail, J. Aeron. Sci., Vol. 7, No. 1, Nov., 1939, pp. 6-11.) (74/22 U.S.A.)

The polarless performance analysis is extended for non-parabolic polars which are characteristic of aerofoils with surface irregularities such as ice accretions. Oswald's aeroplane efficiency factor is interpreted in terms of "pseudo aspect ratio." The condition of maximum rate of climb is analytically defined and its iterative determination is demonstrated for the case of a given non-parabolic polar.

Impairments of best climb due to ice as experienced in flight can, with reasonable accuracy, be considered as a function of the " pseudo aspect ratio " only.

CONCLUSIONS.

By means of the above theory it is possible to establish the relationship between size, shape and location of ice accretion and a generally applicable aerodynamic parameter depending upon the flight or wind-tunnel test results available for analysis. Once this parameter is obtained for the most important ice formations, it will be possible to predict whether or not an aeroplane will be able to maintain flight above a certain altitude under certain anticipated icing conditions. Furthermore, the merits of various anti-icing means can be rated in terms of their effectiveness in preserving climbing ability and ceiling, thus permitting a more rational development of such anti-icing equipment.

No consideration has been given to propeller icing. Very little is known about the effect of surface irregularities upon propeller efficiency and about the shape of ice accretions on propellers. Hence, analyses of climb impairments with ice on the propeller have to be taken with reservations. The influence of propeller ice on performance is, however, small, since only deposition on the shanks is possible.

Reduction of Flight Test Climb Data to Standard Air Conditions. (R. J. White, J. Aeron. Sci., Vol. 7, No. 1, Nov., 1939, pp. 12-17.) (74/23 U.S.A.)

General equations for the reduction of flight test climb data to standard air conditions are given, indicating how the aeroplane and engine characteristics affect the necessary rate of climb corrections. Charts are given to provide an aid in the reduction of climb data of aeroplanes having modern engine installations.

The method of climb reduction presented is then expressed in terms of the " equivalent climb altitude," which has had wide use in the past. The author feels that this correlation shows the limitation of each method, and when one or the other is best suited. The equivalent climb altitude constant K is shown to depend mainly upon Oswald's aeroplane parameter, which enables K to be readily selected for almost any type of aeroplane. While $K \cong 0.37$ for modern bimotor aeroplanes in two-engine climb, it may increase to $K \cong 0.50$ for the same aeroplane in single-engine flight.

Means for Suppression of Interference Burble. (P. E. Hovgard, J. Aeron. Sci., Vol. 7, No. 1, Nov., 1939, pp. 22-25.) (74/24 U.S.A.)

Low-wing monoplanes using radial engines have been in use long enough so that the manner of designing a fillet for the juncture of wing and fuselage no longer presents a serious problem. Expanding fillets are drawn on preliminary design proposals with reasonable expectation of satisfactory functioning. When the liquid-cooled in-line engine came into use, however, the interference burble again became a problem, and new shapes had to be designed to suppress a premature stall caused by malformations at the leading edge of the wing near the fuselage. This paper deals with the latter type of stall, and particularly with the use of leading edge blisters as a remedy.

Wind-tunnel tests of an early blister indicated that the maximum speed of the aeroplane was reduced about two miles per hour thereby. More recently a blister was designed that effectively delayed the stall and at the same time provided a speed increase of three miles per hour, as indicated by tunnel tests, over the aeroplane without blisters. Possibilities of a blister that will both delay the stall and increase the speed are therefore indicated.

The Effect of Nacelle Propeller Diameter Ratio on Body Interference and on Propeller and Cooling Characteristics. (J. G. McHugh and E. H. Derring, N.A.C.A. Report No. 680, 1939.) (74/25 U.S.A.)

An investigation was conducted in the N.A.C.A. 20-foot tunnel to determine

the slipstream drag, the body interference, and the cooling characteristics of nacelle-propeller combinations with different ratios of nacelle diameter to propeller diameter. Four combinations of geometrically similar propellers and nacelles, mounted on standard wing supports, were tested with values of the ratio of nacelle diameter to propeller diameter of 0.25, 0.33 and 0.44.

The results show that (1) the effect of variation in the ratio of nacelle diameter to propeller diameter on propulsive efficiency is not important until the nacelle becomes approximately one-third of the propeller diameter, but, beyond that point, the propulsive efficiency decreases rapidly with further increase in relative body size; (2) the net efficiency of a nacelle-propeller combination decreases rapidly with increasing values of the ratio of nacelle diameter to propeller diameter; (3) the presence of a spinner over the propeller hub increases the propulsive efficiency by an amount varying from 1½ to 4 per cent.; and (4) the maximum pressure drop available with adjustable cowling flaps is about 20 per cent. greater than the maximum pressure drop available with an adjustable-length cowling skirt.

Meteorological Conditions Associated with Aircraft, Lightning Discharges and Atmospherics. (E. J. Minser, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 51-55.) (74/26 U.S.A.)

