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(Prepared by R.T.P.)

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Bell "Airacobra" P-39 Single-Seat, Single-Engine Pursuit Aircraft. (R. J. Woods, Aviation, Vol. 39, No. 3, March, 1940, pp. 40-1 and 104.) (78/1 U.S.A.)

The design of this machine is completely novel. The engine is installed near the middle of the fuselage behind the pilot and an extension shaft is used to drive the propeller. This arrangement not only permits optimum nose shape for low drag, but the location of the heavy weight of the engine near the centre of gravity of the aeroplane makes for economy in structural weight and reduces the polar moment of inertia about the centre of gravity, thereby giving maximum manœuvrability. The engine is an Allison Vee 12-cylinder liquid-cooled. All three elements of the tricycle landing gear are mechanically retractable. Armament consists of a 37 mm. cannon firing explosive shells and four machine guns for synchronised firing through the propeller disc. External surfaces of the machine have been specially treated to reduce skin friction drag to a minimum. The machine is described in detail. Manufacturers' specifications and performances are :—

Wing span	34 ft.
Overall length	29 ft. 9 in.
Overall height	9 ft. 3 in.
Wing area	213 sq. ft.
Wing loading	28.3 lb./sq. ft.
Power loading	5.3 lb./b.h.p.
Empty weight, approx.	5,000 lb.
Useful load, approx.	1,550 lb.
Gross weight, approx.	6,000 lb.
Maximum speed, around	400 m.p.h.
Cruising speed, approx.	325 m.p.h.
Service ceiling, above	36,000 ft.

Labour in Aircraft Production. (Aeroplane, Vol. 58, No. 1506, 5/4/40, pp. 481-2.) (78/2 Great Britain.)

It is estimated that to maintain an air force at a total permanent strength of 26,000 aeroplanes, necessitating 117,000 aircraft and 221,000 engine replacements per annum, the total labour force required will be approximately 2,400,000 people. With an additional number of, say, 6,500 for maintenance repair and overhaul, and labour in auxiliary industries, the total becomes approximately 3,600,000 workers in the direct and indirect labour forces required to establish and maintain an air force of this size. Enlargement of available man power can be achieved by the following measures:—

1. Longer working hours;
2. Female labour;
3. Transfer from non-essential occupations;
4. Utilisation of the unemployed.

In Germany, at present, 49 per cent. of potential female labour is occupied, in Britain only 34 per cent., leaving 66 per cent. still available. Non-essential occupations in Britain also occupy some 3,000,000 persons. The available margin in Germany in similar trades is not so great, and production of ersatz materials further reduces Germany's disposable margin of man-power.

New Italian Military Aircraft. (Les Ailes, No. 977, 18/4/40, p. 4, and Le Vie dell'Aria, Vol. 13, No. 13, 28/3/40, p. 12.) (78/3 Italy.)

The following table gives some particulars of new fighter aircraft:—

	Caproni Vizzola F.5	Aeronautica Umbra T.18	Reggiane Re.2000.
Span (m.)	11.29	11.50	11.0
Length (m.)	7.90	8.76	7.55
Height (m.)	3.0	2.88	2.28
Wing area (m.²)...	17.4	19.0	20.4
H.p.	840	1,000	1,000
Supercharged height (m.) ...	3,800	4,100	4,000
Total weight (kg.)	2,270	—	2,060
Useful load (kg.)	420	—	—
Min. speed (km./h.)	115	—	117
Landing run (m.)	200	—	—
Time of climb to 6,000 m. (min.)	6.0	—	6.0

All these aircraft are low wing monoplanes with radial engines and are fitted with retractable undercarriages. The F.5 has wooden wings, steel tube fuselage and dural tail. The engine is Fiat A-74 RC. 38 with a Fiat-Hamilton constant speed propeller. The undercarriage retracts inwards towards the fuselage.

The F.5 is characterised by a very large strength coefficient (> 16) and has a very high rate of climb (less than 6 min. for 6,000 m.). It is stated to be very manœuvrable in spite of its high speed.

The T. 18 bears some resemblance to the Seversky fighter. The Aeronautica Umbra factories are situated at Foligno and belong to the Macchi Group (designer is F. Trojarri). The engine is Fiat A-80 RC. 41 with Fiat-Hamilton constant speed propeller. The construction is entirely metallic (dural and steel). The undercart retracts towards the wing roots.

A fuselage of elliptic shape is adopted both for the F. 5 and T. 18 and considerable attention is paid to the fairing of the rear end of the roof of the pilot's cockpit into the top of the fuselage.

The Re. 2,000 is a dural shell structure, both for the wings and the fuselage. A Piaggio XI RC. 40 engine is fitted together with a variable pitch propeller. In spite of its high speed, the manœuvrability is stated to be excellent.

No further details have been released concerning these three fighters. (Top speed of F.5 is rumoured to be of the order of 510 km./h.). Nothing is known about the armament.

Apart from these three fighters, attention must be called to a new three-engined bomber Cant Z 1,007 bis, which is constructed entirely of wood (shell structure)

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and in order to increase the fineness ratio, the two pilots are seated behind each other. The following data have been released for publication:—

Span—24.80 m.
Length—18.35 m.
Height—5.22 m.
Useful load—4,200 kg.
Minimum speed—135 km./h.
Climb to 4,000 m.—11 minutes.

The bomber is stated to be heavily armed (both offensively and defensively) and have a large radius of action (designer, Zappata).

The Stabilisation of an Aerial Bomb. (C. Cremona, L'Aerotechica, Vol. 20, No. 1, Jan., 1940, pp. 11-19.) (78/4 Italy.)

In order to obtain high terminal speeds and therefore maximum penetrations, the bomb must be of streamline shape. As is well known, such a shape is unstable at small incidence. This instability can be reduced, but never cured by a forward shift of the C.G. As in the corresponding case of the airship, stability can, however, be ensured by the provision of a suitable tail surface. The dimensions of such a surface are determined from wind tunnel experiments on the lift and moment coefficients of the tail-less bomb at various angles of incidence. The lift of the tail surface should be responsible for the major part of the restoring couple and this entails the use of high aspect ratios. Unfortunately, questions of stowage limit this factor and hence small oscillations of the bomb during its trajectory cannot be avoided. The motion in this case can be studied by the same method as is applied to the corresponding case of the dirigible, and the author hopes to refer to this problem in greater detail in a subsequent paper.

Germany and Roumanian Petroleum. (C. Berthelot, La Science et la Vie, No. 275, May, 1940, pp. 523-7.) (78/5 France.)

Roumanian production of petroleum increased to 6.6 million tons in 1938. Normally the supply of Roumanian petroleum products to the Reich is about 1.5-1.8 million tons per annum, mainly petrol (more than 1 million tons) and fuel oil. The greater part of this supply has always been transported by sea, but now has to travel by the Danube and by railway. Due to lack of tank wagons and tankers, and to railway difficulties, Germany has probably not received more than 500,000 tons of petroleum during the first six months of the war—barely two-thirds of peace time imports. During January, 1940, transport on the Danube was stopped by ice, and it is estimated that during January and February no more than 30,000 tons of Roumanian petrol reached Germany. Any large spring offensive by Germany is likely to lead to shortage of petrol supplies. The war reserves probably amount to 3-4 million tons of petrol, but from experience of the Polish war this would probably suffice for only 3-4 months of operations. In the present state of affairs all that Germany can hope, now that the Danube is the only route, is that its annual imports will increase to 1.5 million tons. In expert opinion this appears impossible.

Captive Balloons and Aerial Barrages. (W. Kirchner, Berlin, Publisher, E. S. Mittler and Sohn, 1939, 100 pp.) (78/6 Germany.)

CONTENTS.

A. CAPTIVE BALLOONS.

Captive balloon companies at the outbreak of the World War (1914), their organisation, strength and equipment; activities during the war and subsequent development. Methods of balloon observation; observation of transport behind the enemy front, observation during enemy attack, firing by the aid of balloon observation. The World War from the enemy side. Modern balloon observation companies.

B. Aerial Barrages.

Historical survey. Modern equipment—balloons, cables, winches, holding mechanism. Protected targets—targets of large area and point targets. Attack and defence, and the effect of aerial barrages on the attacker. Newest war experiences in Germany and abroad.

Bibliography.

The Armament of Enemy Aircraft. (J. Beseler, Luftwissen, Vol. 7, No. 3, March, 1940, pp. 46-53.) (78/7 Germany.)

The armament of the following machines is briefly discussed:—

British.
Armstrong-Whitworth " Whitley."
Bristol " Blenheim."
Vickers " Wellington."

