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Co-operation Between the Army and the Air Force. (O. Teplinski, Luftwehr, Vol. 6, No. 3, March, 1939, pp. 92-95. From the Russian, Wjestnik Wosduschnovo Flota, August, 1938.) (75/1 U.S.S.R.)

During the fighting in Spain and China the utilisation of aircraft against ground troops on the actual field of battle has played such an important *rôle* that some critics have looked upon this method of co-operation as the chief *rôle* of an air force. It must however not be forgotten that the number of aircraft participating in these campaigns was relatively small and that, especially in Spain, the armies lacked the equipment in artillery considered normal in a major war. Under these conditions participation of the aircraft in ground fighting may play a decisive part in the issue of a battle, especially if the moral effect of this new weapon is effective. The purpose of war is, however, not to win a battle but to win the campaign, and this can only be done if full use of the air arm is made by means of attacks far into the interior of the enemy territory. A large scale offensive by an army or fleet requires a preliminary extensive air reconnaissance. When the attack is launched, the air force will be called upon again to prevent the enemy bringing up reinforcements and supplies. The air force may indeed take part on the actual battle field, but such action will be limited (protection of mechanised units, bombing of machine gun nests, etc.). In no case should such co-operation be regarded as a major *rôle* of the air force. Only by making full use of its destructive capacity " in depth " will the air force come into its own. Moreover, these long distance attacks must be exactly co-ordinated with the exigencies of the situation as a whole. This is true " army co-operation " and requires a high degree of skill for its proper employment.

American Estimate of Relative Rates of Production of Military Aircraft by the Belligerents and the U.S.A. (Inter. Avia., No. 691, 4/1/40, pp. 1-2.) (75/2 U.S.A.)

According to H. W. Baldwin, military correspondent of the " New York Times," the German aircraft production was of the order of 1,600 machines per month in December, 1939. For the same period the rates of production of Great Britain, France and the U.S.A. are given as 1,000, 400 and 350 respectively. The American production should be more than doubled by the spring of 1940; only a proportion of these machines will, however, be available for export. The German December production must not be regarded as a limit, and ultimate production rates as high as 5,000 a month have been mentioned. These are regarded as unduly optimistic. It seems to be established, however, that Germany

The author has divided the belligerent countries into zones of constant distance from the enemy frontier and marked the position of all towns with a population above 150,000. Assuming further that the combined air power of France and England is the same as that of Germany and that the methods of defence are also equal, the vulnerability reduces to $p\,(d_0 - d)$, where d_0 can be put as equal to 1,000 km. Under these conditions the summation gives a vulnerability factor of 94.7 for the Allies against 112.2 for Germany. It is interesting to note that maximum vulnerability in the case of France and England occurs in the London zone (distance 500-600 km.), whilst in the case of Germany the Hambourg and Vienna (distance 400-500 km.) give the highest individual summation.

The following table shows the variation of the vulnerability with distance:—

Zone	0	1	2	3	4	5	6	7	8	9	
Distance in km.	0/100	100/200	200/300	300/400	400/500	500/600	600/700	700/800	800/900	900/1000	
Great Britain and France											
Principal Towns	Strasbourg	—	Lille	Paris	Hull	L'nd'n	Birm'gham	Glasgow	Dublin	—	Total
v	.18	0	1.6	25.4	2.70	37.7	17.1	8.4	1.6	—	94.7
Germany											
Principal Towns	Stutgart	Cologne	Munich	Leipzig	Vienna	Berlin	Breslau	—	—	—	Total
v	5.9	17.5	21.0	11.4	30.1	23.1	3.2	—	—	—	112.2

Some Tactical Episodes in the Polish Campaign. (Flugwehr und Technik, Vol. 1, No. 11-12, Nov.-Dec., 1939, pp. 274-5.) (75/8 Germany.)

(1) The results of all bombing attacks are photographed either from a separate reconnaissance machine accompanying the raiders or from the last bomber taking part in the attack. Only in this way can the effect of the raid be judged and needless repetition avoided.

(2) During the retreat of the Polish armies, bridges found a favourite objective for the bombers. Such bridges were only destroyed when the troops were on the point of crossing. In this way the retreating armies were forced to move in predetermined directions.

(3) The best method of blocking railway lines is to tear up the track by dive bombing immediately in front of a moving train.

(4) By withholding machine gun fire to the last minute and camouflaging the guns, the Poles shot down several low flying bombers. It appears that the small calibre gun is only effective under such conditions of surprise. On the other hand, the Germans claim that in many cases their aircraft withstood successfully direct hits by 2-4 c.m. anti-aircraft shells.

Researches on Steam Turbine Nozzle Efficiency. (H. L. Guy, J.I.C.E., Dec., 1939, pp. 91-124.) (75/9 Great Britain.)

The main lines of research carried out on steam turbine nozzle efficiency, including that due to the Steam Nozzle Committee of the Institution of Mechanical Engineers, are reviewed. Methods of determining the efficiency of nozzles are described; these involve use of a minute pitot tube in a plane parallel to the outlet face of the nozzle, and the use of wind tunnel experiments in which the nozzle specimen is reproduced several times full size so that the "Reynolds number" is maintained at a value of interest in turbine work, but with the low air speeds usual in wind tunnel experiments. A comparison is made of experiments to determine the variation in nozzle coefficient of velocity with steam velocity, and the bearing of these experiments on turbine design is pointed out. The work of J. E. Stanton and J. R. Pannell on flow through rectangular channels is employed to calculate skin friction losses in the nozzle.

should be capable of maintaining her present numerical superiority in aircraft right up to the early summer of 1940, and that the Allies, taking into account American purchases, cannot be expected to take the lead before the autumn of 1940 or the spring of 1941.

Characteristics of the Projectiles for the 20 mm. Madsen Gun. (Rev. de l'Arm. de l'Air, No. 119, Nov.-Dec., 1939, p. 660.) (75/3 Denmark.)

The following types are available:—

1. Explosive. 2. Explosive with special fuse. 3. Explosive tracer. 4. Incendiary. 5. Practice.	Shell.
6. Tracer. 7. Armour piercing tracer. 8. Practice tracer. 9. Explosive armour piercing. 10. Practice.	Bullet.