From an analysis of a large number of actual cases, lightning discharges to aircraft in flight are determined to be between two oppositely-charged regions in cumulo type clouds and to occur most frequently in the zone adjacent to the freezing isotherm, *i.e.*, from 26° to 34°F. The origin of the electrical charge in cumulo type clouds is explained as resulting from the selective separation of positive and negative ions in the earth's electrical field by cloud and precipitation particles, and final concentration at the freezing isotherm through disruption of rain drops. Flight procedure through cumulo type clouds to avoid lightning discharges should be as follows:—

(1) Avoid, if possible, instrument flight through large cumulo-type clouds, especially at the level where the temperature is between 25° and 35°F.
(2) If, when on instruments, it is apparent from the temperature and degree of static and corona discharge that the aeroplane is in a highly-charged zone, and a discharge is imminent, reduce speed and descend.
(3) If a change in altitude is not possible and reduction of speed does not materially reduce corona or static, keep eyes focused on the instrument panel, which should be brightly lighted at night. This will help to prevent temporary blindness if a discharge occurs near the cockpit.

In no instance was a discharge encountered when this procedure was followed.

Dynamic Problems of the Tricycle Alighting Gear. (J. Wylie, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 56-57.) (74/27 U.S.A.)

After a brief review of the research programme of the Douglas Aircraft Company on tricycle alighting gear, a mathematical analysis is developed for the longitudinal stability of the plane while taxi-ing on the ground. From this analysis certain criteria are developed for the avoidance of porpoising. A second and extremely necessary theoretical analysis of nosewheel shimmy discusses not only the cause, but also the amounts of damping that have yielded satisfactory gears. From the equations and sample figures given, routine calculation only is necessary to compute damping requirements on any installation, provided all constants are given or can be estimated.

A Simple Method of Measuring Landing and Take-off Speed. (C. L. Johnson, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 75-76.) (74/28 U.S.A.)

The usual camera method for measuring landing and take-off speeds is cumbersome and expensive.

The alternative method proposed by the author and stated to give good results is the following:—

A swivelling pitot static head is located on the aircraft away from slipstream and boundary layer effects. The head swivels about the span-wise axis of the aircraft and the total pressure lead only is used during flight. This total pressure K is measured at the instant of ground contact (recorded electrically from the undercarriage). After coming to rest, the aircraft returns to the original landing point, faced into the wind, and the static pressure at the pitot head is measured. Provided the wind speed is not excessive, this static pressure

$= P_0 =$ true static pressure away from aircraft.

Further, if $V_0 =$ true landing speed,

$P_A =$ local static pressure at pitot on landing (depends on pressure distribution round aircraft),

$V_A =$ local velocity at pitot,

we have $P_0 + \frac{1}{2}\rho_0 V_0^2 = P_A + \frac{1}{2}\rho_A V_A^2 =$ total pressure $= K$.

Since ρ_0 is nearly equal to ρ_A, true landing speed $V_0 = \{ 2 (K - P_0) / \rho_0 \}^{\frac{1}{2}}$

Surface Heat Transfer Coefficients of Finned Cylinders. (H. H. Ellerbrock, Jnr., and A. Biermann, N.A.C.A. Report No. 676, 1939.) (74/29 U.S.A.)

1. The surface heat-transfer coefficients of finned cylinders can be correlated for any one air-flow arrangement by plotting a factor involving the surface heat-transfer coefficients, the fin space, and the conductivity of the cooling air against a factor involving the velocity, the density and the viscosity of the cooling air and the fin space, the fin width, and the cylinder diameter.

2. A variation of the initial turbulence in the tunnel airstream for the range covered in the present tests had very little effect on the surface heat-transfer coefficient.

3. The improvement in heat transfer obtained with a fin-plane/airstream angle of 45° as compared with one of 0° is appreciably affected by the value of the space between fins.

4. The pressure difference across a finned cylinder is affected by the fin width, the cylinder diameter, and the front baffle opening in direct proportion to the effect that these three dimensions have on the length of path l as defined in the report.

Siebenthaler De-Icer Spinner. (Inter. Avia., No. 687, 5/12/39, p. 10.) (74/30 U.S.A.)

The Siebenthaler Division of the Aircraft Accessories Corp. has substantially improved its airscrew spinners, widely used by the American air-lines, and made it available for use on both Curtiss and Hamilton airscrews of all current sizes (ranging from 20 in. to 50 in. in diameter). The spinner is mounted, through the use of rubber in shear; two sets of shock mounts on either side of the blades are employed. In rotation the spinner " floats " in a balanced position; the formation of ice on the spinner destroys the condition of balance, allowing the spinner to vibrate and throw off the ice. The slinger ring with the channels to feed the de-icing fluid on to the airscrew blades is cast integral with the bottom part of the spinner.

Operating Temperaturees of Air-Cooled Engine Cylinders of French Transport Aircraft. (Autom. Ind., Vol. 81, No. 11, 1/12/39, p. 572.) (74/31 France.)

The three transport machines investigated are the Potez 62, the Bloch 220 and the Dewoitine 338. The two former are twin-engined, whilst the last is a trimotor. The weights of these machines vary between 16,000 and 25,000 lb. with cruising speeds between 160 and 180 m.p.h. All three machines are fitted with Gnome-Rhone engines and modified N.A.C.A. cowlings.

The following average temperatures were noted under cruising conditions:—

Temperature °F.	Potez	Bloch	Dewoitine
Head	329	338	329
Barrel	158	158	158

Flying with one engine dead, the temperatures become

Temperature °F.	Potez	Bloch	Dewoitine
Head	446	428	392
Barrel	221	230	221

Engine Bearings—from Design to Maintenance. (A. B. Willi, J.S.A.E., Vol. 45, No. 6, Dec., 1939, pp. 513-25.) (74/32 U.S.A.)

