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Dollar Values in Airplane Design. (K. Perkins, Journal of Aeron. Sciences, Vol. 4, Feb., 1937, pp. 139-148.) (56/1 U.S.A.)

In view of the present interest in mass production, attention is called to an equation proposed by the author for determining manufacturing cost.

Cost per aircraft in dollars

$$= [WA/qn + pB + WC/qs\,(1+b)]\,(1+r/q)$$

where W = complete empty weight of aircraft (lb.).
q = number of machines built in one lot.
p = total rate brake horse-power.
B = cost of engine with all accessories and instruments (per b.h.p.).
C = cost of labour for one aeroplane per lb. weight.
A = cost of material for one aeroplane per lb. weight (excluding engines and instruments).
b = ratio of factory overhead to direct labour cost.
r = ratio of total development cost to production cost per aeroplane.

In the case of all-metal military aircraft

$B = 15$; $b = 0.9$;
$C = 5.6$; $r = 5$;
$A = 1.2$;
n = material quantity exponent $= 0.075$;
s = labour quantity exponent $= 0.30$.

Taking 100 machines, this becomes, per lb. of aircraft:—

Cost of material = \$1.7.
Cost of labour = \$1.4.
Cost of overhead = \$1.3.
Total cost of frame = \$4.4 per lb.
= 17/6.

(See also Abstracts No. 42, item 12.)

On the Maximum Error in a Series and the Dispersion of a Volley. (O. v. Eberhard, Z.A.M.M., Vol. 18, No. 2, April, 1938, pp. 128-35.) (56/2 Germany.)

The author shows, in the case of m series of observations, how to calculate the probable error of the single observation from the maximum apparent error of each of the m series. The same method is applied to the determination of the probable error from the total dispersion obtained in m groups of hits.

On the Lessons to be Drawn from the Spanish Aerial War. (L'Aeronautique, Vol. 20, No. 227, April, 1938, pp. 69-70.) (56/3 France.)

1. There is no doubt that the various governments, supplying aircraft to Spain, have gained valuable experience as to the reliability and ease of maintenance under active service conditions.

2. The number of aircraft is much too small to enable any definite opinions being formed as to the possibility of obtaining a major decision by aircraft alone.

3. The conditions in Spain are peculiar in that poison gas has, so far, not been employed by either side.

The war can thus scarcely be classified as "modern," and any deductions have to be treated accordingly.

4. The fact that this is a civil war may account, to some extent, for the evident reluctance to subject large towns, such as Madrid, to a ruthless attack by all available means.

In a major war such an attack would be carried out by the simultaneous action of 3-4,000 aircraft. (It is estimated that the whole of the air force available in Spain does not amount to more than 700 machines on either side).

A New Type of Aerial Mine. (Kjerstrom, U.S. Nav. Inst. Proc., Vol. 64, No. 5, May, 1938, p. 765.) (56/4 Sweden.)

A new type of aerial mine has been invented by the Swedish engineer Kjerstrom. These mines are suspended under captive balloons whose height and situation can be controlled from the ground. They are fitted with an apparatus for detonation by means of high frequency radio waves. The mines are to contain one of the following ingredients: high explosive; poison gas; smoke; or metal dust. The latter is favoured, as it covers so much territory, and is guaranteed to ruin any aeroplane engine which comes into contact with the dust. Metal dust filling for shells is also to be used with anti-aircraft guns.

Lessons from the Spanish Aerial War. (A. Langeron, Les Ailes, No. 884, 26/5/38, p. 11.) (56/5 France.)

The following are the main conclusions:—

(1) There is no danger from A.A. artillery at 6,000 m. It is essential that the crew be protected against the cold at altitudes of this order.

(2) Armour plating, fitted to the back and seat, has proved very effective in protecting single-seater fighters.

(3) The result obtained by the relative small number of aircraft employed in Spain indicate that the air arm may, by itself, force a decision provided sufficient machines are available (several thousands).

(4) Superiority of speed is of paramount importance, not only from the tactical point of view, but also, because it raises the morale of the aircraft crew.

Formation Flying for Bombers. (C. Pigeon, Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 366-378.) (56/7 France.)

From the point of view of defence against fighters, the author recommends:—

(1) The bombers fly in a plane inclined forward at an angle of approximately 15° with the vertical.

(2) The formation in this plane is in the form of a symmetrical figure (flattened polygon).

(3) The maximum span of the formation (width at right angles to trajectory) must not exceed 200 m.

When attacking an objective defended by A.A. artillery, the formation should be such that successive aircraft pass the target under different bearing angles. This entails a spreading out of the formation from that previously adopted against fighters. Examples of suitable manœuvres are illustrated.

The Military Application of Light Aeroplanes. (Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 363-5.) (56/6 France.)

There is no doubt that light slow speed aircraft, operating at feeble altitudes in proximity to artillery positions, would be very useful for spotting purposes. It appears, at first sight, as if the " autogiro " would fulfil all requirements in this direction. Recently, however, fixed wing aircraft have been designed which approximate closely to the " autogiro " performance with the additional advantages of greater mechanical reliability and pay load. A specification for such an aircraft would be the following:—

Normal altitude	300 m.
Time to reach this	2 minutes.
Max. speed	190 km./h.
Min. speed	50 km./h.
Landing run	70 m.
Take-off run	150 m.
Endurance	2 hours at cruising speed.
Armament	Nil.
Useful load	250 kg. (pilot, observer, wireless).

It appears that Germany is designing aircraft of this type.

The " autogiro " would, however, be very useful for Red Cross work near the front line (collection of wounded, etc.), and since this type of aircraft is easily distinguished, the author enters a plea for its international recognition for work of this nature.

Armament Patents Purchased by the Junkers Firm. (Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 475-478.) (56/8 Germany.)

The two patents (No. 676,264 and 751,572) were originally taken out by F. Mannebach in 1929 and 1933, respectively.

The former refers to a pivoted gun mounting in aircraft characterised by the fact that the weight of the operator, sitting on a portion of the mounting, is practically balanced by the weight of the gun. The elevation of the gun is, thus, controlled by a slight leg action whilst orientation in a horizontal plane is effected by a servo motor. The second patent refers to gun operation at high altitude, the operator being in a sealed cabin with the gun outside. Various types of control mechanisms for the gun are described.

Military Aspects of Civil Aviation. (C. Rougeron, Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 379-397.) (56/9 France.)

Commercial aircraft differs from other means of transport in that it is still available when other means may become impossible, due to enemy action (destruction of roads and railways, blockade of harbours). From the military point of view it has the additional advantage that the civil machine can be very easily transformed into an offensive weapon. It is therefore not surprising that civil aviation is subsidised by the various governments and severe restrictions are applied by certain countries as to landing and transit rights. Unlike the sea, which is free to all, the air is becoming nationalised and unless international agreement is reached, it appears quite possible that a country possessing favoured air routes may be able, in the future, to derive sufficient commercial revenue by forcing out competitors to defray a considerable proportion of its military budget.

Aircraft Armament Research in 1910-11. (L. C. Bellenger, Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 398-424.) (56/10 France.)

The author gives a most interesting account of work carried out at Vincennes, in the year 1910, under the general direction of Col. Etienne. It appears that the first official bomb dropping experiments were carried out that year in the

U.S.A. It was soon realised that the chance of hitting a restricted military target was very small, whilst the indiscriminate bombing of civilians in towns was considered contrary to international law.