French.
Amiot 143.
Leo 45.
Potez 63.
Morane 406.
Curtiss P. 36 (supplied by the U.S.A.).

The following guns are described in some detail:—

British.
Browning Mark II.
Vickers M.I.

French.
Aviation 34.
Hispano-Suiza Cannon, Mark 9.
" " Mark 404.

The captured material had been manufactured over the period 1935-40 and the lines of development are clearly indicated. The Lockheed Hudson (supplied by the U.S.A.) was fitted with British guns, whilst the P. 36 (also bought in the U.S.A.) and utilised by the French Air Force was fitted with the Belgian Browning gun, type F.N. 1938.

Very few critical comments are given.

(1) The view from the rear turret of the " Whitley " is to some extent spoilt by the curvature of the plexi glass and access to the turret is difficult, the passage way being very restricted.

(2) The view from the turrets of the " Wellington " is not very good and the space is very cramped if the gunner wears altitude clothing.

(3) The French armament (Aviation 34 and Hispano Mark 9 and 404) appears to be of more modern conception than the British. This applies especially to the gun mountings.

(4) Special reference is made to the " splinter " ammunition used on British aircraft. The bullet has a core of very brittle lead and the hollow nose is filled with light alloy for about one quarter of the length. At normal impact, the nose generally breaks off, but on account of the rear position of the C.G., the bullet has little stability and tends to lateral impact.

The author devotes considerable space to a discussion on the sighting angles available in the various turrets and the time taken by the hydraulic mechanism to cover the full range.

Review of Researches on Centrifugal Pumps Carried Out at the Technical High School, Brunswick. (C. Pfleiderer, Forschung, Vol. 2, No. 1, Jan.-Feb., 1940, pp. 43-44.) (78/8 Germany.)

The following are some of the main points covered :—

(1) Effect of blade number on performance.

(2) Losses due to flow reversal (rotor diffuser).

(3) Instability of operation.

(4) Predetermination of pump characteristics from blade shape.

Experiments were also carried out with water jet air pumps. Of special interest is a comparison between the methods of calculation employed respectively for steam and hydraulic turbines. It appears that such methods exhibit in some respect fundamental differences which are not justifiable on the ground of the physical differences in the working media. For example, the opinion is still widely held by steam turbine designers that the lines of flow behind an aexial guide channel are straight, and that therefore the pressure along the trailing edge is constant. In the corresponding hydraulic case of the Kaplan turbine the flow lines are assumed to have a constant velocity moment, and it appears that similar consideration should also apply to the steam case. If this is correct, blade angles as currently used require modification. This matter is being investigated by temperature and pressure measurement in the last stage of an axial flow steam turbine.

Aerodynamic Investigations of Hydraulic Machinery. (W. Spannhake, Forschung, Vol. 2, No. 1, Jan.-Feb., 1940, p. 45.) (78/9 Germany.)

Reference is made to experiments carried out by the Swiss firm of Escher Wyss on a model water turbine utilising air instead of the normal working fluid. This has the advantage that pressure measurements on the rotating blade can be carried out much more easily and the regions of cavitation (*i.e.*, lowest pressure) determined with great accuracy. Moreover, by using a compressed air tunnel it is possible to approximate to full-scale Reynolds numbers.

Conversely, experimental results obtained with incompressible fluids can, in many cases, be utilised in predicting the corresponding performance with air or steam, provided the laws of similarity are suitably extended. Modern aerodynamic theory has thus made it possible to choose the experimental conditions so that the required results are obtained in the simplest and most accurate manner.

The Influence of Reynolds Number at Large Mach Numbers. (A. Eula, L'Aerotecnica, Vol. 20, No. 1, January, 1940, pp. 20-29. Air Ministry Translation No. 1015.) (78/10 Italy.)

The experiments were carried out in the Guidonia supersonic wind tunnel on spheres and cylinders at Mach numbers of 1.85 and 2.15 respectively. The range of Reynolds number for the former was from 100,000 to 800,000 and in the latter from 50,000 to 200,000. This change of *Re* produced no measurable effect on the total resistance coefficient (wave + friction), at constant Mach number. Experiments are in progress for the separate measurement of the friction losses under these conditions.

The drag at these high velocities is in satisfactory agreement with that calculated from the pressure distribution and is almost entirely due to the forward high pressure region on the body (leading hemisphere). It is interesting to note that the total drag coefficient decreases slightly with increase in Mach number. If the effect of *Re* is truly negligible at these high velocities, one of the main objections to small scale supersonic wind tunnels disappears.

New Methods for the Calculation of Critical Velocity of Cantilever Wings Subjected to a Special Form of Elastic Instability. (T. Viola, L'Aerotecnica, Vol. 20, No. 3, March, 1940, pp. 191-204.) (78/11 Italy.)

A peculiar form of elastic instability may arise in cantilever wings due to the superposition of flexural and torsional instability. This problem has been treated analytically by Minelli and resolves itself into the determination of the first positive characteristic value of a certain system of ordinary, linear, homogeneous differential equations containing two unknown functions and satisfying certain limiting conditions. The author illustrates the method of solution of such problems, both analytically and numerically. The results show that, as could have been foreseen a shift of the elastic axis towards the rear increases the tendency of this peculiar instability to arise and hence reduces the critical velocity.

Application of High Lift Devices to Aeroplanes Designed Primarily for High Cruising Speeds. (R. M. Rogallo, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 185-188.) (78/12 U.S.A.)

In horizontal flight, the weight W supported and the thrust T are respectively given by the equations

$$W = \tfrac{1}{2}\rho V^2 C_L S$$
$$T = \tfrac{1}{2}\rho V^2 C_D S$$

where C_L and C_D are the lift and drag coefficients of the aircraft and S is the wing area.

For a given W and S, the thrust h.p.

$$= C\rho^{-\frac{1}{2}}(C_D/C_L) \times (1/C_L^{\frac{1}{2}})$$

where C is a constant. At constant altitude, the thrust h.p. thus becomes a minimum at a certain C_L for which the product $(C_D/C_L) \times (1/C_L^{\frac{1}{2}})$ is a minimum. In the case of a normal wing, this minimum occurs at $C_L = 1.2$ app., the thrust h.p. being then about 92 per cent. of the cruising thrust h.p. ($C_L = 0.84$). By means of high lift devices, especially slotted flaps of the venetian blind type, C_L corresponding to minimum thrust h.p. can be raised as high as 2, the thrust h.p. under these conditions being only 75 per cent. of the cruising h.p. at $C_L = 0.84$. This improvement is made possible by the fact that high lift devices of this kind do not seriously increase the (C_D/C_L) ratio of the complete aircraft and the thrust h.p. thus varies app. inversely as the square root of the possible lift coefficient.

In the case of the conventional split flap, the increase in drag is such that the possible saving in minimum thrust h.p. is very much less. The reduction in minimum thrust h.p. required has a beneficial effect on the rate of climb and on the ceiling of the aircraft. In the case of complete engine failure, although the gliding range is generally not increased, the sinking speed and the landing speed are both reduced by a suitable high lift device.

In the case of multi-engined aircraft, with one engine dead, the venetian blind flap will produce a considerable reduction in engine power required. Thus, if the cruising power ratio is 0.75, the failure of one engine on a twin engine machine would entail overloading the remaining engine 50 per cent. if horizontal flight is maintained at the same C_L. At optimum C_L (standard wing) this is reduced to 38 per cent. and with a venetian blind flap the necessary overload is only 13 per cent. If the engine failure occurred at 8,000 feet, the overload is reduced to zero if the horizontal flight is continued at ground level (thrust h.p. varying inversely as the square root of the density).

Two Formulas for Take-Off Distance. (E. Lesher, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 209-11.) (78/13 U.S.A.)

Two formulas for take-off distance, which are based on a previous paper by Hartmann (N.A.C.A. Tech. Note No. 557), are developed. The first formula takes into account all the important factors affecting take-off distance, and may usually be trusted to give results in error by no more than 2 per cent. The second formula is a simplification of the first, and will usually give results accurate to within 5 per cent. Both formulas permit comparatively rapid solutions.

Wing Loading and its Effect on the Design of Transport Aeroplanes (*concluded*). (Inter. Avia., No. 706, 16/4/40, pp. 1-4.) (78/14 U.S.A.)

The final instalment of this article deals mainly with the effect of icing and according to the opinion of many pilots this effect becomes relatively more important at high wing loading. This conclusion is, however, in error. The larger wing picks up more ice on account of its increased surface and the lower speed increases the time during which the flight may be subjected to icing dangers.