There are six major causes of bearing failures, namely, faulty design, purchase based on incomplete specifications, misuse and abuse in operation, faulty installation, unsuitable lubricants and mechanical faults in the bearings themselves. Although there are four general types of bearing materials in common use for main and rod bearings (tin-base babbits, high-lead babbits, cadmium alloys and copper-lead mixtures), it is shown that not one of them is a universal bearing material, but each has its own particular usefulness. These fields are defined in terms of maximum unit pressure, oil reservoir temperature and crankshaft hardness. Design factors which react against indicated satisfactory performance are discussed, including strength and stiffness of the bearing structure, restrictions in feed grooves, oil clearance, etc. Design standards relating to these points are established.

Identification of failure due to misuse is illustrated by means of typical examples.

Vibration Characteristics of Aircraft Engine—Propeller Systems. (C. M. Kearns, J.S.A.E., Vol. 45, No. 6, Dec., 1939, pp. 540-8.) (74/33 U.S.A.)

Complete isolation of the aeroplane propeller from the engine, except for a very flexible torque drive, appears to be the only satisfactory solution of the vibration problem. Under such conditions much lighter propeller blades can be used to maintain even greater horse-powers than are available at present. The problem of vibration characteristics of engine and propeller when operating jointly has recently become practically the determining factor in the selection of the proper propeller for use with a given aeroplane-engine combination. An intensive investigation of this problem from both the experimental and analytical aspects is reported. The various sources of excitation and modes of motion frequently found in present-day power plants are discussed. It is estimated that if all vibratory excitations were removed from the propeller, the specific weight could be reduced to approximately 0.2 lb. per h.p. Stress measurements were made on a propeller operating at 200 per cent. power and 100 per cent. speed rating on an electric whirl rig. The stresses in this case were found to reach only 15 or 20 per cent. of the permissible alternating value for the particular design, and if it had been possible to design the propellers for this alternating stress, a weight reduction of 0.13 lb. per h.p. could be realised.

Stored Energy. (Fuel, Vol. 18, No. 12, Dec., 1939, p. 355. Mech. Eng., Nov., 1939.) (74/34 Great Britain.)

In connection with the study of auxiliary power in aeroplanes, a computation has been made of the weight of various sources of energy with respect to both the weight of the material and the weight of the container, where the latter is required. The following table gives the weights per kw.-hr. of certain sources of energy, as well as the total weight including the container:—

	Weight, lb. per kw. hr.	Total weight, lb. per kw. hr.
Gasoline	0.18	0.20
H_2 gas (in cylinder)	0.06	3.03
H_2 liquid	0.06	0.18
Cartridge	2.78	5.56
Dry battery	45—65	45—65
Storage battery	108	108
Compressed air (100 lb. per sq. in.)	281	881
Compressed air (1,000 lb. per sq. in.)	128	401
Flywheel	302	302
Rubber	1,292	1,292
Steel spring	443,000	443,000

Problems of Submerged Engine Installations. (Inter. Avia., No. 689, 19/12/39, pp. 1-4.) (74/35 Switzerland.)

The main problems confronting the aircraft designer interested in submerged engine installations can be summarised as follows: (1) the design of a satisfactory propeller shaft; (2) the satisfactory and safe disposal of the exhaust gases; (3) cooling of the engine compartment, cylinders, supercharged air, lubricating oil, accessories and exhaust disposal system; (4) the mounting of the engine. In spite of these difficulties, the authors are of the opinion that the advantages of the submerged engine installation makes the solution of the problem worth while. The gains of such a design are almost entirely in the field of aerodynamic performance; increased propulsive efficiency due to the lack of propeller interference with the nacelles; increased lift because the much smaller extension shafts do not blanket or prematurely stall the wing as is the case with the larger nacelles; the reduction of drag due to the elimination of the large nacelles; and the elimination of wing-nacelle interference. Performance calculations on two practically identical aircraft, one with submerged engines and the other with conventional nacelle air-cooled engines of the same power, showed a gain in speed of approximately 7 to 8 per cent. in favour of the submerged installation.

Design of High-Speed Gears. (K. Knibble, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 68-71.) (74/36 U.S.A.)

Designing a successful reduction gear to handle power outputs of modern aircraft engines in excess of 1,000 h.p. has proved to be a very difficult problem.

In the average high speed application, the conventional tooth strength is not the controlling factor. The final step is in the so-called " Wear Factor." This is a function of the surface stresses on the tooth flank. The purpose of the present paper is to supplement this last and most important phase of the gear problem.

The stress on the tooth surface depends upon the radii of curvature as worked out by Hertz.

Upon this is based a method to determine the maximum energy that can be safely transmitted from one gear to another during one revolution.

This quantity of energy, divided by the square of the diameter of the pinion and a constant is called " power-function of the gear " and is a dimensionless quantity. It can be easily determined by a tooth form layout to any enlarged scale.

This power function is calculated with various pressure angles, addenda, and gear ratios.

The above has been applied to actual gears built, and it was found that whenever the power function was increased, the wear qualities also improved. There was no opportunity to test the theory quantitatively.

U.S.A. Aviation Fuel. (Inter. Avia., No. 687, 5/12/39, p. 11.) (74/37 U.S.A.)

With the increase in production of the American aviation industry to meet American defence requirements and the export demand and, perhaps, also due to the beginning of the war, the American petrol industry was faced with the problem of how to increase the output of high octane aviation fuel. The present annual consumption of anti-knock aviation fuels in the U.S.A. alone is estimated at 20,000,000 U.S. gals., and the present annual output is estimated at 37,000,000 gals. By the expansion of existing plants and the erection of new ones, this production is to be stepped up to 125,000,000 U.S. gals. annually within one year. Greater quantities of fuel would then be available for export. The Standard Oil Development Company is understood to be specially concerned in the development of anti-knock fuels.