The characteristics of these shells and bullets are given in the following table:—

Type.	1	2	3	4	5	6	7	8	9	10
Weight of bullet (gm.) ...	113	113	126	113	113	126	146	146	136	136
Weight of driving charge (gm.)	42	42	38	42	42	38	41	41	41	41
Weight of explosive charge (gm.)	9.5	9.5	6.5	—	—	—	—	—	3.5	—
Range (m.)	4700	4700	2100	—	4700	—	5500	—	5000	5000
Min. time of burning of tracer (seconds)	—	—	6	—	—	9	7	7	—	—
Corresponding vertical range (m.)	—	—	1900	—	—	2400	—	—	—	—
Max. vertical range (m.) ...	2950	2950	1900	—	—	—	—	—	—	—
Distance at which 30 m/m. armour (450 Brinell) is pierced (m.)	—	—	1900	—	—	—	500 to 600	—	400 to 500	—

The propellant is nitrocellulose and the explosive tetryl (except in the case of No. 9 charged with black powder and No. 4 charged with tetryl plus incendiary matter). The maximum pressure is of the order of 2,700 kg./cm.^{2}. Radius of curvature of head of shell 2.6 calibre. No. 2 and 3 are fitted with instantaneous fuses together with a safety device ensuring automatic destruction at the end of 13 and 6 seconds respectively.

Characteristic of the Oerlikon 20 mm. Cannon. (Rev. de l'Arm. de l'Air, No. 119, Nov.-Dec., 1939, p. 661.) (75/4 Switzerland.)

The 20 mm. Oerlikon cannons are of two types. Type A is intended for turret use and is operated by hand. The breech is relatively heavy, and the recoil spring weak, and the rate of fire low. The magazine holds 15 to 30 rounds. Type F has a high rate of fire and is mounted in the wing, the magazine holding either 45, 60, 75 or 100 rounds.

In each type the addition of the letter F, L or S denotes that the muzzle velocity is 600, 750 or 900 m./sec. respectively.

Type	AF	AL	AS	FF	FFL	FFS
Calibre	20	20	20	20	20	20
Length (in calibres)	38	60	70	38	60	20
Muzzle velocity (m./sec.) ...	600	750	900	600	750	900
Rate of fire (rounds/min.) ...	450	370	300	520	450	400
Total length (mm.)	1331	1823	2066	1331	1823	2066
Weight (kg.)	25	92	42	23	30	39
Weight of cartridge (gm.) ...	192	211	240	192	211	240

For the 37 mm. cannon of the American Armament Corporation the following particulars apply:—

Muzzle velocity, 823 m./sec.
Rate of fire, 90 per minute.
Weight of shell, 780 gm.
Force of recoil, 771 kg.
Weight (without mounting), 200 kg.

Effect of Aircraft Bombs. (Rev. de l'Arm. de l'Air, No. 119, Nov.-Dec., 1939, p. 662-665.) (75/5 France.)

The following table gives the probable bombing errors, E_p (range) and E_d (direction) for horizontal launching at various altitudes and speeds, utilising the S.T.Ac. bombsight:—

Speed at release	Height of Release (m) 500		1,000		2,000		3,000		4,000		5,000		6,000	
	E_p	E_d	E_p	E_d	E_p	E_d	E_p	E_d	E_p	E_d	E_p	E_d	E_p	E_d
150 km./hr. ...	20	25	30	40	60	65	90	90	120	115	150	135	185	160
200 km./hr. ...	30	35	45	55	80	90	120	120	155	150	200	180	240	210
250 km./hr. ...	35	55	55	75	100	115	145	150	195	185	245	225	300	260
300 km./hr. ...	40	70	65	95	115	140	170	185	230	230	285	275	345	320

In a further table, the author gives a list of objectives together with suitable bombs for their attack. A 50 kg. bomb dropped on a rail track from an altitude of 1,000 m. produces a funnel-shaped hole, 2 m. deep and 6 m. diameter. The track is displaced over a distance of 40 to 50 m. When dropped on a road surface, the hole is slightly smaller. In order to destroy landing surfaces, a minimum of one bomb for each 50 m. square is required.

The Rôle of the Fighter in Modern Aerial Warfare. (C. Jeromez, Flugwehr und Technik, Vol. 1, No. 11-12, Nov.-Dec., 1939, pp. 272-274.) (75/7 France.)

In the 1914 war, more than 90 per cent. of all the aircraft were brought down by surprise attacks carried out at very short range. The enemy was "assassinated" from behind, from a distance of less than 20 m. The author is of the opinion that similar tactics will still apply under present conditions. Firing from a distance rendered possible by the increased calibre of the weapons employed is very uncertain and has the great disadvantage of warning the enemy should the first shots miss. Modern high speeds are no disadvantage in a tail action, since the rate of approach can always be adjusted to give the necessary time (4-5 seconds) for close range shooting. When attacking a bomber, the best position is from the rear, slightly below, either on left or right. The bomber is then passed on the opposite side to which his gun turrets are pointing. The whole art of the fighter is to remain "invisible" as long as possible and carry out the actual attack at short range without the need of sighting corrections. In conclusion, the author raises the important question of obtaining the necessary number of trained pilots to make up for losses in a modern war.

Aerial Vulnerability. (E. Herrera, L'Aérophile, Vol. 47, No. 12, December, 1939, pp. 262-264.) (75/6 France.)

Vulnerability V to air attack of a given territory can be expressed by the following equation:—

$$V = f \Sigma p (d_0 - d).$$

f = air power of the enemy.
p = population of each town in the territory considered.
d = shortest distance (km.) of town from the enemy.
d_0 = longest distance (km.) over which an effective raid can be carried out.

(This summation can obviously only be carried out if the towns can be defended equally well.)

Calculation of the Aerodynamic Characteristics of Tapered Wings with Partial-Span Flaps. (H. A. Pearson and R. F. Anderson, N.A.C.A. Report No. 665, 1939.) (75/10 U.S.A.)