The effect of ice is to reduce the maximum lift coefficient by about 30 per cent. and increase the cruising drag by 50 per cent. Most important, however, is the fact that the angle of stall is progressively reduced and the pilot has no means of telling how close he is to critical conditions.

Present day mechanical de-icers do not extend beyond 5 per cent. of the chord, yet a ½ in. ice ridge at this point on a 100 in. chord wing reduces the maximum lift by 50 per cent. An improved de-icer extending over 15 per cent. of the chord is in an advanced stage of development.

The following table gives the improvement possible by adopting the new mechanical de-icer on a three-engined aircraft with a wing loading of 40 lb./sq. foot:—

	Icing conditions.		All ice
	Old deicer.	New deicer.	removed.
Stalling speed (m.p.h.), flaps up ...	135	109	102
,, ,, ,, down ...	90	84	79
Absolute ceiling (ft.)	13,000	17,400	20,700
Rate of climb (sea level) (ft./min.) ...	520	740	940

Alternative methods of removing ice by means of exhaust heat are receiving considerable attention. Although it appears that sufficient heat is available for this purpose, mechanical difficulties connected with corrosion, expansion and the presence of fuel tanks in the wings have still to be overcome. It is interesting to note that the presence of guide vanes in air scoops may cause a complete blockage by ice, whilst in the absence of the vanes the scoop will work satisfactorily under the same icing conditions.

Calculation of Diving Velocity. (E. Groth, Luftwissen, Vol. 7, No. 2, Feb., 1940, pp. 31-33.) (78/15 Germany.)

If the aircraft dives at a constant path inclination ϕ, the following equation represents the forces acting along the path (gravitational units):—

$$(G/g)\,(dv/dt) = G \sin\phi - W \quad . \quad . \quad . \quad . \quad (1)$$

where G = weight of aircraft.
V = path velocity.
W = resistance of aircraft.

The propeller thrust is neglected.

Putting $\lambda = (G \sin\phi)/(FC_w)$
where F = wing area
C_w = resistance coefficient and
$Y = V^2/2g$.

Equation (1) assumes the form

$$dy/dh = (\gamma/\lambda)\,Y - 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where h = altitude
$\gamma = \text{density} = (1.2255)\,(288 - 0.0065\,h)/288^{4.255}$.

The author shows how this equation can be integrated in terms of certain exponential functions and gives graphs showing the diving velocity as a function of λ for a given change in h.

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From equation (2) it appears that V is a maximum if $Y=\lambda/\gamma$, *i.e.*, $q=\lambda$. Similarly

$$q_{max}=\lambda\ 1/\{1+(\lambda/\gamma^2)(d\gamma/dh)\}$$

Thus the dynamic pressure reaches its maximum at a lower altitude than the velocity. The difference is, however, not very great and can generally be neglected in preliminary calculations.

Calculating Table (Nomograph) for High Speed Aircraft. (Luftwissen, Vol. 7, No. 2, Feb., 1940, p. 33.) (78/16 Germany.)

The nomograph gives the h.p. (N) required per kg. of aircraft for horizontal flight at various speeds at an altitude of 4 km., provided the following characteristics of the aircraft are known :—

$$v_{min},\ fs/G,$$
$$C_{wp}/C_{a\ max} \text{ and } G/b^2$$

where G = weight of aircraft in kg.
f_s = parasite resistance area in m.^{2}.
b = span of aircraft in m.

In addition to giving the total N/G ratio as a function of the speed, the diagram enables a sub-division of the h.p. into profile, parasitic and induced components which is of great use in the preliminary stages of design.

Wind Tunnel Investigation of an N.A.C.A. 23030 Aerofoil with Various Arrangements of Slotted Flaps. (I. G. Recant, N.A.C.A. Tech. Note No. 755, March, 1940.) (78/17 U.S.A.)

An investigation was made in the N.A.C.A. 7 by 10-foot wind tunnel of a large chord N.A.C.A. 23030 aerofoil with a 40 and a 25.66 per cent. chord slotted flap to determine the section aerodynamic characteristics of the aerofoil as affected by flap chord, slot shape, flap position, and flap deflection. The flap positions for maximum lift, the positions for minimum drag at moderate and high lift coefficients, and the complete section aerodynamic characteristics of selected optimum arrangements are given. Envelope polars of various flap arrangements are included. The relative merits of slotted flaps of different chords on the N.A.C.A. 23030 aerofoil are discussed, and a comparison is made of each flap size with a corresponding flap size on the N.A.C.A. 23021 and 23012 aerofoils.

The lowest profile drags at moderate lift coefficients were obtained with an easy entrance to the slot. The 25.66 per cent. chord slotted flap gave somewhat lower drag than the 40 per cent. chord flap for lift coefficients less than 1.8, but the 40 per cent. chord flap gave considerably lower drag for lift coefficients from 1.8 to 2.5 and a larger value of the maximum lift coefficient. The drag coefficients at moderate and high lift coefficients were greater with both sizes of flap on the N.A.C.A. 23030 aerofoil than on either the N.A.C.A. 23021 or the N.A.C.A. 23012 aerofoil. The maximum lift coefficient for the deflections tested with either flap was practically independent of aerofoil thickness.

Studies of High Speed Aeroplanes. (F. Flader and E. R. Child, J. Aeron. Sci., Vol. 7, No. 6, April, 1940, pp. 235-43.) (78/18 U.S.A.)

Future high speed possibilities are examined by study of an aeroplane design with certain systematic variations in gross weight, wing loading and power. The factors used as a basis for the present design studies are :—High wing loading ; entirely enclosed power plant ; selection of optimum propeller, arranged as a pusher ; mid-wing and tail arrangement with elimination of unfavourable interference ; a cabin and windscreen enclosed within the normal contour lines of the fuselage ; a finely streamlined fuselage shape ; smooth body, wing and tail surfaces with suppression of all excrescences, wrinkles, rivet heads and skin laps ; elimination of exposed scoops outside the normal contour lines of the aeroplane ; elimination of exposed exhaust pipes ; entire elimination of drag due to imperfectly retracted landing gear; selection of an optimum critical altitude; selection of best aerofoil section for the design maximum speed. An analysis is made of factors influencing propeller design, with a prediction of the propulsive efficiencies which may be obtained. The maximum attainable efficiency becomes less as speed and altitude are increased. Possibilities of increasing the indicated optimum propulsive efficiencies and the desirability of a variable gear drive device are briefly discussed. For aircraft designed according to conventional practice the maximum attainable speed is predicted to be possible of accomplishment within two years.

Magnesium for Aircraft Construction. (E. W. Conlon, J. Aeron. Sci., Vol. 7, No. 6, April, 1940, pp. 252-5.) (78/19 U.S.A.)

The present status of magnesium as a material for aircraft construction is similar to that of aluminum in about 1922, and the material is going through the same stages of development. Of the new alloys that are constantly being introduced, the designer should consider only those alloys rated A or B by the producer, as regards corrosion resistance, and alloys with low elongation as compared with aluminum alloys should be avoided.

Static tests referred to in this paper prove that magnesium alloys are satisfactory from a strength-weight standpoint, although much more research must be done to determine the most efficient forms, particularly extrusion and corrugation.

Full-scale static and service tests on wings, fuselages, or tail surfaces must be made to definitely prove that the material and method of surface protection are satisfactory under actual service conditions.

The practice of some manufacturers to use magnesium alloy sheet for fairings and cowlings appears to be a hard way of learning how to fabricate the material. These parts are difficult to form in any material, and strength is a minor consideration. It would seem more practical to first use magnesium sheet where little forming is required and where the high buckling strength is important, such as the covering of a wing or fuselage.

It appears to the author that the stamped butt-welded or cast wing and fuselage may offer as much possibility for low cost quantity production as any of the various plastics which have recently been suggested.

Modern Aircraft Valves. (A. T. Colwell, J.S.A.E., Vol. 46, No. 4, April, 1940, pp. 147-65.) (78/20 U.S.A.)

The development of American and European aircraft and automotive engine valves is reviewed and present types are described, including designs, materials, manufacturing processes, operation and maintenance. Three major developments are responsible for the low valve temperatures and long service under high output conditions of modern aero engine valves:—Development of the sodium-cooled valve, development of forging technique and cylinder head design. In addition, three minor developments are mentioned:—Adoption of T.P.A. austenitic steel for exhaust valves; use of stellite or a similar hard facing material puddled on the valve seat; and the use of T.P.A or silcrome X-9 for seat inserts. A much needed major development is a constant clearance aircraft valve mechanism which will meet all the requirements sought in America. Data from research work on improving gas flow in the valve ports are presented. Specific designs of valves discussed include Wright, Pratt and Whitney, Allison, Hispano-Suiza, Gnome-Rhone, Rolls-Royce, Bristol, Siemens, Junkers, Daimler-Benz, B.M.W., Bramo, Fiat, and Alfa-Romeo, as well as the Buick automobile valve.