As the restricted weight carrying capacity of aircraft of this period prevented the dropping of a sufficiently large number of bombs to allow for dispersion, attention was given to an alternative, the light weight metal dart. It is interesting to note that at this period, a proposal to fit a machine gun to the aircraft was turned down by the French War Office, partly because it was thought to endanger the structure of the aircraft and partly because it interfered with what was considered the primary duty of the aircraft crew, *i.e.*, ground observation.

Some Contracts Placed by the U.S. Army Air Corps in 1937. (Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 459-460.) (56/11 U.S.A.)

The following are the average prices paid, per machine, and include spares:—

Type	Number ordered	Cost per machine
Sikorsky Amphibian S.43	6	£21,000
Boeing B.17 4-engined bomber	13	£38,000
Douglas 2-engined bomber	177	£13,000
North American Trainer	73	£2,400
North American Fighter	95	£3,200
Curtiss Fighter P.36	210	£4,000
Douglas Fighter A.17A	29	£4,400
North American Reconnaissance	55	£6,000
Kellet Autogiro	6	£8,000

The Choice of Calibre for A.A. Artillery. (R. Maurer, Rev. de l'Arm. de l'Air, No. 105, April, 1938, pp. 433-436.) (56/12 France.)

At the present moment there exists two distinct classes of A.A. artillery; long range guns using explosive shells fitted with time fuses and short range guns using percussion ammunition.

It is obvious that the chance of hitting fast moving aircraft depends on the time taken for the projectile to reach the target, the type of shell (*i.e.*, whether a direct hit is required or whether an explosion in the close proximity suffices) and the rate of fire. There is no doubt that for altitudes above 4,000 m., calibres in excess of 3in. are required, the shell being fitted with a time fuse. In this case the necessary rate of fire is obtained by grouping a number of guns. It has been suggested that all altitudes below 4,000 m. can be successfully covered by automatic guns of 1.5in. calibre.

The author, however, points out that these light weight projectiles are not ballistically efficient and that the increase in rate of fire is not sufficient to compensate for the increase in dispersion. Time fuses on such small shells are not satisfactory, and an urgent plea is entered for the retention of 3in. calibre guns for altitudes between 2,000-3,000 m., the smaller calibre 1-1.5in. being used for altitudes below this.

The provision of three types of guns necessarily complicates the equipment of the A.A. artillery, but it is held that this is unavoidable.

Fighters v. Modern Bombers. (C. Pigeon, Rev. de l'Arm. de l'Air, No. 103, February, 1938, pp. 125-142. Available as Translation No. 649.) (56/13 France.)

The author investigates the case of a fighter attacking bombers from the rear. Mutual fire is assumed to start at a distance of 600 m., the fighter gradually overtaking the bomber. Depending on the number of guns in action, their rate of fire and dispersion as well as the relative size of the two targets, the difference in probability, of the fighter hitting the bomber or vice versa, reaches a maximum at some definite distance of approach. At this point the fighter breaks off the action and retreats, still keeping in line with the tail. After reaching the maximum distance of 600 m., the attack is repeated or the fighter replaced by a second machine.

The case of simultaneous attack by several fighters on one bomber formation is also considered as well as the relative advantages of cannon and machine gun. It appears that unless the bombers can maintain close formation at high speed, the fighter fitted with four machine guns constitutes a very dangerous adversary.

The general conclusion which may be drawn from the above is that high rate of fire is of the utmost importance.

Measurement of Wake. (F. Horn, Eng. Absts., Vol. 1, No. 3, Section 3, April, 1938, p. 21. Trans. of N.E.C. Inst. of E. and S., 31/3/38.) (56/14 Great Britain.)

The author discusses the analysis of wake into its various components—streamline, frictional and wave wake—and compares different methods of measurement. Evidence on the subject of scale effect, in going from the model to the ship, is cited and an expression for the relation between the streamline wake and the corresponding thrust deduction (to which must be added the frictional thrust deduction) is derived. The wake behind a ship model can be found, either indirectly from the model screw results, or directly, by means of blade wheels or pitot tubes. In the former case the results may differ according to whether the thrust or torque values are utilised, and in the latter there are different methods of averaging over the disc, which do not all yield identical results. As regards the relation between the directly and indirectly determined values, the torque wakes are stated to be generally in fair agreement with the volume mean of blade-wheel or pitot tube readings. The ship frictional wake is appreciably less than that of the model, but there is little direct evidence on other scale effects, a knowledge of which would allow a satisfactory correlation of model and ship results.

Aerofoil Sections in Screw Propellers. (J. F. Allen, Eng. Absts., Vol. 1, No. 3, Section 3, April, 1938, p. 21. Trans. of N.E.C. Inst. of E. and S., 31/3/38.) (56/15 Great Britain.)

Results of tank tests on lift, drag and pressure distribution are given for five sections: A, segmental; B, " Clark Y " aerofoil; C, modified segmental with rounded nose; D, sharp-nosed " Clark Y "; E, circular back " Clark Y " nose. The Reynolds number of the tests was 3.5×10^5, and all the sections had a thickness ratio 0.12. The sharp-nosed sections show high drag at low incidence, which is elucidated by means of the pressure plotting, and confirmed by certain model screw test results. Both the original and modified circular-back sections show a reduced lift-curve gradient at the higher angles of incidence. The maximum back-suction occurs nearer the nose and is greater in amount for the aerofoil sections than for the others. It is concluded that a well-rounded nose, and lifting the nose relative to the face gives good results. The maximum ordinate should, however, not be too far forward, as the high suction may produce cavitation.

Experiments on Water Waves of Translation in Small Channels. (J. Allen, Phil. Mag., Vol. 25, No. 170, 12/5/38, pp. 754-68.) (56/16 Great Britain.)

In an extremely tortuous channel a wave is propagated at a speed approximately as calculated from the depth of water measured along the deepest axis of the channel, and neglecting the speed of the stream in which the wave travels.

In straight channels of triangular cross-section the wave velocity is very closely equal to that calculated on the basis of the average depth. In trapezoidal channels, however, the effective depth is somewhat greater than the average.

In straight or comparatively straight and uniform channels a bore is propagated with velocity closely equal to

$$\sqrt{\{2g(h+k)^2/(2h+k)\}} - v,$$

where v is two-thirds of the maximum surface velocity indicated by a shallow float (or approximately the mean velocity over the cross-section) and h is the depth measured along the deep-water axis of the stream, k = height of wave crest above surface of stream. (Both v and h are measured just previous to the arrival of the bore.)

Possibilities of Error in Model Experiments on Vehicle Air Resistance. (C. Schmid, Z.V.D.I., Vol. 82, 19/2/38, pp. 188-194. Eng. Absts., Vol. 1, No. 4, Section 2, April, 1938, p. 58.) (56/17 Germany.)

The work of Flachsbarth, in continuation of the early experiments of Eiffel and of Prandtl, indicates that the air-resistance coefficient of a sphere, *e.g.*, of 150 mm. (6in. diameter), is practically constant with a Reynolds number exceeding 3.5×10^5. The author discusses the possibility of carrying out model experiments on cars in this super-critical range. The principal methods of suspending the model are as follows: (1) free; (2) on ground plane; (3) double reflected model with and without ground plane; (4) on a ground track moving at wind speed. The author summarises experimental values derived from experiments made at Gottingen and Stuttgart. He discusses the difficulty of making a model representative of the actual vehicle, with special reference to the air-flow through the radiator, around the wheels, and past windows and door-fittings.