Because of the widespread use of tapered wings equipped with partial span flaps, it is desirable to have means for computing their aerodynamic characteristics. The present report presents factors, deduced from aerofoil theory, for use in calculating the induced drag, the angle of zero lift, the pitching moment and the aerodynamic centre of tapered wings with partial span flaps of constant flap chord ratio. The factors are given for wings of aspect ratio 6 and 10, of taper ratios from 0.25 to 1.00, and with flaps of various lengths. The reliability of the theoretical factors was checked against test results obtained with two tapered wings with partial span flaps. In addition, tests were made of three rectangular wings with full span flaps to provide section data for use in calculating the characteristics of the tapered wings. Fair agreement with experimental results was found.

Aerofoil Section Data Obtained in the N.A.C.A. Variable Density Tunnel as Affected by Support Interference and Other Corrections. (E. N. Jacobs and I. H. Abbott, N.A.C.A. Report No. 669, 1939, 32 pp.) (75/11 U.S.A.)

Aerofoil data obtained in the variable density wind tunnel, and published previously by the N.A.C.A. have been known to contain certain consistent errors due to certain corrections not having been applied (*e.g.*, tunnel wall effects, strut support interference, turbulence of the flow). The effect of support interference or aerofoil drag data has now been investigated, tests being made of N.A.C.A. 0012, 0018, 0025, 0030 and 0040 symmetrical profiles to study the variation of support interference with aerofoil thickness. N.A.C.A. 43012, 43018 and 8318 were also tested to investigate the variation of support interference with camber. It is found that previously published data from the variable density tunnel have shown too large drag coefficients and too large a rate of increase of drag coefficient with aerofoil thickness. The practical effect of the corrections on the choice of the optimum sections is briefly considered and corrected data are given for a selected list of aerofoils. Methods of correcting published data for other aerofoils are presented.

A large amount of recent data, however, has suggested that these or other corrections applied to aerofoil data obtained in the V.D. tunnel will not produce ultimately satisfactory results. It is planned, therefore, to obtain further aerofoil section data under test conditions more favourable than those in the V.D. tunnel.

The Wing of Minimum Total Resistance. (H. Reissner, J. Aeron. Sc., Vol. 7, No. 3, Jan., 1940, pp. 114-118.) (75/12 U.S.A.)

As is well known, the wing of minimum induced resistance has an elliptic circulation function.

The author extends the investigation to the case of total resistance (*i.e.*, induced + parasite). The problem is thus to determine the best distribution of induced velocity and the corresponding best lift distribution along the span if the span b, the total lift L, the velocity of flight V and the distribution of drag angle δ are given ($\delta = C_D/C_L$).

The following conclusions are reached:—

1. Minimum total resistance requires that the sum of the induced inflow angle charge and $\delta/2$ should be constant.
2. If δ is constant along the span, the elliptical lift distribution gives both minimum induced drag and minimum total drag.
3. If δ decreases parabolically from the middle of the span to the tips, the circulation distribution for minimum total drag is given by

$$\Gamma = \Gamma_1 \sin\psi + \Gamma_3 \sin 3\psi.$$

4. The more general case of any symmetrical distribution of the drag angle along the span can be solved by means of Fourier's series with sufficient accuracy.
5. From a worked out example it appears that for minimum total drag the elliptic lift distribution must be distributed in the sense of an increase towards the tips (fuller shape) and a corresponding reduction of the maximum circulation.

Effects of Elevator Nose, Gap, Balance, and Tabs on the Aerodynamic Characteristics of a Horizontal Tail Surface. (H. J. Goett, J. P. Reeder, N.A.C.A. Tech. Report, No. 675, 1939.) (75/13 U.S.A.)

Results are presented showing the effects of gap, elevator nose shape, balance, cut-out, and tabs on the aerodynamic characteristics of a horizontal tail surface tested in the N.A.C.A. full-scale tunnel.

The presence of a gap caused an 18 per cent. reduction in the variation of normal force with elevator deflection, but the size of the gap (between 0.005 $\bar{c}$ and 0.010 $\bar{c}$ where $\bar{c}$ = average chord) was an unimportant factor. At small elevator deflections the effectiveness of aerodynamic balance of the elevator in reducing hinge moments was much lower with the tapered nose than with the blunt nose. The tapered nose, however, maintained its effectiveness to much greater deflections and gave a greater maximum normal force increment than did the blunt nose. With the blunt nose, the hinge moments were reduced 30 and 40 per cent. with 10 and 20 per cent. balances, respectively. This reduction is fairly uniform up to the stall of the elevator. The decrease in normal force and hinge moment caused by a cut-out was proportional to the area removed. The variation in tab effectiveness with a change in tab span was found to be approximately proportional to the area moment of the tab about the elevator hinge line. A comparison of the various experimental aerodynamic characteristics with those computed from Glauert's thin aerofoil theory for hinged flaps is also given.

Interference of the Tail Surfaces and Wing and Fuselage from Tests of 17 Combinations in the N.A.C.A. Variable Density Tunnel. (A. Sherman, N.A.C.A. Tech. Report No. 678, 1939.) (75/14 U.S.A.)

An investigation of the interference associated with tail surfaces added to wing fuselage combinations was included in the interference programme in progress in the N.A.C.A. variable density tunnel. The results indicate that, in aerodynamically clean combinations, the increment of the high speed drag can be estimated from section characteristics within useful limits of accuracy. The interference appears mainly as effects on the downwash angle and as losses in the tail effectiveness and varies with the geometry of the combination. An interference burble, which markedly increases the glide path angle and the stability in pitch before the actual stall, may be considered a means of obtaining satisfactory stalling characteristics for a complete combination.

The Radiation of the Acoustic Air Jet Radiator Derived from Observation of the Amplitude of the Aerial Vibrations in the Oscillator. (J. Hartmann and F. Lazarus, Phil. Mag., Vol. 29, No. 193, Feb., 1940, pp. 140-147.) (75/15 Denmark.)

An air jet discharged at supersonic speed is characterised by a series of equidistant sections which are unstable. If a cylindrical oscillator (*e.g.*, a sharp edged cavity in the end of a piece of brass) is arranged with the aperture facing the stream, resonance of the air in the cavity will occur, if the aperture is within one of the unstable sections of the jet. The arrangement is particularly well suited for the frequency range 10^4 to 10^5 cycles/sec. For an excess pressure of 3 atmospheres in the jet, an acoustic output of 6 watts at 5×10^4 cycles and about 160 watts at 10^4 cycles/sec. can be obtained.