Performance of Aircraft Spark-Ignition Engines with Fuel Injection. (O. W. Schey, J.S.A.E., Vol. 46, No. 4, April, 1940, pp. 166-76.) (78/21 U.S.A.)

Fuel injection offers two main advantages over the carburettor: Low volatile fuels (safety fuel) (which reduce the fire hazard) can be used and the combustion chamber can be scavenged without the loss of fuel by the use of large valve overlap. Other advantages are improved starting, acceleration, manœuvrability, and distribution of fuel, as well as freedom from icing.

The National Advisory Committee for Aeronautics has investigated the factors influencing the injection of fuel into the engine cylinder. This investigation included the time of start of injection, the length of the injection period, the location of the fuel injection valve in the cylinder, the rate of fuel injection, the type of fuel spray, and the maximum injection pressure. Tests were conducted on cylinders with two and four valves having pent-roof, disc, and spherical combustion chamber forms. The performances of a modern air-cooled cylinder fitted with a carburettor, a fuel system injecting into the manifold, and a system injecting into the cylinder were investigated. Tests with different pumps and injection valves, with petrol and with four safety fuels of different volatility, both with and without valve overlap, were also made.

The power output for each of three methods of mixing the fuel and the air follows the volumetric efficiency closely and is higher with fuel injection into the cylinder than with a carburettor or manifold injection.

The minimum specific fuel consumption obtained in single-cylinder engine tests is the same with each method of mixing the fuel and air.

Junkers Inter-Cooler for Two-Stage Superchargers on Radial Engines. (Inter. Avia., No. 706, 16/4/40, p. 9.) (78/22 Germany.)

The two stages of the supercharger are mounted one behind the other on the rear cover plate, the second stage facing the engine.

The inter-cooler between the two stages is placed just outside the main engine cowl and surrounded by a short second cowl of larger diameter which finally joins the fuselage skin.

The air intake to the first stage faces forward and is placed in front of the engine inside the main cowling.

(The path of the cooling air is not described in the article. Judging from the diagram of the installation some measure of reversed flow is apparently adopted.)

The Effect of Piston Head Shape, Cylinder Head Shape, and Exhaust Restriction, on the Performance of a Piston-Ported Two-Stroke Cylinder. (A. R. Rogowski, C. L. Bouchard and C. Fayette Taylor, N.A.C.A. Tech. Note No. 756, March, 1940.) (78/23 U.S.A.)

A full-scale, three-dimensional, steady flow model of the two-stroke engine described in N.A.C.A. Technical Note No. 674 (4½ in. bore, 6 in. stroke), was constructed for the purpose of observing the scavenging air flow obtained with the various inlet port arrangements tested in the actual engine. Based on experience gained from correlation of the flow tests with engine tests, several piston head shapes were developed, and the most promising were tested in the engine. Several modifications of the successful round edge piston previously used, were also tested. Three types of cylinder head, spherical, cylindrical, and flat in cross section were tried, first in the flow model and then in the engine.

The principal conclusions are:—

1. The steady flow model is not a complete indicator of results to be expected in the engine.
2. The relative scavenging efficiencies of various piston and cylinder head shapes are little affected by scavenge ratio, above a scavenge ratio of 1.0.
3. It appears from a limited number of tests that the best port timing is not affected by piston or head shapes.
4. Within the range of scavenge ratios investigated, the difference in net power between the best and worst piston tested was within 12 per cent. The difference in net power between the best and worst cylinder head

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tested was within 25 per cent. The most suitable port arrangement was used in all cases.

5. Swirl produced by partially blocking off the inlet ports on one side of the engine was detrimental to performance.
6. Some supercharging was obtained by reducing the height of the exhaust ports without changing their time of opening or closing, but only a small increase in net power was obtained in this way. Scavenging efficiency was reduced by excessive exhaust restrictions of this type.

Double Test Stand for Aero Engines. (C. Weltin, Z.V.D.I., Vol. 83, No. 47, 25/11/39, pp. 1237-8.) (78/24 Germany.)

When carrying out acceptance tests of aero engines on the test stand it is usual to first run-in the bearings and sliding surfaces by means of an electro-motor, while circulating oil and cooling agent, before running the engine under its own power for the continuous test under load. In order to save the expense of the electro-motor and its running costs a double test stand has been designed in which two test engines are mounted facing one another; the one running under its own power is provided with an airscrew, the flow from which drives a windmill attached to the second test engine which has to be run in. The latter is first " wind driven " for the required period, then run on its own power, and by simple interchange of propeller and windmill vane it is used in turn to run-in a new engine. The cooling systems of the two engines are connected up so that the heated cooling agent from the petrol-driven engine warms up the wind-driven engine. The oil systems of the two engines are separate. In most cases the wind alone is sufficient to provide the turning moment necessary to start up the second engine, which is previously decompressed. In absence of a valve for reducing the compression, an inertia starter or compressed air may be used.

Limitations of Single Stage Centrifugal Superchargers. (K. Kollmann, Luftwissen, Vol. 7, No. 3, March, 1940, pp. 54-61.) (78/25 Germany.)

The maximum supercharged height of single stage compression is determined by the following five factors:—

(1) Material of rotor.
(2) Compression efficiency (temperature rise).
(3) Manufacture (type of shrouding).
(4) Bearings.
(5) Method of drive (gears and clutches).

(1) In theory, any material can be utilised which has a ratio *yield point* of the same order as high duty steel (10.7) density.

It is possible to obtain this value with electron, whilst for dural the relative strength factor is as high as 13.6. From the point of view of fatigue, however, the light alloy is definitely inferior to steel. This difficulty can, however, be overcome by proper design. It is interesting to note that the Mercedes-Benz dural rotor only weighs 880 gm. whilst the R.R.Merlin rotor is stated to weigh 3,000 gm.

(2) Although by means of special devices (double shroud, rotating entry vanes, etc.) the D.V.L. have been able to achieve compression efficiencies as high as 83 per cent. at tip speed of the order of 230 m./sec., the efficiency falls to 68 per cent. at tip speeds of the order of 380 m./sec. and is thus no better than that given by a single shrouded impeller without entry vanes operating at the same tip speed. It is not considered likely that efficiencies higher than 70-75 per cent. will be realisable in the near future at high tip speeds. With a limiting induction temperature of 80°C. this means that single stage compression will give compensation up to a maximum altitude of 6-7 km.

(3) Manufacturing difficulties and considerations of weight definitely rule out complicated rotors such as the D.V.L. double shrouded type. The possible gain

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in compression efficiency of such designs is limited in any case to relatively low tip speeds which are of no great practical interest.

(4) A useful empirical rule for roller bearings is given by the product of shaft diameter in mm. with r.p.m. This product should not exceed 600,000, *i.e.*, a 25 mm. shaft supported in roller bearings will run satisfactorily at 24,000 r.p.m. Speeds in excess of this are possible, but require extreme care in the fitting of the bearing and its lubrication. The practical limit of operation seems to be of the order of 30,000 r.p.m.

(5) With a compression efficiency of 70 per cent. the provision of 1.3 atmosphere absolute at 6 km. absorbs about 12-13 per cent. of the engine power. The work wasted near the ground is thus very considerable unless a variable speed drive is provided. An infinitely variable speed gear is the ideal solution.

The D.V.L. Torque Hub. (E. Gilbert and W. Ulrich, Luftwissen, Vol. 7, No. 3, March, 1940, pp. 64-66.) (78/26 Germany.)

The D.V.L. torque hub forms a complete unit with a three-bladed propeller, the blades of which are adjustable on the ground. It can easily be fitted to any engine of 500-1,500 h.p., and is sufficiently stiff not to lower the torsional vibration characteristics of the engine appreciably. Only in the case of heavily geared engines is the fundamental lowered by about 10 per cent. If necessary, a correction for the presence of the hub can easily be applied by the method of Behrens. The torque is recorded by means of the well known D.V.L. scratch method, the lines being sufficiently fine (0.01 mm.) to keep measuring errors below 1 per cent. The film is 12 mm. wide and of sufficient length (8 m.) to enable about 40 separate torque measurements to be taken (each lasting about two seconds). The film is moved electrically and provided with time base and engine revolution marks as well as a reference line for the torque measurements. The weight of the hub is 68 kg. without and 126 kg. with propeller blades.