The Theory of the Hele-Shaw Experiment. (F. Riegels, Z.A.M.M., Vol. 18, No. 2, April, 1938, pp. 95-106.) (56/18 Germany.)

This paper gives a solution of the Navier Stokes equations by a method of iteration in the case of a flow round a cylinder between parallel walls of small distance. (Hele-Shaw flow with inertia.) The flow is determined by a non-dimensional characteristic number which contains the Reynolds number and the ratio between the distance of the walls and the diameter of the cylinder. The results of the theory are verified experimentally.

On the Field of Flow Round a Thin Slightly Curved Aerofoil. (F. Weinig, Z.A.M.M., Vol. 18, No. 2, April, 1938, pp. 107-21.) (56/19 Germany.)

The motion of the air in the field of an aerofoil may be visualised by six systems of curves: Curves of equal direction of the motion and curves of equal velocity; curves of equal curvature of the stream-lines and curves of equal acceleration; curves where the change of curvature of the stream-lines is constant and curves of equal change of acceleration. In first approximation they are given by the real and imaginary parts of three functions of a complex variable, which are calculated by the author.

Theory of Active Anti-Rolling Tanks (G. Weinblum, Z.A.M.M., Vol. 18, No. 2, April, 1938, pp. 122-7.) (56/20 Germany.)

After discussing some examples of the heeling moments exerted on a ship by the waves (as given by the approximate (linear) theory), the author shows the

limits of validity of that theory and indicates some necessary developments. The ordinary " passive " anti-rolling tanks may be rendered more efficient by applying supplementary " active " forces. The different methods of activation are studied by means of the diagrams of amplitudes.

Boundary Layer in Compressible Fluids. (T. v. Kármán and H. S. Tsien, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 227-32.) (56/21 U.S.A.)

The first part of the paper is concerned with the theory of the laminar boundary layer in compressible fluids. The known solution for incompressible fluids is extended to large Mach's numbers by successive approximation. The compressibility effect on surface friction is discussed, and the results applied to estimate the ratio between wave resistance and frictional drag of projectiles and rockets. In the second part the heat transfer between a hot fluid and a cool surface, then between a hot body and a cool fluid is discussed. A general relation between drag and heat transfer as function of Mach's number is given. The limits where cooling becomes illusory because of the heat produced by friction are determined.

The Stability Problem in Hydrodynamics—II. (C. L. Pekeris, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 237-240.) (56/22 U.S.A.)

The author shows that parabolic flow of a viscous fluid between two fixed walls is stable for small disturbances which have symmetrical stream lines. Unsymmetrical disturbances have already been discussed in a previous paper (Proc. Camb. Phil. Soc., Vol. 32, 1936, p. 35), and it was shown that the damping in this case is greater than for the symmetrical disturbance.

It thus appears that the method of small oscillations is incapable of explaining the break down of parabolic flow, which occurs, in practice, as soon as certain range of Reynolds number is exceeded. Two possibilities are considered by the author:—

(1) The break down is due to finite disturbances.
(2) Instability of boundary layer in entrance region, *i.e.*, before parabolic flow is established.

Further researches will be required before this problem of stability can be considered as solved.

A Water Tank Model Tests on the Motion of Airships in Gusts. (A. Kuethe, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 243-4.) (54/23 U.S.A.)

A water tank and the auxiliary apparatus for determining the free motion of airships in gusts is described. The set-up is in operation at the Guggenheim Airship Institute and a series of tests, financed by the Navy Bureau of Aeronautics, is being carried out. The method utilises a water basin across a section of which a stream of water, simulating a gust, flows. An airship model immersed in the water and moved across the gust is free to turn and drift. The position and azimuth of the model are registered as functions of the time. The interpretation of the results in terms of forces and moments acting on the ship are discussed.

Determination of Profile Drag from Measurements in the Wake of a Body. (W. Bollay, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 245-8.) (56/24 U.S.A.)

Formulæ for the parasite drag from wake measurements corresponding to those by Betz and Jones have been deduced from basic principles. It is pointed out that Betz neglected quadratic terms of small velocities which, when measurements are carried out very close to the body, may introduce appreciable errors. Jones's formula does not suffer from this defect; in fact it should hold best close to the body before the wake has suffered much energy dissipation.

Both Jones and Betz neglected the quantity $\rho/2\ (v_1^2 + w_1^2)$ in their formulæ as small, which should be justified experimentally. Jones's assumption of no energy loss in the wake appears reasonably good, but requires also more through experimental verification. It should also be verified whether the pressure in the turbulent wake is the same as that calculated from a pure potential flow. It is pointed out that the plane of measurements in the wake should be normal to the free stream velocity, otherwise a small correction should be introduced.

(See also (1) Profile Resistance Measurements in the Large Wind Tunnel of the D.V.L., H. Doetsch and M. Kramer, L.F.F., Vol. 14, pp. 173 and 371—available as translations No. 465 and 501. (2) Remarks on Profile Resistance Measurements at the D.V.L., H. Muttray, L.F.F., Vol. 14, p. 372—available as translation No. 500.)

The Increase in Frictional Resistance Caused by Various Types of Rivet Heads as Determined by Tests of Planing Surfaces. (S. Truscott and J. B. Parkinson, N.A.C.A. Tech. Note No. 648, May, 1938.) (56/25 U.S.A.)

The increase in the frictional resistance of a surface caused by the presence of rivet heads was determined by towing four planing surfaces of the same dimensions in the N.A.C.A. tank. One surface was smooth and represented a surface without rivet heads or one with perfectly flush countersunk rivets. The other three surfaces were each fitted with the same number of full-size rivet heads, but of a different type arranged in the same pattern on each surface. The surfaces were towed at speeds representative of the high water speeds encountered by seaplanes during take-off and the range of Reynolds number covered by the tests was from 4×10^6 to 18×10^6.

The rivet heads investigated were oval countersunk, brazier, and round for rivets having shanks 5/32 inch in diameter. The oval countersunk heads were sunk below the surface by dimpling the plating around them.

The results of the tests showed that, for the rivet heads investigated, the increase in the friction coefficient of the surface is directly proportional to the height of the rivet head. The order of merit in regard to low resistance is flush countersunk, oval countersunk (whether sunk below the surface or not), brazier, and round.

Pressure Distribution Over Aerofoils with Fowler Flaps. (C. J. Wenzinger and W. B. Anderson, N.A.C.A. Report No. 620, 1938). (56/26 U.S.A.)

A test installation was used in which the model was mounted in the wind tunnel (7×10 and 5-foot vertical) between large end planes so that two-dimensioned flow was approximated.

The data are given in the form of pressure distribution diagrams and as plots of calculated coefficients for the aerofoil-and-flap combinations and for the flaps alone. The pressure distribution tests show that the effect of increasing the chord of the Fowler flap (for a given lift of combined aerofoil and flap) is to increase the portion of the total load carried by the flap and to decrease the adverse pressure gradients of the main aerofoil and thereby its tendency to stall. The maximum values of the normal force coefficient of the Fowler flap were found to be much smaller than previously indicated and approximately the same as those of the external aerofoil flap and of the simple split flap. The flap load data given in this report supersede those given in Report No. 534.

Compressible Flow About Symmetrical Joukowski Profiles. (C. Kaplan, N.A.C.A. Report No. 621, 1938.) (56/27 U.S.A.)