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In both cases the efficiency is of the order of 4 per cent., *i.e.*, the acoustic output is 4 per cent. of the power theoretically required for maintaining the jet.

The authors have carried out experiments on the total radiation by direct observations of the amplitude of the oscillations in the resonator, using an optical method. (Riemann mirror or shock wave.) The results of the new method are in satisfactory agreement with those obtained with a Rayleigh disc.

Formation of a Vortex at the Edge of a Plate. (L. Anton, Ingenieur Archiv., Vol. 10, No. 6, Dec., 1939, pp. 411-27.) (75/16 Germany.)

The flow around an infinitely broad plate can be represented as a potential flow with surfaces of discontinuity starting off from the plate. By means of a conformal representation it is possible to calculate the velocity field corresponding to a given form of the surfaces of discontinuity and given vortex distribution. A necessary condition is that the velocity must be finite at the edges of the plate. However, this is not sufficient to determine the shape and vortex distribution of the surfaces. Nevertheless, on the basis of a similarity condition, it is possible to find for an infinitely broad plate a solution of this problem which is correct for the first commencement of fluid motion. Setting out from this solution, further development of vortex distribution and shape of the surface is followed up for the case of a plate of infinite breadth.

Observations in Flight of the Region of Stalled Flow Over the Blades of an Autogiro Rotor. (F. J. Bailey, F. B. Gustafson, N.A.C.A. Tech. Note No. 741, December, 1939.) (75/17 U.S.A.)

The flow over the inner halves of the rotor blades on a Kellett YG-1B autogiro was investigated in flight by making camera records of the motion of silk streamers attached to the upper surfaces of the blades. These records were analysed to determine the boundaries of the region within which the flow over the blade sections was stalled for various tip-speed ratios. For the sake of comparison, corresponding theoretical boundaries were obtained. Both the size of the stalled area and its rate of growth with increasing tip-speed ratio were found to be larger than the theory predicted, although experiment agreed with theory with regard to shape and general location of the stalled area. The stalled region may be an important factor in both the rotor lift-drag ratio and the blade flapping motion at the higher tip-speed ratios. The method of study used in this paper should be useful in further studies of the problem, including the reduction of the size of the region.

Contribution to the Aerodynamics of Rotating Wing Aircraft. (G. Sissingh, N.A.C.A. Tech. Memo. No. 921, December, 1939.) (75/18 U.S.A.)

The conventional methods for the mathematical investigation of rotors of rotating wing aircraft with hinged blades are extended and refined.

The chief defect of the investigations up to now was the assumption of a more or less arbitrary " mean " drag coefficient for a section of the blade. This defect is remedied through replacement of the constant coefficient by a function of higher order which corresponds to the polar curve of the employed profile. The treatment includes the twisted rectangular blade and a non-twisted taper blade.

The theory includes all flight stages of rotating wing aircraft from autogiro without power input to helicopter with forward tilted rotor axis without regular propeller, and gives results up to coefficients of advance of from 0.4 to 0.5 which are in satisfactory agreement with wind tunnel tests.

The calculation becomes uncertain when, at higher coefficients of advance, the zone of the separated flow within the rotor area is no longer covered by the stipulated assumptions and the effect of the occasional reversed velocity region, for which the substitute functions for the air force coefficients on the blade element are no longer applicable, is observed as interference.

Shoulder Safety Belts. (Sci. Am., Vol. 162, No. 2, Feb., 1940, p. 98.) (75/19 U.S.A.)

Records of accidents suffered by Air Corps pilots recently revealed a larger number of injuries to the head and face than to other parts of the body. The reason is that the lap type safety belt prevents the lower part of the body from being thrown forward; in case of a crash, the upper part of the trunk and the head are unrestrained and jack-knifed forward and the head strikes the instrument panel or other structural parts of the aeroplane. To meet this situation the Material Division of the Army Air Corps has developed a shoulder type safety belt.

If service tests are as favourable as experimental tests, the shoulder belt will become standard Air Corps equipment with added safety for U.S.A. pilots.

The Influence of Running Propellers on Aeroplane Characteristics with Discussion. (C. B. Millikan, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, pp. 85-106.) (75/20 U.S.A.)

As is well known, the propeller slipstream exerts a powerful effect on the static and directional stability of an aircraft as well as on $C_{L\,max}$.

The only satisfactory method of investigating these effects in the wind tunnel is to carry out experiments with models fitted with running propellers. The author describes the equipment of the California Institute of Technology (Calcit), paying special attention to the induction motors employed for the propeller drive. These motors employ three-phase alternating current of frequency up to 300 cycles and deliver 5 h.p. at 18,000 r.p.m., the outside diameter being $3\frac{3}{4}$in. and the length (excluding propeller shaft) $6\frac{5}{8}$ in. The power absorbed is measured electrically after calibration on a special dynamometer. The speed of rotation is obtained by matching on an oscilloscope the alternating current from a magnetic pick-up on the motor shaft against a saw tooth current wave produced by a variable speed commutator, the speed of which is measured directly with a Jaquet indicator. The aircraft model utilised has a span of the order of 7 feet. The author gives details of the experimental procedure adopted and concludes by emphasising the need of correlating the results obtained in various laboratories. In the discussion, the need for extending the experiments to include counter rotating propellers and more full-scale experiments is emphasised.

Vibration of Crankshaft Propeller Systems (New Method of Calculation). (M. A. Biot, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, pp. 107-112.) (75/21 U.S.A.)

The calculation of torsional oscillation in crankshaft propeller systems is carried out by a new method which reduces considerably the numerical work in the case of in-line engines. The theory is briefly outlined and the reader is referred to another publication of the author for further details. Three applications follow. In the first, all six natural frequencies and the corresponding modes are calculated for a V-12 engine. In the second example the method is adapted to the direct determination of the fundamental frequency. The third example deals with a 12-cylinder flat opposed engine coupled to a blower and through gears to a propeller; all eight natural frequencies are determined. The natural frequencies are determined by plotting a simple curve generally close to a straight line and the corresponding modes of oscillation in the crank are expressed in terms of a sine function. The amount of numerical work involved in the procedure is independent of the number of cylinders of the engine.