The instrument is undergoing development for adopting it to variable pitch propellers of large power output.

Effect of Increased Finning of the Cylinders on Cooling of Air-Cooled Engines. (G. L. Sheremetov, Aeron. Eng., U.S.S.R., Vol. 14, No. 2, Feb., 1940, pp. 34-51.) (78/27 U.S.S.R.)

A theoretical investigation is made of the effect of variations in degree of finning on the heat transfer from an engine cylinder. Degree of finning is defined as the ratio of the total surface to the initial unfinned surface, and it is varied by independently altering the height of the fins, thickness of the fins and the distance between them. The purpose of the paper is comparative determination of the heat transfer from a cylinder of basic dimensions 160 × 100 mm. with various degrees of finning (7.65-89.38) during flight at 7,000 m. and $v_0 = 300$ km./hr., and for two different values of the cowling outlet aperture. The power expended on cooling during horizontal flight at 500 km./hr. at the same altitude was also calculated. It is found that the most effective means of increasing the finning is to increase the height of the fins; decrease in thickness and in distance between the fins does not give corresponding increase in heat transfer. For the conditions investigated the optimum thickness for steel fins was 0.8 mm. and for aluminium fins 0.4 mm. The optimum distance between the fins was 2 mm.

Calculation of a Cooling System for Aero Engines taking into Account the Compressibility of Air. (V. G. Nikolaenko, Aeron. Eng., U.S.S.R., Vol. 14, No. 2, Feb., 1940, pp. 52-66.) (78/28 U.S.S.R.)

Calculation of an aero engine cooling system must take into account air compressibility, and it is thus necessary to allow for variation in the physical properties of the air as it passes through the system, *i.e.*, variations in temperature, density and pressure at all the characteristic cross-sections. The present theoretical study leads to the following main conclusions:—(1) Aerodynamic calculations must take into account heating up of the air on passing through the system. (2) The type of radiator mounting is of fundamental importance since it determines the external head drag. The optimum radiator dimensions and total power expended on cooling are fundamentally determined by this external drag. (3) A radiator of "zero" drag may be obtained either when the temperature difference is large (130-140°), or in the case of a temperature difference of 110-115° if the radiator mounting is of special design with small head drag. (4) The internal cooling drag of the cowling of an air-cooled engine, not taking into account the external drag at high velocity, nearly always creates reaction thrust, due to heating up of the air during its passage through, provided that the design is suitable to give correct deflection by the cylinders and that the outlet opening is correctly adjusted.

Freezing Points of the System Ethylene Glycol-Methanol-Water. (F. H. Conrad, E. F. Hill and E. A. Ballman, Ind. and Eng. Chem. (Ind. Ed.), Vol. 32, No. 4, April, 1940, pp. 542-3.) (78/29 U.S.A.)

With a view to producing an "optimum" anti-freeze agent from a mixture of methanol-ethylene glycol and water, to be superior in general properties to either alone, it is necessary to investigate the physical properties of this system over the temperature range to which anti-freeze mixtures are subjected. Freezing point determinations of this ternary system as a function of composition are as follows:—

Blend. Ethylene glycol. % by weight.	Blend. Methanol. % by weight.	Freezing Point, with following % by weight of total blend in aqueous solution. 10 °C.	20 °C.	30 °C.	40 °C.	50 °C.
100.0	0	−3.6	−8.3	−14.4	−22.6	−34.6
78.1	21.9	−4.2	−9.6	−16.1	−25.4	−37.9
65.0	35.0	−4.8	−10.2	−17.7	−28.0	−41.6
58.0	42.0	−5.0	−10.8	−18.9	−29.4	−44.1
49.6	50.4	−5.5	−11.7	−20.1	−31.1	−46.5
40.2	59.8	−5.7	−12.2	−21.0	−32.3	−47.7
29.8	70.2	−5.9	−12.9	−22.0	−33.6	−49.6
21.4	78.6	−6.3	−13.8	−23.6	−35.4	−52.0
12.1	87.9	−6.5	−14.8	−25.0	−37.9	−54.0
0	100.0	−6.8	−15.3	−26.3	−39.7	−54.9

Synthesis of Lubricating Oils (Part I), Condensation of Chlorinated Paraffin Wax with Aromatic Hydrocarbons. (W. R. Wiggins, T. G. Hunter and A. W. Nash, J. Inst. Petrol, Vol. 26, No. 197, March, 1940, pp. 129-145.) (78/30 Great Britain.)

Chlorinated paraffin waxes can be condensed with aromatic hydrocarbons, using metallic aluminium as catalyst to give viscous hydrocarbon oils. The oils have high viscosity indices, and the viscosity gravity constants are in many cases comparable to those of paraffin base oils. The Conradson carbon residues of the benzene and toluene condensation oils are extremely low. All the condensation oils have good oxidation resistance; after oxidation the change in colour is small, no asphalt is deposited, and the increase in viscosity is similar to that of commercial motor lubricants.

The Manufacture and Use of Tetra Ethyl Lead. (G. Edgar, J. Inst. Petrol., Vol. 26, No. 197, March, 1940, pp. 146-149.) (78/31 U.S.A.)

During 1939, the total yearly consumption of petrol in the U.S.A. was of the order of 2,000 million gallons, of which over 75 per cent (*i.e.*, 1,500 million gallons) contained varying amounts of tetra ethyl lead.

A very large plant has been put up at Baton Rouge for the manufacture of this dope according to the equation

$$4\ \mathrm{Pb\ Na} + 4\ \mathrm{C_2H_5Cl} = \mathrm{Pb\ (C_2H_5)_4} + 4\ \mathrm{Na\ Cl} + 3\ \mathrm{Pb}.$$

The pressures and temperatures during this reaction are moderate, but must be closely controlled to prevent wasteful and dangerous side reactions.

After the chemical changes are complete the tetra ethyl lead is distilled off in steam and the lead sludge reconverted into pig lead for making fresh sodium alloy. The necessary sodium is obtained from the electrolysis of salt whilst the chlorine produced at the same time is converted into hydrochloric acid by burning it with hydrogen. The hydrochloric acid is finally made to react with either ethyl alcohol or ethylene to produce ethyl chloride. Thus, with the exception of lead, all the raw materials for the manufacture are produced at the plant itself. The tetra ethyl lead, however, requires admixture both with ethylene dibromide and ethylene dichloride before it becomes serviceable. The latter chemical is bought in the open market whilst the ethylene dibromide is made at the Ethyl-Dow Plant (N.C.), using bromine extracted from sea water.

In the early stages the American plant supplied tetra ethyl lead both for home consumption and for export. Manufacturing plants are, however, now in operation both in Germany and in France and are planned for other countries. A share of the foreign demand is still supplied from the U.S.A.

Flame Speeds and Energy Considerations for Explosions in a Spherical Bomb. (E. F. Fiock, C. F. Marvin, Jr., F. R. Caldwell and C. H. Roeder, N.A.C.A. Report No. 682, 1940.) (78/32 U.S.A.)

Simultaneous measurements have been made of the speed of flame and the rise in pressure during explosions of mixtures of carbon monoxide, normal heptane, iso-octane and benzene, in a 10-inch spherical bomb with central ignition. From these records, fundamental properties of the explosive mixtures, which are independent of the apparatus, have been computed. The transformation velocity, or speed at which flame advances into and transforms the explosive mixture, increases with both the temperature and the pressure of the unburned gas. The rise in pressure has been correlated with the mass of charge inflamed to show the course of the energy development.

Comparable mixtures of the three hydrocarbon fuels expanded about the same amount upon burning and therefore developed about the same power, despite differences in the rate of burning. The addition of ethyl fluid produced no measurable change in flame speed over the range of conditions studied. None of the characteristics of normal burning seems to give a clue as to the relative tendency of fuels to knock. The observed values of pressure are lower than these calculated on the assumption that reaction goes to equilibrium within a very short distance behind the flame front. This fact, together with other independent evidence, points to a continued evolution of energy within gas that has already been traversed by flame.

The Accuracy of Altitude Determinations of Aircraft, based on Atmospheric Measurements. (H. J. Van Der Maas and J. H. Greidanus, Nat. Luchtvaartlab., Amsterdam, 1939, 30 pp.) (78/33 Holland.)