The method of Poggi is employed for the determination of the effects of compressibility upon the flow past an obstacle. A general expression for the velocity increment due to compressibility is obtained. An application is made to the case of a symmetrical Joukowski profile with a sharp trailing edge, fixed in

a stream of velocity v_0 at an arbitrary angle of attack and with the circulation determined by the Kutta condition.

Since actual experimental data for Joukowski profiles are lacking, the theoretical results are applied to a thin and a thick profile at zero angle of attack, and the velocity and pressure distributions are calculated and compared with those for the corresponding incompressible cases. The critical values for the ratio of the stream velocity v_0 to the velocity of sound in the stream c_0 (corresponding to the attainment of the local velocity of sound c by the fluid on the surface of the aerofoils) are also obtained.

The Lift and Moment on a Flat Plate in a Stream of Finite Width. (T. H. Havelock, Proc. Roy. Soc., Series A, Vol. 166, No. 925, 19/5/38, pp. 178-96.) (56/28 Great Britain.)

The paper gives a new treatment of the problem of a flat plate in a stream bounded by plane parallel walls, including circulation round the plate. The plate is considered as the limiting case of the elliptic cylinder; an integral equation is obtained, whose solution by continued approximation leads to expansions for the lift and moment on the plate. The solution is modified to give similar results when the stream is bounded by parallel free surfaces, taking the condition of a free surface in an approximate form; and a further modification gives the case when one boundary of the stream is a plane wall and the other is a free surface. The problem of the elliptic cylinder in general is also considered with reference to the moment of the forces when the stream is bounded by plane walls and when there is no circulation.

Flight and Wind Tunnel Tests of an XBM-1 Dive Bomber. (P. Donely and H. A. Pearson, N.A.C.A. Tech. Note No. 644, April, 1938.) (56/29 U.S.A.)

Results are given of pressure distribution measurements made in flight over the right wing cellule and the right half of the horizontal tail surfaces of a dive-bombing biplane. Simultaneous measurements were also taken of the air speed, control surface positions, control forces, and normal accelerations during various abrupt manœuvres in a vertical plane. These manœuvres consisted of push-downs and pull-ups from level flight, dives and dive pull-outs, and push-ups from inverted flight.

In addition to the pressure measurements, flight tests were made to obtain (1) wing fabric deflections during dives and (2) variation of the minimum drag coefficient with Reynolds number. Supplementary tests were also made in the full-scale wind tunnel to obtain the characteristics of the aeroplane under various propeller conditions and with various tail settings.

The results indicate that: (1) By decreasing the fabric deflection between pressure ribs, the span load distribution was considerably modified near the centre and the wing moment relations were changed; and (2) the minimum drag was less for the idling propeller than for the propeller locked in a vertical position.

Some Aspects of the Stalling of Modern Low-Wing Monoplanes. (H. A. Soule and M. N. Gough, N.A.C.A. Tech. Note No. 645, April, 1938.) (56/30 U.S.A.)

Basically the stalling problem consists of the elimination of the rolling instability. The complete elimination of rolling instability, however, does not seem possible. It may be possible, nevertheless, to delay rolling instability to angles of attack that cannot be attained with conventional elevator controls.

The present emphasis on stalling characteristics is primarily a result of the high taper ratios and the low-wing positions employed on modern aeroplanes.

With small low-wing single-engine aeroplanes, the undoubted benefits obtained by the simplicity of retracting the landing wheels makes it probable that this

low-wing arrangement will be adhered to. With large transport aeroplanes, the wing height relative to the ground has become so large, owing to the increases in propeller diameter, that there is no need to keep the fuselage above the wing. Lowering the fuselage relative to the wing would, in addition to improving the elevator-force variation, have no effect on the retracting mechanism for the main wheels and, in the case of the level three-wheel landing gear, would simplify the installation of the front wheel.

Wind Tunnel Tests of a Two-Engine Aeroplane Model as a Preliminary Study of Flight Conditions Arising on the Failure of One Engine. (E. P. Hartman, N.A.C.A. Tech. Note No. 646, April, 1938.) (56/31 U.S.A.)

Wind-tunnel tests of a 15-foot-span model of a two-engine low-wing transport aeroplane were made as a preliminary study of the emergency arising upon the failure of one engine in flight. The added drag resulting from the unsymmetrical attitudes required for flight on one engine was determined for the model aeroplane.

The effects of the application of power upon the stability, controllability, lift, and drag of the model aeroplane were measured. A dynamic-pressure survey of the propeller slipstream was made in the neighbourhood of the tail surfaces at three angles of attack.

The added parasite drag of the model aeroplane, resulting from the unfavourable conditions of flight on one engine, was estimated to be approximately as follows:—

At ceiling, 30 per cent.
Full-throttle climb at sea level, 40 per cent.
High speed, 19 per cent.

From 35 to 50 per cent. of this added drag was due to the drag of the dead-engined propeller and the other 50 to 65 per cent. was due to the unsymmetrical attitude of the aeroplane. The mode of flight on one engine, in which the angle of sideslip was zero, was found to require less power than the mode in which the angle of sideslip was several degrees.

Lessons to be Drawn from Natural Flight and Their Application to the Problem of the Hovering Helicopter, with Some Remarks on the Helicostat. (E. Oehmichen and J. Tilbo, Comp. Rend., Vol. 204, No. 19, 9/5/38, pp. 1355-1359.) (56/32 France.)

The authors are of the opinion that the stability of insect or bird flight, when hovering, is largely due to the mass of the air associated with the motion of the wings. Similar stabilising effects can be obtained with a screw helicopter, working under hovering conditions, by attaching an air capacity to the machine in a suitable position.

This was demonstrated in 1935, the four helicopter screws being surmounted by a spherical balloon of 100 m^3 capacity filled with cold air. The available horse-power amounted to 40, and sufficed to lift the pilot to various altitudes between four and 20 metres, the heights being maintained entirely by engine power (no other control surfaces). In the present paper the authors suggest filling the stabilising volume with a lifting gas (H or He) the capacity being sufficient to reduce the rate of descent to 4 m./sec. with the engine cut out.

The gas assisted helicopter thus has to produce a smaller lift and will work at a correspondingly greater efficiency. By inclining the lifting screws forward, translation as well as lift will be obtained. A machine of this type is named Helicostat by the authors and it is claimed that it will be particularly suitable for operation in difficult colonial country (Forests).

Aileron Hinge Moments Utilised to Ensure Automatic Stability. (M. Victor, Les Ailes, No. 884, 26/5/38, pp. 8-9.) (56/33 France.)

Toussaint has already shown, in 1928, that the aileron hinge moment is a linear function of the deflection of the aileron and the incidence of the wing. Moreover, the lift is controlled by the aileron deflection, and since the inertia of the aileron is very small compared with that of the complete aircraft, a sufficiently rapid aileron control should enable the aircraft to maintain a steady course in gusty weather.

Recent experiments carried out under Toussaint's direction at St. Cyr, have shown that sufficient control force can be obtained with ailerons of normal size, by utilising a pivoted form of horizontal tail surface suitably interconnected with the aileron.

From the experimental figures it appears that the lift of a model, so equipped, will remain constant over large variations of air speed and incidence.—Note: The utilisation of aerodynamic forces for stability and lift control also forms the basis of the well-known Constantin Wind Vane Stabiliser.