The Characteristics of Atmospheric Type Burners when Used with Natural Gas. (E. D. Howe and H. Johnson, Trans. A.S.M.E., Vol. 61, No. 8, Nov., 1939, pp. 673-7.) (74/38 U.S.A.)

In this paper it is determined that the design of atmospheric-type gas burners depends upon the stability of the flame produced, which is related to the speed of flame propagation in the combustible mixture. Experiments made upon single-port gas burners have served to show that the effective velocity of flame propagation is greater than the velocity of flame propagation in still mixtures.

Lubricants from Fish Oil. (Ind. and Eng. Chem. (Industrial Edition), Vol. 17, No. 22, 20/11/39, p. 710.) (74/39 Japan.)

The Japan Oil and Fat Company has decided to industrialise its process of manufacturing aircraft lubricants from fish oil. A site for the plant has been selected near Japan Oil's Amagasaki factory. Besides whale oil, sardine and herring oils will serve as raw materials. The oil produced by the company's secret process is supposed to be superior in quality.

Researches on the Activity of Castor Oil. (J. J. Trillat and P. Nardin, Pub. Sci. et Tech., No. 152, 1939.) (74/40 France.)

The surface tension between two liquid phases is considerably modified by presence of other substances in one of the phases, owing to adsorption in the transitional layer of molecules or particles capable of modifying the total energy of the system. Considering an oil as a mixture of active and neutral molecules, it is to be expected that the concentration of one type of molecules will be modified in the separation layer oil/liquid, causing a variation in surface tension. Systematic study of this phenomenon as a function of time has previously been carried out by putting distilled water into contact with a pure paraffin oil (neutral molecules) in which increasing quantities of oleic acid (active molecules) are dissolved. In the present paper measurements have been made of the interfacial tension of pure water in contact with specifically active oils, i.e., consisting entirely of active molecules. With these oils there was again found a lowering in interfacial tension in relation to time of contact. In this case the interfacial tension is a function of the orientation of the molecules in the transitional layer and the recorded curves show the variations of this orientation as a function of time. It is deduced that organisation of the molecules takes place rapidly at the commencement of contact and then is completed slowly. With increasing temperature the recorded variations in interfacial tension decrease and are practically eliminated at about 40°C. Since castor oil is practically insoluble in water it is mainly the phenomena of orientation at the interface which cause these variations and it is thus possible to interpret the effect of temperature.

Thermal Study of the Oxidation of Motor Fuels. (Mme. Dufour-Estradère, Pub. Sci. et Tech., No. 154, 1939.) (74/41 France.)

An experimental study is made of the mechanism of the slow oxidation of hydrocarbons, which, as has previously been shown by the author, takes place in successive stages. The thermal effects of these reactions are studied and it is shown that in certain cases the laws of the kinetics of chain reactions are defective. It is then a matter of reactions in "thermo-accelerated ramified chains." The conditions in which cracking plays a part during the course of oxidation is also examined, this effect varying greatly according to the hydrocarbon concerned. Passing to the study of petrols it is shown that the thermal effect accompanying their oxidation is all the more feeble as the octane number is higher, even if the high octane number is the result of addition of an anti-detonating agent.

1. CONTENTS.—Combustion of hydrocarbons, successive phases of oxidation in the temperature scale; kinetic laws governing the combustion of hydrocarbons; interpretation of the thermal diagrams for pentane according to these laws. 2. Occurrence of cracking during oxidation; method of investigation; relation between cracking and knock susceptibility. 3. Diversity of observations made during thermal analysis by the method described. 4. Possibility of generalisation of the kinetic laws and application of thermal analysis to the study of petrols.

Problems of Mass Production of Aircraft. (Luftwissen, Vol. 6, No. 7, July, 1939, pp. 223-224.) (74/42 Germany.)

At a recent meeting of the Lilienthal Society, a number of papers were presented dealing with the subject of production. The following are some of the conclusions reached.

1. From the point of view of efficiency and cost it is advantageous to carry out the entire manufacturing process under one roof. This, unfortunately, conflicts with A.R.P. requirements.

2. For a given factory, the man-hours required per aircraft depend on the number of machines passing through the shops and the position in the series. As a result of extensive research it is now possible to estimate the total time for a series if the man-hours for the prototype are known.

3. In order to stimulate production, a wage bonus is paid depending on the position of the machine in the series. This bonus in some cases depends also on the amount of skill required by the workman.

4. Changes in design during production add enormously to the cost and for this reason sufficient time must be allowed for the first series to incorporate any necessary modifications. Large scale production should only be started after complete agreement has been reached between the design and production departments.

5. Cost can be reduced and floor space saved by reducing the number of special appliances, jigs, etc., to the utmost. Those ultimately retained should, if possible, always serve a variety of purposes and be made of the cheapest material.

6. A further effective way of reducing costs consists in modifying manufacturing processes, e.g., the extensive use of pressed components instead of riveted assemblies.

Shear Field Aircraft Spars. (J. E. Lipp, J. Aeron. Sci., Vol. 7, No. 1, Nov., 1939, pp. 1-5.) (74/43 U.S.A.)

Experience has shown that the intrinsic cost of manufacture of shear-web spars (Wagner type) is the lowest of all types of spars.