This report deals with the accuracy obtainable in determining the actual altitude of an aeroplane from measurements of pressure, temperature and humidity. The theoretical fundamentals of these atmospheric methods are discussed, particular attention being paid to the simplifying assumptions generally made in calculation, errors in measurement, the humidity of the atmosphere and of vertical air currents. Methods of measurement for pressure, temperature and humidity are described and instructions are given for carrying out the measurements during flight, correction of the measurements and two methods of evaluation suitable for practical use. As regards total accuracy, it is stated that it should be possible to attain a relative accuracy of 0.3 per cent. of the actual altitude for 4,000 m. and over, and 0.7-0.8 per cent. at 1,000 m. Results are given of calibration tests of a precision altimeter and investigation of the error which may arise if altitude has to be determined on the basis of incomplete measurements.

Calibration of Dynamic Pressure Velocity Recorders and the Reduction of Their Readings to Actual Velocities. (S. Wynia and A. J. Marx, Nat. Luchtvaartlab., Amsterdam, Vol. 8, 1939, pp. 81-92.) (78/34 Holland.)

The velocity of an aircraft is usually determined from dynamic pressure, static pressure and temperature, on the basis of the flow theory; this calculation is only accurate in practice if the flow is treated as compressible. The scale of a dynamic pressure meter used as a speed indicator cannot therefore be graduated to always read the actual air speed, but is only correct for 760 mm. pressure and 0°C. The present report describes how the actual velocity can be deduced from the speed indicator readings by taking into account the compressibility of the air, and the results are given in a form ready for use in conjunction with a speed indicator, free from instrumental error, calibrated for 0m. altitude in the standard atmosphere.

Flight Ray, a Multiple Instrument Indicator. (P. R. Bassett and J. Lyman, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 199-204.) (78/35 U.S.A.)

The present paper is a progress report on the development of an instrument by means of which the information from those flight instruments constantly requiring the pilot's attention is concentrated into an easily readable diagram on the fluorescent window of a cathode ray tube. Attitude and positional information and air speed are shown diagrammatically. A switching arrangement couples each primary flight instrument in turn to the cathode ray tube. The switching is carried out at a rate well above the threshold frequency so that the image gives for all practical purposes a continuous picture of the movements of the aeroplane as shown by the actuating instruments. The arrangement of the information, flight tests, and various problems encountered in the development along with their tentative solutions are described.

The Telegon System of Remote Instrument Indication by Self-Synchronous Electric Motors. (A. G. Binnie, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 211-212.) (78/36 U.S.A.)

The use of self-synchronous electric motors for duplicating motion at some point distant from its source has been well known for some time.

The application of this method to the distant reading of aircraft instruments requires special care and leads to the characteristic feature of the Telegon system. In this system, all slip rings are avoided by having the primary coil fixed and the soft iron armature supported on jewelled bearings. The secondary circuit consists of two phase windings placed at right angles. Two such instruments are connected so that the primary coils are in series, the phase windings forming a closed circuit, the centre of which is attached to one pole of the A.C. supply. A displacement of the rotor of one unit by the indicating instrument will on account of the unsymmetrical shape of the armature cause a change in the induced magnetic field. Currents are now induced in the phase windings so as to render the magnetic patterns of the two motors identical with the result so that the second rotor will turn into step with the first, *i.e.*, the reading of the measuring instrument is transmitted. Each telegon unit absorbs about 1.25 watt, weighs 4 ounces, has dimensions $1\frac{1}{2} \times 1\frac{1}{2}$ inches and will operate on any A.C. voltage between 24 and 120 and 300-800 cycles.

The 1-Phase Magnet Motor. (T. Buchhold, E.T.Z., 4th January, 1940, pp. 7-10.) (78/37 Germany.)

The author discusses the nature of the electrical power characteristic of magnet motors, such as are used for driving synchronous clocks, the problem of harmonics and the necessary reactive VA. He also investigates under what conditions such a motor is capable of running at different synchronous speeds. He deals in particular with the following: Bi- and multi-polar designs, principle of operation of the magnet motor, influence of harmonics and power input, possible speeds, useful torque, recorded current curve.

Illustrated with six diagrams.

(Abstract supplied by Metropolitan Vickers Research Department.)

The "Guidonia" Aircraft Speed Indicator. (Les Ailes, No. 977, 18/4/40, p. 5.) (78/38 Italy.)

This instrument has been designed to cover accurately the very large speed range between landing and maximum speeds.

The usual aneroid box, the inside of which is subjected to the total pressure whilst the outside is under the influence of the static pressure, deflects relatively more at low than at high aircraft speeds. In the new instrument the motion of the diaphragm is transferred to the pointer by means of an off-set lever which rotates a toothed sector engaging with a gear on the pointer. In order to maintain sensitivity, the geared sector is in turn off-set with respect to the lever so that the effective multiplication is increased with increasing deflection and thus produces a more uniform scale.

Materials for Slack Diaphragms. (T. Puschmann, Forschung, Vol. 2, No. 1, Jan.-Feb., 1940, pp. 35-42.) (78/39 Germany.)

So-called "Slack" diaphragms made of rubber, leather, or synthetic materials, are frequently employed in measuring and control instruments. Up to now no systematic experiments have been carried out on the suitability of such materials for work of this kind and hence the choice was rather haphazard. The author first investigates the conditions under which such slack membranes are employed and then describes a number of instruments for the testing of such materials as regards deflection under load, hysteresis and the effects of temperature and moisture. It appears that synthetic leather (treated with castor oil) is the most suitable material for the small pressure range generally required (20-50 mm. water). Balloon cloth is nearly as good. Gold beater skin and synthetic rubber are definitely unsuitable.

The D.V.L. Accelerometer. (H. Freise, Luftwissen, Vol. 7, No. 2, Feb., 1940, pp. 30-31.) (78/40 Germany.)

The D.V.L. accelerometer weighs about 1 lb. and covers the range -4 g. to $+8$ g. The dimensions of the instrument are:—

Diameter, 80 mm.
Depth, 100 mm.

The accelerometer is intended to measure acceleration at right angles to the longitudinal axis of the aircraft such as occurs when pulling out of a dive. It consists of a mass held between two horizontal springs and free to move in the required direction.

If

N_0 = natural frequency of undamped system (about 11 vibrations/sec).
a = deflection of mass.
b = acceleration.

We have

$$a = b/(2\,\pi N_0)^2$$

provided the damping is sufficient (logarithmic decrement 1.3 at 24°C.).

The mechanism of the instrument is simple and robust. The oscillating mass is immersed in a viscous liquid, a rubber diaphragm providing the necessary seal for the racket transmission to the indicating pointer. The latter is provided with maximum and minimum indicators, either of which can be reset by hand.

Some Stress-Strain Studies of Metals. (R. L. Templin and R. G. Sturm, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 189-98.) (78/41 U.S.A.)

(1) An annealed or heat-treated metal which has not received any cold working subsequent to the thermal treatment given it, has substantially the same stress-strain curve in compression and in tension. The characteristic stress-strain curve for aluminum alloys in this condition shows a gradually rounded shape above the proportional limit with no sharp knee in the curve.

(2) Uni-directional cold work such as stretching beyond the original yield strength gives dissimilar stress-strain curves in tension and compression, the yield strength being raised higher in the direction of the stress used in producing the cold work.

(3) The characteristic tensile stress-strain curve for aluminum alloys which have been stretched beyond the original yield strength is one which lies distinctly higher than that for the unstretched material and which shows a relatively sharp knee just below the yield strength.

(4) The characteristic compressive stress-strain curve for aluminum alloys which have been subjected to uni-directional cold work by stretching is substantially the same as that for the unstretched material.

(5) The characteristic shape of stress-strain curve for material which has been subjected to uni-directional cold work in compression is just the reverse of that for stretched material, that is, the sharp knee and the large increase in yield strength occurs in the compressive stress-strain curve, while the tensile stress-strain curve retains substantially the same shape as for the material in the condition of zero cold work.

(6) Poly-directional cold working of aluminium alloys, such as is produced by forging, cold rolling, drawing through a die, or extruding, results in tensile and compressive stress-strain curves which lie distinctly above those for the material in the condition of zero cold work, but which are substantially the same shape as those for the metal in the condition of zero cold work. The characteristic knee of the stress-strain curve which accompanies uni-directional cold work is entirely absent if the cold working has been truly poly-directional.

(7) In the case of aluminium alloys, cyclic uni-directional cold work produced by subjecting a piece of metal alternately to axial tensile and compressive forces above the elastic range tends to produce the same general stress-strain characteristics as those produced by poly-directional cold working, provided the degrees of cold work in the two halves of each cycle are substantially equal.

(8) Cyclic uni-directional cold working produces no significant changes in the shape of the stress-strain curves of a copper rod, but completely alters those of the brass and magnesium alloys tested. In all cases there is a marked reduction in the proportional limit of the material in both tension and compression, often to the point where there is no longer any initial straight-line portion of the stress-strain curve.