Wind Tunnel Tests of a Clark Y Wing having Split Flaps with Gaps. (C. J. Wenzinger, N.A.C.A. Tech. Note No. 650, May, 1938.) (56/34 U.S.A.)

Tests were made in the N.A.C.A. 7- by 10-ft. wind tunnel of a Clark Y wing, having split flaps with a gap between the flap and the lower surface of the wing. Lift, drag, and pitching moments were measured for the wing with three different sizes of flap. It was found that any gap between the flap and the wing reduced the lift, the drag, and the pitching moments, but that the centre-of-pressure movement and the ratio of lift drag were little affected.

Measurement of Air Flow Over Cylinders having Very Small Distances between the Cooling Fins. (A. Berndorfer, Year Book of German Aeronautical Research, Vol. 2, 1937, pp. 162-4.) (56/35 Germany.)

On modern engine cylinders, fin spacings of the order of 2 mm. are not uncommon. Investigation of air flow inside these narrow gaps by means of the usual pitot tube is difficult. The hot wire anemometer is too fragile and its supports are liable to introduce considerable disturbances of the flow. The author describes a simple form of total pressure recorder, consisting of a copper tube 0.5 mm. outside and 0.3 mm. inside diameter, which is introduced facing the air stream. The static pressure is measured by means of a similar tube closed at the end and provided with an orifice on its upper surface. The experiments were carried out with a single engine cylinder (without piston and valves), the cowling being airtight at the cylinder base and head and projecting some distance beyond the cylinder confines. Air speed measurements were carried out over the central section facing the air stream and the integrated air flow agreed within 14 per cent. with the quantity entering the cowling from the blower. The air speed between the fins varied between 50 and 80 m./sec., the maximum speed occurring in the central gap on the head between the valves. The high value at this region is probably due to a venturi effect of the head passages. The air speed at the entrance section of the cowling was of the order of 10 m./sec., the total pressure being approximately 300 mm. of water. Power and flight experiments are in hand.

New Surfaces for Pistons. (E. Koch and P. Sommer, Year Book of German Aeronautical Research, Vol. II, 1937, pp. 193-197.) (56/36 Germany.)

Anodic treatment of aluminium pistons provides a hard skirt surface which was originally considered beneficial. The authors, however, describe experiments on aircraft engines which demonstrate that the anodised piston is distinctly inferior and will seize, even during the running-in period, although the clearances are

identical with those of the untreated piston. Only under conditions of repeated cold starting in the presence of excess fuel does the anodised piston show up to advantage. Although this may be of importance in the case of the motor car engines, this case is not likely to arise for aircraft engines. It is possible, however, that anodising the piston crown only is beneficial in reducing the effect of spark electrode sputter.

Much more promising than anodising appears to be a deposit of tin on the piston skirt. The authors describe how such deposits can be obtained electrolytically and satisfactory results have been obtained on motor car engines. Experiments with aero engine pistons are in progress. In this case the process is evidently limited by the working temperature of the piston skirt.

Cylinder Wear. (G. I. Finch, Autom. Eng., Vol. 28, No. 371, May, 1938, p. 166.) (56/37 Great Britain.)

It has been established that during the process of " running in," an amorphous " Beilby Layer " is formed, both on the piston and cylinder wall. The resultant smooth surface allows equalisation of oil pressure and prevents metal to metal contact. The fact that the cylinder wall wears more rapidly than the softer aluminium piston was formerly attributed to the lapping action of grit or dust which becomes embodied in the aluminium.

It has, however, been recently discovered that on prolonged running, the Beilby Layer on the aluminium piston (consisting originally of amorphous Al_2O_3) recrystallises into a form of sapphire which is responsible for the wear.

It appears possible that this harmful recrystallisation can be prevented by treating a suitable magnesium-aluminium alloy with a mixture of Al and Mg oxides. (Spinelising).

Engine trials with aluminium pistons treated in this manner are in progress.

Motion Pictures of Engine Flames Correlated with Pressure Cards. (G. M. Rassweiler and Lloyd Withrow, J.S.A.E., Vol. 42, No. 5, May, 1938, pp. 185-204.) (56/38 U.S.A.)

This paper represents a continuation of the work with the high-speed motion picture camera, described before the Semi-Annual Meeting of the Society, June, 1936.*

The experimental observations consist of pictures showing successive positions of the flame at intervals of 2.4 crankshaft deg. during single explosions, and pressure-time records of the same explosions.

A method, finally, is described for sorting out the pressure changes due to combustion from an observed pressure card. When the pressure changes resulting from combustion are summed, and put on a percentage basis, it is found that the percentage of pressure rise, due to combustion, is approximately equal to the percentage of charge burned (by weight) at the corresponding instants in the combustion period.

The Accessory Drive Problem of Aircraft Engines. (R. P. Lansing, J.S.A.E., Vol. 42, No. 5, May, 1938, pp. 205-8 and 224.) (56/39 U.S.A.)

A brief history of the subject is given, tracing the growth of accessory drives from their initial being as magneto drives down to the present stage, which embraces such items as automatic pilot pumps, de-icer compressors, and propeller governors. This review indicates that the present groups may well be divided into two parts; one, intimately associated with the operation of the

* See " Industrial and Engineering Chemistry," June, 1936, pp. 672—677: " High-Speed Motion Pictures of Engine Flames;" also S.A.E. Transactions. August, 1936, pp. 297—303: " Slow Motion Shows Knocking and Non-Knocking Explosions," both by Gerald M. Rassweiler and Lloyd Withrow.

engine, the other with that of the plane. The difficulties facing the engine designer, the installation engineer, and the operator, are outlined to illustrate the necessity of a new approach to this problem.

In view of the present general interest in auxiliary power plants, a short description of such an engine is included. The paper terminates by mentioning the present tendencies in the field and classifying the various means of accessory drive with the size of plane with which it, probably, will be employed.

Diesel Supercharging—the Effect on Design and Performance. (R. Pyles, J.S.A.E., Vol. 42, No. 5, May, 1938, p. 215.) (56/40 U.S.A.)

Methods of increasing engine output are discussed, and supercharging is said to involve few difficulties. The location of the blower drive as it affects frequency and gear loading is considered. Bearing-load diagrams are analysed for a high-speed and a low-speed engine.

Tests indicate a negligible increase in piston temperatures. Fuel consumption curves show fuel economy comparable with that of the normal engine.

Engine Installation and Related Problems in Large Aircraft. (I. L. Shogram, J.S.A.E., Vol. 42, No. 5, May, 1938, pp. 225-8.) (56/41 U.S.A.)

The author bases his arguments mainly on his experience with the Douglas D.C.4, a four-engined transport plane, 6,000lb. gross weight, accommodating 42 passengers and a crew of five.

This aircraft is propelled by four P. & W. Twin Hornet engines fitted with Hamilton constant r.p.m. full feathering propellers (hydraulically operated). The author considers, in detail, the following features:—

Nacelles, Cockpit, Oil and Fuel System, Engine Controls, Exhaust System, Cowling and Induction System.

On the D.C.4, auxiliary engines are housed behind the main engine in the two inboard nacelles. These auxiliary engines each drive an 800 cycle 110 volt alternator as well as all air pumps and hydraulic units required either for the instruments or accessories. No batteries are installed.

It appears in these large machines the principal difficulty is the provision of simplified controls, bearing in mind, the complexity of the equipment.