Second Annual Rotating Wing Aircraft Meeting. (J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, pp. 120-121.) (75/22 U.S.A.)

Short digests of the following papers are given :—

Army Experience with Rotary Aircraft (E. S. Nichols).

Rotor Craft Drive Systems (J. M. Shuckers).

New Parameter for Lifting Rotors (A. M. Young).
Roof Landing Problems (J. M. Miller).
Commercial and Military Uses of Rotating Wing Aircraft (I. Sikorsky).
Economic Significance to Passenger Traffic of Central City Landings (C. E. McCollum).
Mechanical Design on Rotary Aircraft (J. S. Pecker).
Gyroplanes and Combination Types (E. B. Wilford).
Performance Losses on Rotors with Centre Cut-Outs (P. H. Stanley).
Span Analysis of Rotor Blades (H. Mulvey).
Photographic Observations in Flight of the Stalling of Rotor Wings (F. T. Bailey).
Rotor Controls (H. S. Campbell).
Frequency and Vibration Problems of Rotors (R. H. Prewitt and R. A. Wagner).
Notes on Autogiro Rotor Longitudinal Stability (A. Klemin and others).

(See Abstracts 75/23 to 75/30.)

Army Experiences with Rotary Aircraft. (E. S. Nichols, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 120.) (75/23 U.S.A.)

The author described experiments demonstrating the effective use of autogiros for: (1) Direct wire telephone communication with ground crews; (2) use near the front lines where the small space required for take-off and landing makes their concealment relatively easy; (3) conducting troops on the march. It was concluded by the author that the autogiro is capable of defending itself against attacking aeroplanes from all sides except possibly from overhead attack. Their military use would be enhanced by improved roadability to facilitate their movement over the ground.

New Parameter for Lifting Rotors. (A. M. Young, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 120.) (75/24 U.S.A.)

The author described his experiments with rotors in which the tendency of the rotor to tip when its support was tipped was considered as the important factor determining whether or not the rotor was stable. The new parameter mentioned in the title was the " tipping factor," or the extent to which tipping of the rotor affects the angle of attack of a blade which is perpendicular to the plane in which the rotor is tipped. In the model tests the rotor with a tipping factor of zero (blades hinged at hub) was unstable while that with a tipping factor of unity (rotor mounted on a universal joint) was stable. The latter type was unstable in a wind. A rotor with a tipping factor of 0.5 was stable both in a wind and in still air.

Gyroplanes and Combination Types. (E. B. Wilford, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 121.) (75/25 U.S.A.)

The various types of gyroplanes and combination types were compared, including (1) Cierva (hinged blade with tilting axis control), (2) Hafner (hinged blade with feathering control), (3) Herrick (rigid rocking blade with rotor control), and (4) Wilford (semi-rigid blade with feathering control), on the basis of ruggedness, ease of balance, positiveness of control and reduction of control forces, stability in flight, and other factors. Each type was given a " figure of merit " based on the author's engineering judgment. Helicopters with single rotor, two coaxial rotors, and two side-by-side rotors were treated in a similar manner. Finally, combination types of autogiro, helicopter, and aeroplane were described and were considered to be a promising type.

Treatment of Performance Losses on Rotors with Centre Cut-Outs. (P. H. Stanley, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 121.) (75/26 U.S.A.)

The paper described efforts to eliminate the detrimental losses around the root-ends of the blades and at the hubs of autogiros. First attempts comprised fitting a lenticular covering of porous elastic fabric around the hub. This was found to be unsatisfactory. A second fairing, of sheet metal, covered with porous fabric, increased the top speed by 1 m.p.h. and cut down the rotational speed from 144 to 131.5 r.p.m. Analysis indicates that if the gross weight had been changed to bring the tip speed ratios of the faired and unfaired rotors to the same value at high speed, a greater advantage would have been shown for the faired rotor. The author recommends a fairing of rubberised fabric around the hub extending to the blade root-ends; the lenticular shape would be maintained by air bladders inside the fairing. The performance of blades running through the hub and those that end outboard of the hub and the effect of solidity were considered.

Photographic Observations in Flight of the Stalling of Rotor Wings. (F. J. Bailey, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 121.) (75/27 U.S.A.)

The author described recent experiments at Langley Field in the wind tunnel and in flight. The wind tunnel experiments on l/d as a function of the tip speed ratio led to an optimum tip speed ratio of 0.35. The angles of attack of the blades were calculated for all points on the disc and compared with the stalled area determined in flight. A camera was mounted at the hub pointing along a blade; motion pictures of wool tufts attached to the blade were taken and analysed. The stalled region was slightly larger than that calculated. The moving pictures were shown. It was concluded that the stalling angle of the blades of an autogiro should be greater than 15°.

Rotor Controls. (H. S. Campbell, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 1, No. 3, Jan., 1940, p. 121.) (75/28 U.S.A.)

For attitude control the following two systems appear equivalent as far as aerodynamic characteristics and control loads are concerned. (*a*) Flapping pivots through centre of rotation with pitch control. (*b*) Flapping pivots through centre of rotation with tilting control fulcrums centred at plane of rotation. Tilting control has the following advantages: (*a*) Absence of torsional inertia blade loads in the controls. (*b*) In designs where pivot offsets do not create excessive control loads—simplicity of design for hub and control parts. (*c*) Adaptability for use with blade mountings on angular pivots to provide pitch change responsive to torque, left effects, over-speeding, etc. (*d*) Freedom from vibrations arising from torsional motion of the blades. Among the advantages of feathering control systems are listed the following: (*a*) For use in heavy machines having considerable offset of the flapping pivots. (*b*) For control systems in which simultaneous pitch change is desired under operating conditions which cannot be readily reduced to simple automatic actuation. (*c*) For rotors which are intended to be used on different machines having widely different design characteristics. By modifying the control hook-up different characteristics may be imparted to the same rotor system.

Frequency and Vibration Problems of Rotors. (R. H. Prewitt, R. A. Wagner, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 121.) (75/29 U.S.A.)