Apart from low cost, an aircraft spar must possess other features, chief of which are:—

1. Low vulnerability (high degree of redundancy).

2. Low weight.
3. High rigidity.

From investigation carried out by the Douglas Aircraft Co., it appears that the Wagner type of shear field spar fulfils the above requirements and has therefore been generally chosen for wing and tail surface construction.

The author describes how thickness of web and size of stiffeners can be selected to fulfil certain load conditions.

Web thicknesses may range from .02 to .08 inches and above. The allowable shear stress increases with thickness of sheet from 18,000 lb./in.^{2} at 0.2 to 25,000 lb./in.^{2} at .08 for 24 Stal material.

Webs thinner than .02 in. are not used on account of riveting difficulties.

Occasionally a large access hole must be put through a spar web. In this case the type of framework around the hole depends upon the loads involved. An efficient type developed by the Douglas Company is in the form of a diagonal truss, the truss members being made of extruded bulb angles fastened to the web surrounding the hole. Gussets are added at the four corners of the diamond.

Synthetic Bearings for Rolling Mills. (C. D. Phillipe, Met. Ind., 15/12/39, pp. 503-6. Met. Vick. Tech. News Bull., No. 690, 22/12/39, p. 5.) (74/44 Great Britain.)

In this article, the author classifies plastics as thermoplastic, or as thermohardening materials and describes the manufacture and properties of the phenol-formaldehyde resins which he places in the latter classification. The main classes of material derived from these resins are (1) moulding materials, (2) paints, varnishes and lacquers, (3) laminated materials. The manufacture and characteristics of laminated materials are described and points, economic and mechanical, which are in favour of the use of these materials as bearings, are listed. Some practical applications will be discussed in a subsequent article.

Illustrated with one photograph and three diagrams.

A Rapid Method for Determining Carbon in Plain Carbon Steels for Control Purposes. (Trans. A.F.A., Dec., 1939, pp. 469-90. Met. Vickers Tech. News Bull., No. 690, 22/12/39, p. 10.) (74/45 U.S.A.)

The method described in this article consists of comparing the magnetic permeability of a bar of known carbon content, with the magnetic permeability of the bar of unknown carbon content. The actual magnetic permeabilities are not measured, but the effect of the difference in induced emf. existing in coils, by the collapse of induced magnetic flux is measured with a ballistic galvanometer. The deflection of the galvanometer depends on the difference of carbon content in the two bars. It is claimed that the time taken in determining carbon content of steels by this method is not over 2.5 min. as compared with 5 min. or over for chemical methods. The effect of alloying elements, such as manganese, silicon, nickel and molybdenum on the accuracy of the method are discussed.

Illustrated with one photograph, one diagram and four graphs.

Bearing Testing Machine for Different Types of Loads. (E. A. Cornelius and E. H. Barten, Z.V.D.I., 18/11/39, pp. 1219-21. Met. Vick. Tech. News Bull., No. 690, 22/12/39, p. 6.) (74/46 Germany.)

The authors describe a new machine developed for the purpose of carrying out tests, in one machine, on bearings under loads of different types (rotating, sinusoidally oscillating, rapidly variable, combined). They give details of the design and principle of operation of the machine, also of the trial run and the first test results obtained.

Illustrated with four diagrams and two photographs.

Testing Gear Wheel Material. (A. Meldahl, B.B. Rev., Oct., 1939, pp. 235-40. Met. Vickers Tech. News Bull., No. 690, 22/12/39, p. 6.) (74/47 Great Britain.)

In connection with gear wheel material testing, the author points out the desirability of using test pieces of simple design, and that in order to reproduce faithfully the conditions pertaining to teeth faces, it is necessary to generate a sliding movement, as well as a rolling movement, between the test faces. Apparatus in which it is claimed that these conditions are satisfied is described in this article. Results of tests are given, and the operation of the machine is investigated from a kinematical point of view.

Illustrated with two diagrams, eleven photographs and one graph.

Heat Treatment Department. (J. Bentley, El. Engineer, 15/12/39, pp. 190-3. Met. Vickers Tech. News Bull., No. 690, 22/12/39, p. 8.) (74/48 Great Britain.)

This article deals with the electrical installation and equipment of a heat treatment department. The author discusses the size and rating of furnaces, and in connection with choice of resistance material, the use of nickel chrome alloy is advocated. Supply transformers, temperature control devices, contactor and busbar arrangements are discussed and notes on the control of maximum demand are given. The position of control instruments and thermocouple leads is discussed.

Illustrated with six diagrams and one photograph.

Preparation of Metals in a Compact Form by Pressing and Sintering. (J. D. Fast, Philips Tech. Rev., Nov., 1939, pp. 310-6. Met. Vickers Tech. News Bull., No. 690, 22/12/39, p. 9.) (74/49 Great Britain.)

Due to their high melting points, the metals tungsten, molybdenum tantalum, etc., cannot easily be melted or cast. These metals can, however, be prepared in powder form. This article describes the preparation of the compact metal, by methods of powder metallurgy. A general discussion is given of the preparation and working of ductile tungsten for the electric lamp industry and the preparation and use of hard cemented carbides as cutting tools is reviewed. The use of self-lubricating bearings, prepared by powder metallurgical methods, is noted.

Illustrated with two diagrams and six photographs.

Vulcanisation of Rubber. (H. L. Fisher, Ind. and Eng. Chem. (Industrial Edition), Vol. 31, No. 11, Nov., 1939, pp. 1381-1389.) (74/50 U.S.A.)