Brittle Lacquers as an Aid to Stress Analysis. (A. V. de Forest and G. Ellis, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 205-8.) (78/42 U.S.A.)

The fracture of brittle coatings has long been recognised as a method of checking strain distribution. Flaking of brittle mill scale at the yield point of local areas was used in the testing of the first wrought iron bridges. More recently brittle resin coatings which will fracture within the elastic range of most materials have been developed to give good qualitative pictures of strain distributions.

The present work describes an improved brittle coating in the form of a sprayable lacquer which air dries over night to form a coating of uniform brittleness within the limits of thickness of three to eight thousandths of an inch. A calibration method is described whereby quantitative values of strain may be estimated within fifteen per cent.

Effective Widths of Stiffened Panels Under Compression. (J. R. Fischel, J. Aeron. Sci., Vol. 7, No. 5, March, 1940, pp. 213-16.) (78/43 U.S.A.)

A general equation is obtained for the effective width of flat sheet in semi-monocoque structures. This equation is similar to that given by von Kármán, differing only in the magnitude of the buckling constant.

The effects of a decreasing modulus of elasticity at high stresses, inter-rivet buckling, and differences in strength between the stiffener material and the sheet material are taken into account. Curves of effective width of sheet versus stiffener stress are plotted to enable the designer to apply the theory readily to the design of structures.

The close agreement between the theory and test data substantiates the several assumptions made in developing the formulæ.

Heat Treatment of Aluminium Alloys. (L. W. Kempf, Metal Industry, 29th March, 1940, pp. 288-90.) (78/44 Great Britain.)

Most of the article is devoted to the fundamentals of solution and precipitation hardening processes. The alloying of aluminium with elements of nearly similar electro-potential value, and the formation of a homogeneous single phase material, give the best corrosion resisting properties. Precipitation hardening leads generally to the formation of polyphase systems, and a solution hardened metal shows distinct advantages. Fatigue resistance increases with higher concentrations of the alloying elements in solid solution, while electric resistivity shows a similar variation. There follows a discussion on the stability of quenched aluminium alloys which is to be continued in a subsequent article. Illustrated with three graphs.

(Abstract supplied by Metropolitan Vickers Research Department.)

Repair Welding, Brazing and Soldering. (E. R. Thews, Metal Industry, March, 1940, pp. 149-153.) (78/45 U.S.A.)

The author commences with a description of preheating furnaces of cases where preheating of the whole specimen is feasible. He goes through the whole welding procedure, the cutting out of the fault and selection of the flame, to the final heating and machining and points out that welding, brazing and soldering each have distinct fields of use in repair work, but favours brazing wherever it is possible. Similarly, fluxes and solders should be individually selected for the job, and especial care should be devoted to exclusion of solder impurity. Illustrated with two diagrams.

(Abstract supplied by Metropolitan Vickers Research Department.)

Tentative Standard Methods for Mechanical Testing of Welds. (Welding Journal, March, 1940, pp. 201-11.) (78/46 Great Britain.)

These standards have been prepared by the Committee on Standard Tests for Welds of the American Welding Society. The report deals with the weld metal, butt welds and fillet welds. Weld metal is to be tested by its density, soundness as shown by an etch test, and its tensile strength; butt welded joints by a nick-bend test, a guided-bend test, tensile strength and ductility; fillet welded joints by a weld-break test, and shearing strength in transverse and longitudinal directions. The report gives dimensioned diagrams of the specimens and procedure and explains the units and significance of the results obtained from such tests. Illustrated with 19 diagrams.

(Abstract supplied by Metropolitan Vickers Research Department.)

Shaping Edges for Welding. (H. E. Rockefeller, Steel, 11th March, 1940, pp. 60-4.) (78/47 Great Britain.)

The article is concerned with the preparation of edges before welding, and explains how single nozzle oxy-acetylene torches may be made to give full " U " or " J " grooves in a single pass. It explains a plate-riding device, the use of which allows the proportions of the grooves to be varied, and it proceeds to discuss the simultaneous use of two or more nozzles. The positioning of the plates to be cut is important, and the merits of different methods of setting up are discussed. Illustrated with nine photographs and two diagrams.

(Abstract supplied by Metropolitan Vickers Research Department.)

Research on Surface Finish. (Schlesinger, Mechanical World, 29th March, 1940, pp. 269-71.) (78/48 Great Britain.)

The article is a summary of the preliminary report of the Research Department of the Inst. Prod. Engrs. The object of the research was to select a suitable unit for measuring surface finish, to suggest symbols for drawings, and to compare methods of observing finish. The report gives a general description of the range of surfaces submitted to test, and points out the variety of finishing tools and methods of abrasion that are in use. The article will be continued in a later issue. Illustrated with two photographs, three diagrams and one table.

(Abstract supplied by Metropolitan Vickers Research Department.)

On the Crippling Load of a Strut. (C. E. Inglis, J. Inst. Civ. Engs., Vol. 14, No. 6, April, 1940, pp. 205-226.) (78/49 Great Britain.)

In the case of an isolated triangular framework :—

(1) The terminal bending moments in the members of a framework with stiff joints may be greatly influenced by changes in flexibility due to axial loading; this is particularly the case when the members are slender and are loaded nearly up to the point of failure.

(2) Owing to the change in flexibility due to axial loads, the principle of superposition does not apply. Terminal bending moments are not proportionate to the applied loads, and as the loading of a framework increases they may actually diminish and change sign.

(3) Secondary terminal bending moments which act in the same direction are less destructive to a compression member than these same terminal bending moments acting in opposite directions.

(4) The B.S.I. formula, $p=9\,(1-0.0038\,l/K)$ tons per square inch, or the A.E.R.A. formula, $p=15{,}000-l^2/4\,k^2$ lb. per square inch, prescribing the safe axial load for a compression member with riveted ends, provide a margin of safety sufficiently wide to accommodate the secondary stresses which are likely to be induced in any ordinary stiff-jointed framework.

Behaviour of Polyvinyl Chloride Plastics Under Stress. (J. J. Russell, Ind. and Eng. Chem. (Ind. Ed.), Vol. 32, No. 4, April, 1940, pp. 509-12.) (78/50 U.S.A.)

The procedure used to determine the tensile stress-strain diagrams for polyvinyl chloride plastics over a temperature range of $-50°$ to $+80°$C. is described. For compounds containing little or no filler, Poisson's ratio is about 0.5. This value is practically the same as that obtained for soft vulcanised rubber. The stress-strain curves change in shape as the temperature is lowered and ultimately reduce to the " brittle point." This temperature is characteristic for each composition of plasticised polyvinyl chloride. The stress vs. temperature plot consists of at least two portions: a lower temperature portion exhibiting a linear relation between stress and temperature, and a higher temperature portion following an exponential relation. The heats of activation thus derived are of the same order of magnitude as those obtained for a number of pure metals.

Effect of Acceleration on the Human Organism. (V. Streltsov, Aeroplane, U.S.S.R., No. 10, Oct., 1938, pp. 28-31.) (78/51 U.S.S.R.)

The effect of acceleration on the human organism is mainly on the heart and vascular system, the maximum effect being produced when the force acts from feet to head. The work of Kudenko and Chirkin, at the Lenin Institute of Physical Culture, has shown that by suitable physical training it is possible to accustom the heart and vascular system to accelerations which would normally cause hæmorrhage. Special training equipment has been designed and special courses of exercises worked out. Two examples of the sequence of exercises are given. Special equipment includes a " Triplex " consisting of three revolving rings mounted one within the other. The pupil attaches himself to the inner ring and by changing the position of his centre of gravity sets it in rotation; at the same time the two other rings are set in rotation in two other planes mutually at right angles. The pilot thus experiences complicated conditions of acceleration.

Technology and Medicine in Aviation. (J. Jongbloed, Luftwissen, Vol. 7, No. 2, Feb., 1940, pp. 21-23.) (78/52 Germany.)

Aircraft performance (speed, manœuvrability, rate of climb, altitude) is determined not only by the technical excellence of the aircraft as such, but also by the limitations of the human organism. The technical advantages of flying at great altitudes are well known, but although machines can now be designed to operate under such conditions, the proper protection of crew and passengers still leaves much to be desired. Protection against cold is relatively simple, but lack of oxygen concentration is more difficult to guard against. The wearing of masks is cumbersome and it cannot be expected that the ordinary passenger will put up with such discomforts for any length of time and the author considers that some form of pressure cabin will become essential for all operations above 3,000 m. At the lower altitudes, leaks are not dangerous and can be balanced by an excess of oxygen supply over a short period. It is only by gaining experience under these conditions that the reliability of such devices can be improved to the point when flight at greater altitudes (of the order of 10,000 m.) can be carried out in safety.