On the basis of a theoretical investigation the following conclusions were drawn: (1) With normal vertical pin locations, and without additional centring springs, the natural pendular frequency of the blade about the vertical pin is from one-third to one-fifth the rotor speed. (2) With additional specialised centring means, the natural pendular frequency of rotor blades may be made to vary with amplitude of oscillation. (3) The natural flapping frequency of a rotor blade with the flapping axis perpendicular to the blade and located on the axis of rotation, neglecting damping, is equal to the rotor r.p.m. (3*a*) Moving the flapping axis outboard increases that natural frequency in a normal design roughly $2\frac{1}{2}$ per cent. (3*b*) Average coning of the blade reduces the basic natural frequency in a normal design roughly 3 per cent. (3*c*) Damping reduces the basic natural frequency approximately 15 per cent. with the flapping axis perpendicular to the blade. (3*d*) Cocking the horizontal hinge toward the leading edge of the blade has the effect of increasing the value of the damped natural frequency with increases in the angle of cocking. (4) The natural bending frequency in the plane of flapping depends so much upon the structure of the blade that no one value can be given for this term. The natural bending frequency in the plane of rotation for a plywood covered blade having a chord of 1 ft., a radius of 20 ft., and a 17 per cent. thickness ratio, at 200 r.p.m. of the rotor, is approximately $2\frac{3}{4}$ times the rotor speed.

Notes on Autogiro Rotor Longitudinal Stability. (A. Klemin, V. R. Haugen, S. B. Sherwin, Second Annual Rotating Wing Aircraft Meeting, J. Aeron. Sci., Vol. 7, No. 3, Jan., 1940, p. 121.) (75/30 U.S.A.)

To clear up the disagreement between experimenters with and designers of autogiros, the authors carried out a theoretical investigation and arrived at the following conclusions: (1) For a rotor with offset hinges, with moments referred to the centre of the rotor, there is always a stalling moment; (2) the thrust moment may be positive or negative depending on the character of the flapping motion, but the inertia moment is so much greater that it determines the sign of the resultant moment; (3) the stalling moment increases with the tip speed ratio, and the centre of pressure moves forward with increased angle of attack, *i.e.*, the rotor is inherently stable.

Cooling on the Front of an Air-Cooled Engine Cylinder in a Conventional Engine Cowling. (M. J. Brevoort, U. T. Joyner, N.A.C.A. Tech. Report No. 674, 1939.) (75/31 U.S.A.)

Measurements were made of the cooling on the fronts of model cylinders in a conventional cowling for cooling in both the ground and the cruising conditions. The mechanisms of front and rear cooling are essentially different. Cooling on the rear baffled part of the cylinders continually increases with increasing fin width.

For the front of the cylinder, an optimum fin width was found to exist beyond which an increase in width reduced the heat transfer.

The heat transfer coefficient on the front of the cylinders was larger on the side of the cylinder facing the propeller swirl than on the opposite side. This effect became more pronounced as the fin width was increased. These results are introductory to the study of front cooling and show the general effect of the several test parameters.

100 *Octane Fuel in the U.S.A.* (Les Ailes, No. 962, 4/1/40, p. 5.) (75/32 U.S.A.)

American refineries have taken steps to be soon in a position to produce 100 octane fuel at the rate of 40 million tons a month.

The present daily production of some of the larger refineries amounts to from 100 to 200 tons, whilst many smaller plants produce from 10 to 30 tons daily.

The selective refining processes adopted utilise either phosphoric or hot sulphuric acid. It is stated that more that 200 million dollars have been recently invested in developing the industry for large scale production of 100 octane fuel. Apart from its employment in aero engines, it is thought that a further field of application of this high grade fuel will ultimately be found in road transport.

Some Remarks Regarding the Testing of Engine Lubricants. (C. A. Bouman, J. Inst. Petroleum, Pol. 25, No. 194, Dec., 1939, pp. 771-8.) (75/33 Great Britain.)

This paper is mainly concerned with investigation of the high temperature stability of lubricants. Oxidation tests are unable to represent the various processes of deterioration taking place in the engine, since temperatures and other conditions vary from place to place in the engine so that oils are not rated in the same order of merit for all of them. The application of results of laboratory tests should be restricted only to a certain number of the processes taking place in the engine, the test temperatures having been adjusted as closely as possible to those existing in the parts of the engine in which the reactions under consideration occur. Deterioration of crankcase oil due to contamination by products from incomplete combustion cannot be correctly ascertained from laboratory tests.

Carbon tests are of some value with regard to carbon formation in the combustion space, but not with regard to carbon formation in piston ring grooves or tendency to ring sticking. In the latter case engine testing is the only way to obtain reliable results, and even then the degree of reproducibility is often too small to allow sound conclusions to be deduced from a few tests. Since test results depend so much on mechanical conditions in the engine, engine lubricating oil tests should in general be of a comparative nature, especially when the effect of dopes has to be studied.

Motor Methods of Testing Fuels and Lubricants. (A. Von Philippovich, Oel u. Kohle, Vol. 15, 1939, pp. 551-6.) (75/34 Germany.)

The C.F.R. motor method of knock rating is criticised and suggestions are made for improving its usefulness. To determine the instant at which knocking starts it is essential to have an automatic indicator, preferably recording the second differential of the pressure with respect to time. Octane numbers should be determined with the mixture temperature at 86°F., 122°F. and 212°F., as well as at the standard temperature of 300°F. From these figures diagrams can be drawn showing variation in octane number with temperature. The diagrams thus obtained are of four types:—1, Aromatic; 2, olefinic; 3, alcohol mixtures; 4, paraffinic. It is therefore suggested that in reporting the octane number of a fuel the appropriate suffix should be used, *e.g.*, O.N. 73_2 signifies an octane number of 73 having a temperature variation of the olefinic type. This will enable a more accurate forecast to be made of the behaviour of a fuel in an engine.

For the testing of lubricating oil actual engine tests are again preferable. A useful method is to determine the time required for ring-sticking to occur in an engine run under fixed conditions at different temperatures. This gives an idea of the stability of oils at different temperatures, and thus the most suitable oil for use in any particular engine whose working temperature is known can be deduced.