The Effect of Air Passage Length on the Optimum Fin Spacing for Maximum Cooling. (M. J. Brevoort, N.A.C.A. Tech. Note No. 649, May, 1938.) (56/42 U.S.A.)

Consideration of fundamental knowledge, in part confirmed by the experimental evidence in this report, indicates that optimum fin spacing depends on the baffle length and the ratio of baffle length to fin spacing is approximately constant. With the proper choice of fin variables, as much heat can be dissipated from a short passage as from a long passage for a given pressure drop. Heat transfer can be improved by constructing the baffle so that the air flow is uniform throughout the fin space. The tests indicate that some improvement of cooling may be achieved by streamlining the cylinder and thus increasing the mass flow of air for a given pressure drop.

Further work in this field should be directed toward a more accurate and extensive knowledge of the detailed mechanism of the air cooling process on finned cylinders. With such knowledge as a basis, the problem of determining the optimum cooling arrangement of practical air-cooled cylinders, utilising all the factors within the designer's control, can be subjected to rational investigation.

A Photographic Study of Combustion and Knock in a Spark-Ignition Engine. (A. M. Rothrock and R. C. Spencer, N.A.C.A. Report No. 622, 1938.) (56/43 U.S.A.)

A photographic study of the combustion in a spark-ignition engine has been made, using both schlieren and flame photographs, taken at high rates of speed. Although shock waves are present after knock occurs, there was no evidence of any type of sonic or supersonic compression waves existing in the combustion gases prior to the occurrence of knock. Artificially induced shock waves in the engine did not themselves cause knock. The photographs also indicate that, although auto-ignition, ahead of the flame front, may occur in conjunction with knock, it is not necessary for the occurrence of knock. There is also evidence that the reaction is not completed in the flame front but continues for some time after the flame front has passed through the charge.

Laboratory Method for Determining the Behaviour of Lubricating Oils on Vaporisation. (H. Brückner, J. Soc. Chem. Ind. (Abstracts B), Vol. 57, No. 4, April, 1938, p. 344. Angew. Chem., 51, 1938, pp. 53-5.) (56/44 Germany.)

The sample is heated, under controlled conditions, up to 550° in a current of N_2 and the loss in weight recorded automatically. From the vaporisation-temp. curves are derived two empirical constants that serve to characterise the oils. Non-volatile residues are determined at the same time.

Engine Performance and Knock Rating of Fuels for High Output Engines. (A. M. Rothrock and A. E. Bierman, N.A.C.A. Tech. Note No. 647, April, 1938.) (56/45 U.S.A.)

Data are presented to show the effects of inlet-air pressure, inlet-air temperature, and compression ratio on the maximum permissible performance obtained on a single cylinder test engine with aircraft-engine fuels varying from a fuel of 87 octane number to one of 100 octane number plus 1 ml. of tetraethyl lead per gallon. The limiting factor for the increase in compression ratio and in inlet-air pressure was the occurrence of either audible or incipient knock. The data are correlated to show that, for any one fuel, there is a definite relationship between the limiting conditions of inlet-air temperature and density at any compression ratio. It is concluded that aircraft-engine fuels cannot be satisfactorily rated by any single factor, such as octane number, highest useful compression ratio, or allowable boost pressure. The fuels should be rated by a curve that expresses the limitations of the fuel over a variety of engine conditions.

Pressure Waves Accompanying Detonation in the Internal Combustion Engine. (C. S. Draper, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 219-25.) (56/46 U.S.A.)

The author's general experimental conclusion that the energy associated with pressure waves, due to detonation, is a small percentage of the total energy, agrees with the known result, that the output of a well-designed engine is not affected by moderate detonation intensities.

With the present data it is possible to calculate the maximum particle velocity at the cylinder wall due to the measured pressure waves.

Substituting values for the lowest frequency mode as given by the records, and remembering that the velocity normal to the cylinder wall must be zero, gives a maximum particle velocity of 50ft. per sec. While this figure does not represent a very high speed, the oscillatory motion will take place very close to the cylinder wall and possibly supply the " scrubbing action " suggested by Withrow and Rassweiler. The attendant high rate of heat transfer can well be responsible for the local pitting effects observed in the aluminium combustion chamber surfaces of certain engines.

As regards the selection of a unit of detonation intensity, suitable for all engines under all conditions, it seems reasonable to use the average pressure wave energy density. Thus, if an electromagnetic generator type of indicator is used, the associated electrical circuit should first integrate to reduce all frequencies to a common basis, then " rectify " and amplify, according to a square law with a final steady indication proportional to the rectified output.

Influence of Pressure on Film Viscosity in Heavily Loaded Bearings. (S. J. Needs, Trans. A.S.M.E., Vol. 60, No. 4, May, 1938, pp. 347-58.) (56/47 U.S.A.)

At constant speed and temperature, it has been observed that, when the load was increased to several thousand pounds per square inch the friction-coefficient curves for fitted journal bearings reached a minimum and then started to increase with added load. In the absence of metallic contact this discrepancy between observed and theoretical frictions suggested the probability of the high pressures in the bearing oil film causing an increase in film viscosity. The present paper undertakes a mathematical explanation of this phenomenon by calculating the effect of viscosity increase under pressure on the operating characteristics of plane surfaces of infinite width. Some of the more interesting of the test results are given in the form of curves and these are compared with calculations for plane surfaces of infinite width assumed to be operating under the same conditions.

Effect of Spark-Timing Regularity on the Knock Limitations of Engine Performance. (A. E. Bierman, N.A.C.A. Tech. Note No. 651, May, 1938.) (56/48 U.S.A.)

1. Irregular spark timing may appreciably reduce the non-knocking power range of an engine.

2. In the tests described, a change of one crankshaft degree in spark retard was equivalent to an 0.85 inch of Hg change in allowable inlet pressure.

3. Irregular spark timing may cause large errors in tests of the knocking properties of fuels.

4. Spark-timing errors can be determined with reasonable accuracy by causing the spark to puncture combined thicknesses of paper and cellophane tape attached to the engine flywheel.

Modern Welding Equipment. (Metropolitan Vickers Electrical Company, Vol. Tech. News Bulletin, No. 607, 22/4/38, p. 4. Electrical Engineer, 15/4/38, pp. 900-6.) (56/49 Great Britain.)

A brief survey is given of modern welding methods and equipment by various manufacturers. This includes descriptions of several types of d.c. and a.c. arc welding sets, an atomic hydrogen set, spot, butt and continuous spot and seam welders.

Illustrated with 20 photographs and two diagrams.

Torsion and Torsional Oscillations of Blades. (J. Duncan, Eng. Absts., Vol. 1, No. 3, Section 3, April, 1938, p. 22. Trans. of N.E.C. Inst. of E. and S., 31/3/38.) (56/50 Great Britain.)

The author gives methods of calculating the torsional rigidity of blades, and the natural frequencies of vibration, in terms of rigidity and mass, assuming a knowledge of the amount of the virtual fluid mass. Two methods of obtaining the rigidity, *i.e.*, the thickness-parameter method and the Galerkin method, are given, and detailed results worked out for certain sections. For a thin segment of a circle, and similar sections, the rigidity constant is approximately 16/105 (breadth) × (thickness)^3. An approximate method of calculating the natural

frequencies of the lower modes is given and the results compared with the exact solution for a uniform blade. In an appendix there is a note on airscrew flutter.