Apart from altitude, the human organism is sensitive to acceleration. For this reason passenger-carrying aircraft do not carry out violent manœuvres. High acceleration cannot, however, be avoided in aerial combat and it is important to know not only what maximum the human organism can stand, but also what precautions can be taken to minimise deleterious effects. These effects vary considerably with the direction of the acceleration relative to the foot/head axis of the body. The most dangerous case arises if the acceleration is along the body towards the head, when acceleration in excess of 3 to 4 g. produces already far-reaching physiological effects. These limits can be raised to some extent by assuming a crouching position so that the distance between the heart and the brain is reduced.

If the acceleration acts transversely to the body, much higher acceleration (of the order of 10-15 g.) can be supported for short periods.

From the above it appears futile to design aircraft with large factors of safety unless the crew can be placed in such a position as to be safeguarded as much as possible against the effects of excessive acceleration.

The Physiological Effect of Large Accelerations. (S. Ruff, Luftwissen, Vol. 7, No. 2, Feb., 1940, pp. 24-29.) (78/53 Germany.)

The following four factors decide the effect of acceleration on the human body :—

1. Magnitude of acceleration ;
2. Time of action ;
3. Direction of acceleration ;
4. Physical state of individual.

In the case of a person seated in an aircraft, the centrifugal force acts in the direction head $\rightarrow$ seat and the blood pressure is thus reduced above the heart and increased below it. This would not affect the circulation materially if all the arteries and veins were rigid and maintained their shape. Unfortunately the veins are very elastic and under the effect of the new pressure distribution a considerable quantity of blood is stored in the expanded arteries without taking part in the circulation. This in its turn reduces the oxygen supply to the brain which first affects the vision (black-out) and soon afterwards produces loss of consciousness. It is interesting to note that the optical effects disappear almost immediately if the centrifugal force is removed. Loss of consciousness, however, persists for at least 3 to 5 seconds after the acceleration has already ceased. Experience indicates that a healthy individual occupying the normal seat in an aircraft can withstand an acceleration of 5-6 g. for a period of 3-4 seconds without ill effects. This means that the radius of a turn must not be less than about 500 m. at a speed of 600 km./hour and naturally entails a great sacrifice in manœuvrability. Many attempts have been made to increase the resistance of the human body to acceleration. A theoretical solution would be provided by immersing the body in a liquid of equal density and sealed in a rigid shell.

This is clearly impracticable, but provision of bandages round legs and stomach is certainly beneficial and raises the safety limit by ½ to 1 g. (period of action 3-4 seconds). Even better results are obtainable if a meal is taken some time before exposure to acceleration. This is due to the fact that the digestive operation automatically produces an accumulation of blood in the intestine region and thus prevents large scale displacements in the blood stream. The breathing of CO_2/O_2 mixtures is also beneficial since it facilitates the blood circulation in the brain. Placing the legs high and crouching forward also reduces the harmful effects of acceleration, and by employing all the measures detailed above it is possible to subject the aircraft crew to an acceleration of 7-8 g., provided the duration of application of the force does not exceed 3-4 seconds. Further improvements are only possible if the normal seating in the aircraft is given up in favour of a prone position. Laboratory experiments have shown that under these conditions accelerations as high as 10-14 g. can be supported for 2-3 minutes without ill effects. These conclusions have been confirmed by actual flight experiments utilising a specially built glider. In conclusion, the author calls attention to an alternative solution. Experiment has shown that the human body can stand very high accelerations provided the time of application is less than one second (26 g. for 1/5 second). It is not yet possible to say whether the aircraft can be pulled out of a dive in such a short period of time.

The Basis and Aims of Research in Applied Heat. (E. Schmidt, Forschung, Vol. 11, No. 1, Jan.-Feb., 1940, pp. 1-6.) (78/54 Germany.)

The necessary tools for most thermodynamic investigations are provided by the so-called three laws of thermodynamics (Mayer, Clausius and Nernst), but much requires to be done on the experimental side. Thus, really satisfactory thermodynamic data are only available for steam. Tables for other engineering substances such as air, NH_3, SO_3 and CO_2 are fairly satisfactory, but a whole group of new substances now being employed in the refrigerating industry urgently need fuller experimental investigation. The same applies to the thermodynamics of mixtures and the whole problem of diffusion.

Heat transfer in fluids is intimately connected with turbulence and boundary layer phenomena. The effect of Mach number on these processes still requires experimental investigation.

Although the practical application of combustion is intimately linked up with the history of the human race, the complexity of the phenomenon has only recently been appreciated. The utilisation of the combustion process in prime movers has led to further problems dealing with heat loss and combustion control, many of which still require scientific investigations.

General Laws Governing Heat Conduction (Effect of Nature of Substance and State of Aggregation). (A. Eucken, Forschung, Vol. 11, No. 1, Jan.-Feb., 1940, pp. 6-20.) (78/55 Germany.)

The heat conductivity λ is defined by the equation

$$Q = \lambda F \, (dT/dx)$$

where Q = quantity of heat transmitted per sec.,
F = area of surface,
dT/dx = temperature gradient.

1. With the help of the kinetic theory, it is possible to calculate λ for gases to within 1 or 2 per cent. if the viscosity and specific heat is known.

The resultant equation is very simple, *i.e.*,

$$\lambda = (4.47/C_v + 1) \, c_v \eta$$

where C_v = specific heat at constant volume per gm. molecule, and
c_v = specific heat at constant volume per gm.,
η = viscosity.

2. In the case of liquids, theory indicates an equation of the form

$$\lambda = \delta \rho c \rho u$$

where u = velocity of sound,
δ = mean separation between molecules.

Agreement with experiment is here not so good and discrepancies up to 100 per cent. may arise.

3. At the moment we are unable to calculate the conductivity of non-metallic substances by making use of other physical constants. Theory enables us, however, to draw some general conclusions and the great drop in conductivity of amorphous substances compared with crystals can be explained.

4. The calculation of λ for metals, if the electrical conductivity is known, is based on the Wiedemann-Franz-Lorenz law. The author shows that by applying a small correction factor, it is possible to calculate the thermal conductivity of any member of a group of alloys from the corresponding electrical conductivity within an accuracy of 1-2 per cent.

Non-Steady Method for Determining the Thermal Conductivity of Liquids. (J. Weishaupt, Forschung, Vol. 11, No. 1, Jan.-Feb., 1940, pp. 20-34.) (78/56 Germany.)

Experimental study of the thermal conductivity of liquids is rendered difficult by the fact that convection must be avoided. One method of doing this consists in utilising only very thin layers of liquid (so-called guard ring method). The experiment is, however, difficult and not free from error unless very special precautions are taken. Pfrichm has lately proposed (Z.V.D.I., Vol. 82, 1938. p. 71) a new non-steady method which appears to have considerable advantages. The method is based on the following considerations: A vertical wire is immersed in an infinite liquid and receives instantaneously at time $\tau = 0$ the quantity of heat

W_0 (K cal./metre). A time $\tau=\tau$, the temperature in the liquid at a distance r from the wire is given by

$$t=(W_0 e^{-r^2/4a\tau})/(c\gamma 4\pi a\tau)$$

where c = specific heat of liquid,
γ = density,
a = temperature conductivity.

If a succession of heat quantities at regular time intervals is utilised, t will have to be obtained by summation. By reducing these intervals indefinitely, we finally obtain the case of the wire being heated by a constant current and the temperature becomes

$$t=(N_0/l_0)\,(1/4\pi\lambda)\left[-\int_{\phi}^{\infty}(e^{-\phi}/\phi)\,d\phi\right]$$

where $\phi=r^2/4a\tau$,
λ = conductivity,
$N_0=K$ cal./hour generated,
l_0 = length of wire.

If the wire is sufficiently thin, t as measured from its resistance agrees with the temperature of the liquid on its surface, *i.e.*, r = radius of wire.

The author gives details of an apparatus based on these principles and employing a gold wire 0.07 mm. diameter and about 20 cm. long. The electrical circuit is described and various sources of error are discussed. These are mainly connected with convection and the possibility of turbulence arising. In view, however, of the mean temperature difference between wire and liquid being very small, errors arising from this cause are likely to be small. The new method is particularly suited for liquids which are electrical insulators. It can, however, be extended to semi-conductors or weak electrolytes.