Viscosity Index of Lubricating Oils. (E. W. Dean, A. D. Bauer and J. H. Berglund, Ind. and Eng. Chem. (Ind. Edition), Vol. 32, No. 1, Jan., 1940, pp. 102-107.) (75/35 U.S.A.)

The viscosity index of an oil is defined by the equation:—

$$VI = \{ (L-U)/(L-H) \} \times 100$$

when U = viscosity of oil at 100°F. and L and H are basic constants representing viscosity at 100°F. of hypothetical oils having the same viscosity at 210°F. as the oil in question at the same temperature.

By definition hypothetical oil L has a viscosity index of zero and hypothetical oil H one of 100.

Originally, L and H oils approximated to actual blends representing extreme types of commercial lubricating oils available at the time the viscosity index scale was first proposed (1929). The scale has now been defined more accurately by a series of equations connecting the viscosity at 100°F. with that at 210°F. for both L and H.

If, therefore, the viscosity of an oil at 210°F. is known, L and H can be obtained from tables and the viscosity index follows from the above equation after substituting for U.

The greater VI the less does the oil thicken on cooling from 210°F. to 100°F. At the same time, for the same VI, the ratio of the viscosity at 100°F. to that at 210°F. is the greater the higher the viscosity at 210°F. This is shown in the following tables:—

$VI = 100$.

η 210°F.,	η100°F. (centistokes).
10	88
8	63.5
6	40.5
4	20.5

$VI = 0$.

η 210°F.,	η100°F. (centistokes).
10	155
8	110
6	62
4	26.7

A high viscosity index is of value if the oil has to function satisfactorily over a large temperature range. Apart from engine lubrication, the factor is thus of importance in determining the suitability of an oil for Oleo landing gears as well as for machine gun lubrication.

Experience has shown that the viscosity index of an oil depends mainly on the origin of the crude, and the index will thus also be of use for specification purposes.

Gum Formation in Cracked Gasolines. (D. L. Yabroff, E. L. Walters, Ind. and Eng. Chem. (Ind. Edition), Vol. 32, No. 1, Jan., 1940, pp. 83-88.) (75/36 U.S.A.)

The formation of gum during the induction period of cracked gasolines has been found to proceed at a simple exponential rate at elevated temperatures. The time required for a gasoline to reach a gum content of 10 mg. per 100 ml. (designated as the 10-mg. gum time) is affected by temperature and oxygen pressure in essentially the same manner as is the induction period. The 10-mg. gum time can accordingly be extrapolated to storage conditions, which allows a prediction of the storage life of the gasoline.

The Influence of Various Lubricants on the Seizure Characteristics of Hard Steel and Bronze. (D. Clayton, Engineering, Vol. 149, No. 3865, 9/2/40, pp. 131-5.) (75/38 Great Britain.)

The experiments described show that both lubricant and metal play an important part in determining behaviour as regards both wear and seizure. With steel balls the oil provides a large measure of protection in the low-load range; some wear of a very fine kind occurs and is probably kept low by the partial boundary films of lubricant. With water, boundary film of the same kind is not formed and fine wear takes place to a greater extent. The protection afforded by mineral oil appears as a disadvantage when seizure loads are reached, since more severe cohesion occurring has worse results. The thin liquids have some relatively beneficial quality at this stage, possibly due to their better cooling effects. When a steel ball rubs on bronze balls the yield by the softer material is of considerable importance. Very high loads can be taken without seizure and the lubricant has little effect, possibly because the yielding has allowed a fluid film to form. The thin liquids are exceptional and affect the cohesion, as loss of material occurs at all loads with water, compared with comparatively little with petrol over a considerable range. The relative wear of rotating and stationary balls depends on the material and with bronze and steel together the lubricant affects the bronze, picking up fine steel particles which, in continued running would probably have a lapping action.

The Static Friction of Lubricated Surfaces. (A. Fogg and S. A. Hunwicks, J. Inst. Petrol., Vol. 26, No. 195, Jan., 1940, pp. 1-18.) (75/37 Great Britain.)

For carrying out these experiments the author modified the standard Deely machine by substituting ½ in. steel balls for the flat pegs and also introduced a new method for cleaning the metal surfaces (removal of surplus oil with trichlorethylene vapour and subsequent rubbing with finest grade emery paper—0000 blue black).

The following substances were investigated for static function over the temperature range 20°C.—100°C. :—

(1) Fatty oils.
(2) Mineral oils.
(3) Extreme pressure lubricants.
(4) Graphited oils.
(5) Compounded oils.
(6) Common liquids.

The average results are given in the following table:—

Substance	Static Friction coefficient 20°C	100°C	Remarks
Fatty oils	0.10	0.10	Good repeats—practically no temperature effects.
Mineral oils	0.15	0.20	Consistency not so good
Extreme pressure lubricants ...	0.10	0.10	Good repeats.
Graphited oil	0.13	0.15	After graphite has worked into surface (time lag).
Oil (10 per cent. oleic)	0.14	0.14	(Parent oil 0.15 and 0.20.)
Glycerine	0.20	0.25	Consistent results.
Trichlorethylene	0.33	—	Very consistent results.
Alcohol	0.43	—	Consistent results.
Benzene	0.48	—	Variable results.
Minimum oiliness, steel on steel...	0.58	—	After abrasive cleaning. Consistent results.

From the above, it appears that the class of ordinary lubricants range from 0.08 to 0.20 in static coefficient of friction. It will be noted that extreme pressure lubricants have practically the same static friction coefficient as fatty oils. Yet the latter fail under the working condition of extreme pressure lubrication. The ability to prevent seizure under extremely high pressures is generally attributed to some chemical action between the active constituent of the oil and the metal. The experiments of the author, however, show conclusively that even if a new surface layer is formed under these conditions, it does not affect the coefficient of static friction.

A further point of interest is the behaviour of graphited oils. Here the experiments definitely show a reduction in static friction due to the graphite working into the metallic surfaces. The effect takes some time to develop and persists if the lubricant is replaced by a plane oil (ungraphited).