The Most Suitable Shape of Chamfered Corner for Crankshafts Subjected to Torsion. (H. Deutler and A. Havers, Yearbook of German Aeronautical Research, Vol. II, 1937, pp. 132-136.) (56/51 Germany.)

As is well known, a sudden change in diameter of a shaft produces a considerable stress peak at the corner. This can only be avoided if sufficient room is available for a gradual transition from the smaller to the larger diameter. In most cases the length over which the transition must take place is restricted and a certain stress peak is therefore unavoidable.

Using Foppl's Theory of Torsion as applied to shafts of variable cross-section, the author concludes that an elliptical transition curve is in most cases preferable to the circular chamfer commonly employed. If a and b are the semi-axes of the proposed ellipse

$$a/b = 1 + 2.5\ a/d$$

where a = major semi-axis of ellipse.
= length of chamfer.
b = minor axis of ellipse.
d = diameter of thin portion of shaft.

The main advantage of the elliptical transition curve is in the region

$$0.1 < a/d < 1.$$

The experiments of the authors indicate a maximum reduction of 10 per cent. in the stress peak and an increase in fatigue strength by a slightly smaller amount. If the length a is very restricted, it may be advisable to continue the chamfer into the corner in the form of a hollow groove.

Column Strength of Tubes Elastically Restrained Against Rotation at the Ends. (W. R. Osgood, N.A.C.A. Report No. 615, 1938.) (56/52 U.S.A.)

A study was made of the effects of known end restraint on commercially available round and streamline tubing of chromium-molybdenum steel, duralumin, stainless steel, and heat-treated chromium-molybdenum steel, and a more accurate method than any previously available was developed for designing compression members in riveted or welded structures, particularly aircraft.

The test specimens were centred under load on knife edges held in carriers, and the free lengths were computed by a rational method not heretofore used. Tensile and compressive tests were made on each piece of original tubing from which column specimens were cut. The column data were reduced with the aid of these tests, and formulæ were constructed to represent the column strengths in terms of specified tensile yield strengths of the four materials used.

The design is facilitated greatly by the use of tables and a nomographic chart, both included in this paper. A numerical example is also given.

Ball and Roller Bearings and Their Behaviour. (J. L. Brown, Metropolitan Vickers Tech. Bulletin No. 611, 20/5/38, p. 13. Elec. Journal, April, 1938, pp. 141-4.) (56/53 Great Britain.)

The inherent features and operating characteristics of the plain bearing and of ball and roller bearings are first discussed and compared. The author then proceeds to consider particular features of ball and roller bearings, *e.g.*, the need for a cage separator; troubles of misalignment; problems of lubrication; dangers of corrosion and the abrasive action of dust and dirt. Finally, the effects of high speeds on such bearings and on plain bearings are reconsidered. The article closes with some remarks on clearances and the S.A.E. figures of tolerance. Illustrated with one photograph and four diagrams.

Enamel Lacquered Wire. (J. Hoekstra, Metropolitan Vickers Tech. Bulletin No. 611, 20/5/38, p. 13. Philips Tech. Rev., Feb., 1938, pp. 40-7.) (56/54 Great Britain.)

The properties and applications of enamel lacquered wire are detailed. It is claimed that in addition to being unusually thin this form of insulation has a high breakdown potential, high electrical resistance, low moisture absorption, and good mechanical and chemical properties.

Illustrated with two photographs and four diagrams.

Corrosion Resistance Tests of Aluminium and its Alloys. (J. W. Smith, Metropolitan Vickers Tech. Bulletin No. 611, 20/5/38, p. 15. Light Metals Rev., May, 1938, pp. 124-5.) (56/55 Great Britain.)

It is stated that accelerated corrosion tests should be made both on the unprotected metal (with oxide film removed) and on the same material after its protective coatings have been applied. Standard methods of testing are described. The " oxygenated salt test " due to Mylius is then fully discussed. In this test the corrosion effect is measured in terms of loss in weight per unit area per day as well as decrease in mechanical properties. The " thermal " test of Mylius which employs hydrochloric acid instead of salt is described and precautions for testing tin sheets are pointed out. Finally, the limited validity of the test results is discussed with particular reference to heat treatment.

Heat-Resisting Steels. (W. H. Hatfield, Journal of the Institute of Fuel, Vol. 11, No. 58, April, 1938; Paper read before the Institute of Fuel, March 24th, 1938.) (56/56 Great Britain.)

An attempt has been made to evaluate on a quantitative experimental basis the different heat-resisting steels and alloys which are at the present time finding a progressively wider application. Whereas the time yield of mild steel falls to 400lb. per sq. in. at 700°C., it is shown that there are a number of steels available with a time yield of not less than 3,360lb. at that temperature, which clearly means that reasonably substantial stresses may be borne at a red heat with reasonable permanence of dimensions. It has been shown that such steels possess, along with the increased strength, resistance to oxidation on scaling to an astonishing degree.

Chromium alone, whilst giving resistance to oxidation, does not increase the strength of the steel. By adding substantial quantities of nickel to the chromium, the dual result is attained. It is shown also that the addition of tungsten is valuable in assisting in the attainment of higher strength.

From the economic point of view it is of considerable moment as to which and how much of the different elements are added, and therefore it is important that the engineer shall carefully consider the service required before selecting a given composition.

Polish on Metals. (W. Cochrane, Proc. Roy. Soc., Series A, Vol. 166, No. 925, 19/5/38, pp. 228-37.) (56/57 Great Britain.)

When electron diffraction patterns consisting of diffuse rings are obtained by Thomson's reflexion method, their interpretation is uncertain since such diffuseness may be caused by the geometrical configuration of the surface of the specimen. In order to eliminate this difficulty, a thin layer of gold was formed on a nickel base. The gold film was polished, then stripped off and examined by transmitted electrons incident normal to the film. The resulting pattern consisted of three diffuse rings. It was deduced that the film consisted of very small crystal grains and that the atoms in the polish layer of a metal are arranged similarly to the atoms in a monatomic close-packed liquid at a given instant. After a period of 15 hr. the polished gold film yielded a pattern of sharp rings

characteristic of polycrystalline gold, showing that crystal growth had taken place with a return to the normal crystal size.

Locomotive Axle Testing. (T. V. Buckwalter, O. J. Horger and W. C. Sanders, Trans. A.S.M.E., Vol. 60, No. 4, May, 1938, pp. 335-45.) (56/58 U.S.A.)

Rolled axles compared with unrolled axles show little improved resistance to the development of incipient fatigue cracks as produced by a large number of repetitions of low stresses obtained under ordinary railroad operating conditions of speed and load. Under prevailing conditions of high speeds and load, however, the occasional stresses are considerably increased and cause these incipient fatigue cracks to propagate and ultimately fracture the axle. Rolling provides immense increase in resistance to crack propagation, thus giving greater safety.

Maps for the Air Force. (B. V. Sterligov, Air Fleet News, U.S.S.R., Vol. 19, No. 9, Sept., 1937, pp. 7-15.) (56/59 U.S.S.R.)

1. The Air Force must have maps compiled on three different scales:—

Large scale (50,000)—for exact orientation in the zone of battle, in the vicinity of the objective and when co-operating with ground forces.

Medium scale (500,000)—for " mean " visual orientation in flight.

Small scale (1,500,000)—for general orientation, when choosing the course and when using compass, radio, or astronomical navigation.