The early history of vulcanisation and the beneficial changes wrought on rubber by Goodyear's famous process are reviewed. An outline is given of the methods used in vulcanisation, the principal facts, and the theoretical considerations of the chemistry involved. Non-sulphur vulcanising agents are listed, including some not previously described (yellow mercuric oxide, and the combination of phenols and oxidising agents). A comparison of their chemical activity brings forth the generalisation that probably in all cases a reduction and an oxidation take place. If the agent is already in the reduced state, then it is necessary to add an oxidising agent. An oxidising agent generally makes a better vulcanisate with almost all non-sulphur agents. The reduced form probably adds to the rubber hydrocarbon, and this addition product is then oxidised to make the vulcanisate.

Since all vulcanisates have certain characteristics in common, it is postulated by analogy that some of the sulphur during vulcanisation is reduced to hydrogen sulphide, that the hydrogen sulphide adds to the rubber hydrocarbon forming a mercaptan, and that this mercaptan is oxidised by some of the sulphur to form a disulphide which may connect two sections of the same or of two different molecules. It is shown that many of the facts of sulphur vulcanisation are explained by this theory.

Determination of Cross-Sectional Areas of Structural Members. (J. A. Miller, Bur. Stan. J. Res., Vol. 23, No. 5, November, 1939, pp. 621-636.) (74/51 U.S.A.)

The cross-sectional areas of structural members are often required for computing the stresses corresponding to the applied loads. The areas of many light-weight members cannot be obtained accurately from either nominal or measured dimensions. For example, in thin-walled members small differences in thickness cause large percentage errors in area. Moreover, the shape of a section may not permit adequate measurements of the dimensions required to calculate the area. In such cases it is often advantageous to obtain the average cross-sectional area by a volumetric method if the cross-section is uniform. If the cross-section varies in area from section to section the area of a given section can sometimes be obtained from the average area of a short specimen taken from that location.

The method is illustrated by a determination of cross-sectional area for a typical airship box girder, fabricated from sheet aluminium alloy. The cross-sectional area varied because of a row of flanged circular lightening holes along each side and was a minimum at sections through the centres of the holes. Specimens 0.3 inch long were taken symmetrical to a minimum section. The end surfaces were ground smooth and nominally parallel so that the lengths could be measured accurately. The volume was determined by hydrostatic weighing. A correction was applied to the average cross-sectional area of these specimens to obtain the minimum cross-sectional area. The estimated uncertainty of the determination was ± 0.4 per cent.

Stress Functions for a Plate Containing Groups of Circular Holes. (R. C. J. Howland and R. C. Knight, Vol. 238, No. 793, 24/11/39.) (74/52 Great Britain.)

A number of solutions of the biharmonic equation have been obtained, mostly in connection with the problems of generalised plane stress, when the boundaries have consisted of circles and straight lines. No general method of solution can be given but the methods which the present authors have used in certain cases are here extended to a group of problems. The paper deals with circles in (a) the infinite plane, (b) a strip bounded by parallel lines. The circles, their numbers and relative positions, are restricted by an invariancy condition, which demands that the circles and their boundary conditions remain invariant under one or more of a group of transformations and/or reflections.

In (a) the configurations have the boundaries (i) one pair of circles, (ii) two pairs of circles, (iii) a double infinite row of circles. While in (b) (i) one pair, and (ii) two pairs of circles are dealt with. These together with solutions previously published complete the group of problems to which the method is applicable.

A Recurrence Formula for Shear-Lag Problems. (P. Kuhn, N.A.C.A. Tech. Note No. 739, Dec., 1939.) (74/53 U.S.A.)

The analysis of the bending action in box beams with appreciable shear deformation of the flanges becomes very difficult in the general case of variable cross-section and loading. This paper presents a convenient method of solving the problem by the familiar method of dividing the beam into a number of bays that can be assumed to have constant cross-section and loading. Application of formerly derived shear-lag formulas leads to a general equation closely analogous in form to the well-known three-moment equation. A numerical example and two comparisons between calculation and experimental results are included. In one of these cases the agreement is satisfactory. Discrepancies in the other case may be due to faulty material.

Stress Concentration Around an Open Circular Hole in a Plate Subjected to Bending Normal to the Plane of the Plate. (C. Dumont, N.A.C.A. Tech. Note No. 740, Dec., 1939.) (74/54 U.S.A.)

The test results obtained with a plate containing an open circular hole, whose diameter is relatively large compared with the thickness of the plate and subjected to uniform bending normal to the plane of the plate may be summarised as follows:

1. Stress concentrations occurred at the edge of the hole, the maximum stresses being tangential to the hole at the ends of the transverse diameter.

2. The maximum stress at the edge of the hole was 1.59 times the computed stress on the net section and 1.85 times the computed stress in a solid plate of the same dimensions subjected to the same bending forces.

3. The smallest edge distance was equal to 2-1/2 times the diameter of the hole, and the stress concentration on this side of the hole was the same as on the side where the edge distance was about 4-1/2 diameters.

4. A theoretical analysis of the problem shows that, for an aluminium plate of infinite width, the stress concentration at the edge of the hole would be 1.87 times the stress in a solid plate, which is substantially the same relation obtained on the plate tested.

5. From the foregoing, it may be concluded that the stress-concentration factor based on gross area would be the same for any width of plate provided that the edge distance was at least 2-1/2 diameters.

6. The maximum deflections were about 20 per cent. greater than the corresponding deflection for a solid plate of the same size subjected to the same bending forces.

Tide Water and Weather Exposure Tests on Metals Used in Aircraft. (W. Mutchler and W. G. Galvin, N.A.C.A. Tech. Note No. 736, Nov., 1939.) (74/55 U.S.A.)

Tide water and weather exposure tests on various aluminium alloys, magnesium alloys, and stainless steels are now being conducted by the National Bureau of Standards. Exposures were begun in June, 1938, and, according to present plans, are to continue over a three-year period. The methods of exposure and the materials being investigated are described and some of the more important results obtained up to the conclusion of the first year's exposure are given below.

1. Alloy 52S-1/2H (a binary alloy containing app. 2.5 per cent. Mg.) is the most corrosive resistant of the A1 alloys tested and also the one least attacked when in contact with other A1 alloys, magnesium alloys or stainless steels.

2. Stainless steel containing Mb proved more resistant than the normal varieties. An alloy containing 16 per cent. Cr and 1 per cent. Ni was very much more corroded than the other stainless steels.

3. Magnesium alloys are much more susceptible to attack than either A1 alloys or stainless steels. Contact between magnesium alloys and stainless steels should specially be avoided.

4. Magnesium alloys can be adequately protected against very severe corrosive conditions by suitable choice of surface treatment and paints applied.

Photo-Elastic Analysis of Three-Dimensional Stress Systems Using Scattered Light. (R. Weller and J. K. Bussey, N.A.C.A. Tech. Note No. 737, Nov., 1939.) (74/56 U.S.A.)

A method has been developed for making photo-elastic analyses of three-dimensional stress systems by utilising the polarisation phenomena associated with the scattering of light. By this method, the maximum shear and the directions of the three principal stresses at any point within a model can be determined, and the two principal stresses at a free-bounding surface can be separately evaluated. Polarised light is projected into the model through a slit so that it illuminates a

plane section. The light is continuously analysed along its path by scattering and the state of stress in the illuminated section is obtained. By means of a series of such sections, the entire stress field may be explored. The method was used to analyse the stress system of a simple beam in bending. The results were found to be in good agreement with those expected from elementary theory.

Research into Corrosion and the Protection of Light Alloys. (A. von Zeerleder, Inter. Avia., No. 690, 29/12/39, pp. 1-4.) (74/57 Switzerland.)

According to the type of attack, one may distinguish between general, local and intercrystalline corrosion.

General corrosion is uniformly distributed over the entire surface of the metal and can only occur if the corrosive media dissolve the oxide film which normally acts as a protection.

Local corrosion is provoked by local galvanic couples due to the presence of heterogeneous alloy particles or impurities in the surface or simply due to uneven oxygen distribution over the surface. In this case the corrosive agent does not act as an oxide film solvent but as an electrolyte for the local couples.

Intercrystalline corrosion is the most dangerous form of attack, since it disintegrates the material internally without much apparent surface effect.

Aluminium alloys containing copper or magnesium are particularly liable to this last form of corrosion if the heat treatment is incorrect.

In the case of alloys of the Dural type, experiments have shown that the time interval between tempering and quenching is of importance in determining tendency to intercrystalline corrosion. The exposure time to the air, between these two operations must be short enough (a few seconds) to prevent the precipitation of alumide of copper as a continuous film in the intergranular space.

This film is less " noble " than the mixed crystals of the alloy and is thus liable to be dissolved by the formation of galvanic couples in the presence of an electrolyte.

The Buckling of Spherical Shells by External Pressure. (Th. von Kármán and H. S. Tsien, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 43-50.) (74/58 U.S.A.)

Up to now considerable discrepancy has existed between theory and experiment in the case of the buckling of spherical shells under uniform external pressure. It appears that the experimental buckling load is of the order of $\frac{1}{4}$ of the theoretical value. Whilst theory indicates a wave form extending over the whole spherical surface with no preference as regards inward or outward buckling, the experiments show a definite preference to buckling inward, the buckling wave being, however, restricted to a relatively small dimple. The author removes the discrepancy by showing that there exists an "upper" buckling load given by the classical theory of infinitely small deflections and a " lower " buckling load which is equal to the minimum load necessary to keep the shell in a buckled state with a finite deflection. The essential feature of his theory is that the lower buckling load is determined independently of initial imperfections of the specimen or load arrangement.

The upper limit of the buckling load can only be approached experimentally if extreme precautions are taken and the lower value is the one to be specified for design.

A Fixture for Obtaining Pin-End Conditions in Column Testing. (H. W. Barlow, J. Aeron. Sci., Vol. 7, No. 2, Dec., 1939, pp. 72-74.) (74/59 U.S.A.)

Difficulties attending the use of rollers, knife-edges and other devices used for obtaining ideal hinged-end conditions for tests of columns are discussed briefly. A new testing fixture is described which incorporates ball-bearing assemblies and gives hinged-end results for specimens having flat, parallel ends. Corrections for effective free-lengths are unnecessary. Results of tests on columns fabricated

from thin stainless steel sheets are given to indicate the quality of the results. Possibilities for improvements and further application to tests of elastically restrained columns, eccentrically loaded columns, and sheet-stringer combinations are suggested. The ball-bearing assemblies utilised have the advantage of being commercial products and at the same time extremely accurate.

Stroboscopic Light Source. (H. E. Kallmann, Proc. Inst. Rad. Eng., Vol. 27, No. 11, Nov., 1939, pp. 690-692.) (74/60 U.S.A.)