2. Whereas the large scale maps (up to 200,000) should be edited mainly with a view to the needs of the ground forces, the medium and small scale maps (below 200,000) should be compiled with a main view to the information necessary for the Air Force.

3. The work and conditions of use of a map during flight necessitate an edition of the 500,000 and 1,500,000 maps greatly rationalised as regards the projection, contents, symbols, division into separate sheets and fastening together of the sheets.

4. Considerations of economising the maps and the time for preparing them for a flight make it necessary to publish them in two series with overlaps by half a sheet.

5. The introduction of a system of two maps (1,500,000 and 500,000) provide for all emergencies and any degree of detailed orientation, but it necessitates devising a new system of presentation of the 500,000 map by either cutting it into squares, or folding it into a " double concertina " which can be turned over in two directions.

6. Fighter pilots need a special map holder, which can be strapped to the pilot's knee.

Note on Approximations to Functions and the Solution of Differential Equations. (R. A. Frazer, W. P. Jones and S. W. Skan, Phil. Mag., Vol. 25, No. 170, pp. 740-6.) (56/60 Great Britain.)

The present brief paper gives some comparisons between three known methods of approximation, which will be referred to as (i) collocation, (ii) least squares, (iii) Galerkin's method. A fuller account, with numerical examples, is given in No. 1799 of the Reports and Memoranda of the Aeronautical Research Committee.

The term collocation is here used in connection with approximations to mean the act of assigning the error at one or more given points or stations.

The solution of differential equations by methods (ii) and (iii), which depend on the minimisation of average errors, has been considered by W. J. Duncan (R. and M. 1798). The original papers by V. G. Galerkin, describing method (iii), do not appear to be available in this country, but accounts with references are given in two papers by E. P. Grossman (Trans. C.A.H.I., Moscow, Nos. 186

and 253). Galerkin's method reduces to the method of least squares when it is applied to obtain approximate representations of functions.

The New 400-Degree Partition (of the Circle). (K. Herrmann, Eng. Absts., Vol. 1, No. 4, Section 1, April, 1938, p. 43. Zeit Vermessung, Vol. 47, 15/2/38, pp. 117-20.) (56/61 Germany.)

From 18th Nov., 1937, the 400° partition has been used exclusively for surveying in Germany. Formerly it was statutory only in the south, and Prussia continued to use the " old " (360 deg.) partition. The " new " system is advantageous in measurement, and particularly in calculation; but in order to secure the maximum advantage, both should be carried out in the " new " style. The saving of time is important, particularly in lower geodesy. Since calculation is decimal, no arc table is necessary. In actual use the case of conversion of degrees to superficial distances is important; since 1 m. $= 10^{-7}$ X (meridian quadrant of the earth), 1° (0.01 " new " degrees) = 1 km. distance. A similar relation holds between the sea-mile (1,852 m.) and 1 minute of arc. The author observes that in land surveying and higher geodesy it is already customary to express values in decimals of a degree and of a second respectively, this being a blend of both systems, so that no fundamentally new idea is involved. Disadvantages are the increased difficulty of conversion from astronomical to terrestrial units (1 hr. = 16.6 g against 1 hr. = 15 deg.), and the break in tradition.

Direct Determination of the Electrical Constants of Soil at Ultra-High Radio Frequency. (M. K. Chakravarty and S. R. Khastgir, Phil. Mag., Vol. 25, No. 170, 12/5/38, pp. 793-801.) (56/62 Great Britain.)

In the present investigation the attenuation of ultra-short waves travelling along a Lecher wire system immersed in a specimen of Dacca soil has been determined for a certain range of ultra-high frequencies (73 to 89 megacycles per sec.) and for varying moisture contents from 8 to 41 per cent. The values of the electrical conductivity and the dielectric constant of the soil are then determined by the application of the standard formulæ.

It is to be noted that the values of the electrical conductivity and the dielectric constant of the soil obtained by the direct laboratory method agree well in their orders of magnitude with the values estimated from the attenuation measurements.

Progressive Lightning. (B. F. J. Schonland, D. B. Hodges and H. Collens, Proc. Roy. Soc., Series A, Vol. 166, No. 924, 4/5/38, pp. 56-75.) (56/63 Great Britain.)

The photographic method of studying the lightning discharge by means of the Boys camera has the unique advantage of giving direct information concerning events in the discharge in two dimensions of space and one of time and could be extended if necessary to include the third space dimension. The luminous events which it records are, however, secondary processes, and the primary movements of electrical charge which cause them can only be inferred by an application of ideas gained from the laboratory study of the passage of electricity through gases.

The direct study of these primary electrical processes involves the observation of the electric field during the discharge by means of a cathode-ray oscillograph. The method gives information concerning the total electric moment of the cloud charges and requires to be compared with the photographic data before its results can be interpreted in terms of the charges themselves and their movements.

The present paper is concerned with field studies designed to correlate the information obtained by these two methods.

The Development of the Spark Discharge. (T. E. Allibone and J. M. Meek, Proc. Roy. Soc., Series A, Vol. 166, No. 924, 4/5/38, pp. 97-126.) (56/64 Great Britain.)

The electric spark is shown to consist of two principal components, a leader stroke and a main stroke—analogous to the lightning flash. A leader stroke generally starts from a positive electrode; sometimes the structure of the leader stroke is simple, sometimes it is of the " stepped " variety. The leader stroke is always branched at many places, and the direction of branching is the direction of its propagation in space; branching thus forms a criterion of the direction of leader stroke development. The main stroke develops in the reverse direction to that of the leader stroke and at a velocity too high to be recorded. The velocities of the positive and negative leader strokes are of the order of $10^6 = 10^7$ cm./sec. the positive leaders being the faster.

Special Maps for Use with Loop Direction Finders. (J. M. Coburn, J. Aeron. Sci., Vol. 5, No. 6, April, 1938, pp. 233-236.) (56/65 U.S.A.)

With the normal material, it takes 12 distinct operators to draw a wireless position line. With the simplification introduced by the author the number of operations is halved. The principal novelty is a loop bearing indicator, in which the calibration of the loop is already incorporated in the scale. The process of plotting is further simplified by providing a compass rose on the map round each radio range station. These roses are orientated on the magnetic north, the difference in magnetic variation at the position of the aircraft being neglected. The procedure for position finding is then as follows:—

(1) Radio tuned to desired station.
(2) Loop rotated to give minimum response.
(3) Bearing indicator read.
(4) This bearing added to compass reading.
(5) Deviation added or subtracted.
(6) Position line drawn.

Stability of Two-Metre Waves. (C. R. Burrows, A. Decino and L. E. Hunt, Proc. Inst. Rad. Eng., Vol. 26, No. 5, May, 1938, pp. 516-28.) (56/66 U.S.A.)

By continuously recording a signal of 150 megacycles over a 60-kilometre path for a year, fading of up to 20 decibels has been found. This instability was most pronounced from sunset to a few hours after sunrise. The average field strength also tended to be higher during the night. A comparison of stability over various paths from 60 to over 200 kilometres has revealed similar diurnal characteristics. For a shorter path of 30 kilometres, fading was found to be considerably less than for the 60-kilometre path.

The fading magnitude was found to be approximately the same on several 60-kilometre paths differing widely in attenuation and including both optical and non-optical paths.

Because of the nature of the variations over this 60-kilometre path an increase of 7 decibels in power would have been required to maintain the field equal to or greater than the observed mean value for 99 per cent. of the time.