Stroboscopic light sources are widely used for observation of fast movements. The use of mechanical light-chopping devices is restricted to low frequencies, and is generally inferior to gas-discharge lamps, which are very satisfactory up to flash frequencies of about 20 kilocycles but at higher flash frequencies seem to become impracticable because the inertia of gas molecules prevents an adequately quick discharge. Only spark discharges can at present be used for observation of the very fast movements of sound waves or of projectiles.

The author describes an alternative method in which a blocking oscillator is used, producing short pulses of several ampères of anode current in a vacuum tube. The anode is covered with fluorescent material which thus produces the stroboscopic flash, which may readily reach 10,000 candle power. Flash frequencies of the order of 200,000/sec. can be obtained, each flash lasting about 1/5,000 sec.

The Anode Tank Circuit Magnetron. (E. G. Linder, Proc. Inst. Rad. Eng., Vol. 27, No. 11, Nov., 1939, pp. 732-738.) (74/61 U.S.A.)

A new type of magnetron is described in which the split cylindrical anode is made approximately one-quarter wave in length, the two segments being short-circuited at one end. The anode resonates and acts as a tank circuit. Thus difficulties due to interelectrode capacitance and tube lead inductance are circumvented and a much greater heat radiating area is provided. An output of 20 watts at 3,750 megacycles (8 centimetres wavelength) and an efficiency of 22 per cent. is obtainable. The theory of the anode tank circuit is developed, and expressions are given for wavelength, internal resistance, and logarithmic decrement.

Ultra High-Wireless Frequencies and Their Application to Aeronautics. (W. E. Jackson, J. Aeron. Sci., Vol. 7, No. 1, Nov., 1939, pp. 28-29.) (74/62 U.S.A.)

At the present moment most aviation aids for civil aircraft in the U.S.A. operate on a frequency range of 200--400 kilocycles. Frequencies of this order are subject to atmospheric interference, rain, snow and dust static and multiple course phenomena caused by reflections from the earth's surface. Recently a number of position markers operating at a frequency of 75 megacycles have been installed. These markers are known as the "Z" (or "positive cone of silence marker") and fan (F.M.) markers respectively. The former is intended to mark the instant the aircraft passes over the markers, whilst the fan marker, by the elliptic shape of its field pattern, gives positive indication of a traffic control reporting point on the airway. Both markers in addition to providing audio signals in the headphones also operate lights in the cockpit.

Another application of ultra-high frequencies is to provide a system of instrument landing. The elements of such a system are the localiser, glide path and markers. The localiser is a visual type of radio range whilst the glide path is a vertical plane field pattern contour of constant field strength. Inner markers are located at the edge of the field whilst the outer markers are situated at a distance of approximately 2 miles. The localiser operates at a frequency of 109.9 megacycles whilst the glide path has a frequency of 93.9 megacycles.

A trial system working on the above lines is being installed by the Civil Aeronautics Authority at Indianopolis. Development work is proceeding in order to

obtain a straight line glide path which appears to offer several important advantages.

Results obtained so far with ultra-high frequencies are very encouraging and such frequencies will play an important part in aviation of the future.

Apparatus for Magnetic Testing at Magnetising Forces up to 5,000 Oersteds. (R. L. Sanford and E. G. Bennett, Bur. Stan. J. Res., Sept., 1939, pp. 415-25. Met. Vick. Tech. News Bull., No. 690, 22/12/39, p. 10.) (74/63 U.S.A.)

This article describes an apparatus for general magnetic testing in the range of values of magnetising force from 100 to 5,000 oersteds. Specimens of rectangular cross-section up to 3.8 cms. wide and 1.9 cms. thick can be tested. It is estimated that under favourable conditions values of induction or magnetising force accurate within 0.5 per cent. can be obtained and that under ordinary conditions of routine testing, the accuracy is within 1 per cent. Details of experiments carried out to determine the distribution of flux in the specimen are given. It is claimed that this apparatus is simple to operate, and does not heat the specimen.

Illustrated with two photographs, four graphs and one diagram.

The Electrical Resistance of Metal Contacts. (J. J. Went, Philips Tech. Rev., Nov., 1939, pp. 332-5. Met. Vickers Tech. News Bull., No. 690, 22/11/39, p. 9.) (74/64 Great Britain.)

The electrical resistance of contacts depends in the first instance upon the specific resistance of the material of the contacts, the hardness of the material, and the contact pressure. In addition, the properties of the surface of contacts are also important. On the basis of these factors, a study is made in this article, of the methods by which a high resistance contact may be improved.

Illustrated with two graphs and two diagrams.

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Under-Secretary of State (R.T.P.), Air Ministry, Dept. Z.A., London, W.C.2, and will be supplied as far as availability of stocks permit. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

THEORY OF WARFARE.

TRANSLATION NUMBER AND AUTHOR.	TITLE AND JOURNAL.
985 Possio, C.	*Lateral Firing from Aircraft.* (Turin Polytechnic Aeronautical Laboratory Report, No. 120, March, 1939, XVII.)
999 Templehof von ...	*Improvements in the Technique and Tactics of Gas Warfare Since the Great War.* (Z.G.S.S., Vol. 34, No. 5, May, 1939, pp. 148-51.)

AERO AND HYDRODYNAMICS.

980 Sottorf, W.	*New Method for Determining the Full-Scale Gliding Resistance of Floats and Boats from Model Experiments.* (L.F.F., Vol. 16, No. 8, 20/8/39, pp. 412-8.)