A Two-Load Method of Determining the Average True Stress-Strain Curve in Tension. (C. W. MacGregor, J. App. Mech., Vol. 6, No. 4, Dec., 1939, pp. 156-8.) (75/39 U.S.A.)

A method developed at the Massachusetts Institute of Technology is described, whereby the complete average true stress-strain curve in tension may be deter-

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mined for a material from the beginning of yielding up to fracture under ordinary testing speeds by the observation during the test of only two loads applied to a tapered specimen, namely, the maximum and fracture loads. Diameters at various positions along tapered specimens are measured before and after the test, and stress and reduction-of-area values are computed from these observations.

Adaptation of Electric Motors to the Drive of Machine Tools. (J. Roy, Electricité, Nov., 1939, pp. 327-34. Met. Vick. Tech. News Bull., No. 691, 29/12/39, p. 8.) (75/40 France.)

The author first discusses the question of motor frames, their ventilation and methods of fixing, following which he deals with A.C. motors dealing with electrical protection, choice of motor, slow running, reversal, electrical braking, speed regulation, multipole motors, speed reducing and varying mechanisms. He then briefly considers D.C. motors, and in conclusion gives a number of examples of electrical drives.

The Protective Effect of a Cladded Layer with Additional Surface Protection in the Case of an Aluminium-Copper-Magnesium Alloy. (W. Geller, Zeit. für Metallkunde, Vol. 31, No. 12, Dec., 1939, pp. 365-6.) (75/41 Germany.)

The effect of an additional surface protection on the long period protective action of a cladded layer of pure aluminium or an alloy of the Al-Cu-Mg type has been investigated. It was found that the long-period protective effect only remains intact in the case of slight damage to the cladding; with greater damage it is completely lost. An additional surface treatment as a protection against corrosion is therefore advisable only if the cladded layer as such will not withstand attack, or if the type of corrosion present does not permit a long-period protective effect on the part of the layer of cladding.

X-Ray Stress Measurement without Use of a Calibrating Substance. (A. Thum, K. H. Saul and C. Petersen, Zeitschrift für Metallkunde, Vol. 31, No. 12, December, 1939, pp. 352-8.) (75/42 Germany.)

A new method is described for obtaining accurate reflection photographs, required particularly for X-ray measurement of elastic stresses; the distance between the camera and the test piece, instead of being measured by simultaneously photographing the interference rings of a calibrating substance, is measured by an "artificial line" produced by scattered radiation. It is shown that a cylindrical camera has many advantages over the flat camera previously used. All the formula necessary for evaluating the photographs are summarised. Examples of the application of the method are described; the accuracy obtained in a measurement made on steel is stated to be ± 0.5 kg./mm. in the best case.

Ignitron Contactor Control of Resistance Welding. (W. C. Hutchins, G.E. Rev., Dec., 1939, pp. 544-7.) (75/43 Great Britain.)

This article describes the operation of the ignitron contactor for the control of resistance welding. Design details of a number of contactor panels are given, and graphs of the tube rating plotted against duty cycle illustrate the performance of this type of equipment. Water-cooling requirements are described.

Dynamic Fatigue Life of Rubber. (S. M. Cadwell and others, Ind. and Eng. Chem. (Analytical Edition), Vol. 12, No. 1, 15/1/40, pp. 19-23.) (75/44 U.S.A.)

Dynamic fatigue is the gradual deterioration and rupture of a rubber member due to mechanical vibrations imposed on it. The number of repeated mechanical vibrations required to rupture the rubber member is referred to here as the dynamic fatigue life of the member for that particular condition of vibration.

Mention has been made in the literature (1-5) that the dynamic fatigue life of rubber in extension is less when the minimum of the oscillation cycle falls near zero strain; but heretofore no complete study has been published. The fatigue lives of rubber as a function of the oscillation stroke are examined for minimum distortions varying from high compressions through all possible elongations.

The general dynamic fatigue characteristics of rubber in linear vibration in a dark, dry enclosure are (L_{min} = minimum length during the vibration; L_0 = free unstrained length): (1) For a given oscillation stroke the dynamic fatigue life is a minimum when $L_{min} = L_0$; (2) for a constant value of L_{min} the dynamic fatigue life decreases as the oscillation stroke increases; (3) for given strain limits of oscillation the dynamic fatigue life is usually lower the harder the stock; (4) the dynamic fatigue life depends to a large degree on the rubber temperature.

The dynamic fatigue life of rubber worked in shear can be related to the dynamic fatigue life of rubber vibrated through linear strains.

Magnesium Castings Used in Germany. (Metal Progress, Vol. 37, No. 1, Jan., 1940, pp. 63, 78, 82 and 84.) (75/45 U.S.A.)

Since Germany has ample raw materials for the preparation of magnesium and its alloys, it is only natural that great attention has been given to this metal. It appears that casting alloys have been used to a much greater extent than forgings or extensions.

Three families of alloys, with Al, Si and Mn respectively are most favoured. The suffixes indicate the approximate percentage.

Al Series.

$$\left.\begin{matrix} Mg\text{-}Al_{10}\text{-}Zn_5 \\ Mg\text{-}Al_6\text{-}Zn_3 \\ Mg\text{-}Al_4\text{-}Zn_3 \\ Mg\text{-}Al_3\text{-}Zn_1 \end{matrix}\right\} + 0.5\%\ \text{Mn.}$$

Si Series.

$Mg\text{-}Si_2$ (for liquid tight castings).

Only the 10 per cent. Al alloy is heat treated (annealing alone or together with temper hardening). This raises the ultimate strength of the casting from an original value of about 25,000 lb. per sq. in. to a maximum of 40,000 lb. per sq. in., together with a corresponding increase in hardness.

Casting alloys are generally free from stress corrosion. Corrosion resistance is increased by treatment with a nitric acid-alkali-bichromate pickle. Varnish is the best protection at the present time.

As a result of its elastic behaviour, magnesium alloy constructions are not very sensitive to sudden blows and they possess great capacity to absorb work.

Their power to absorb noise is useful for gear housings.

The Oscillations of a Gyroscope Electrically Coupled with a Mass. (K. Magniss, Z.V.D.I., Vol. 83, No. 6, 11/2/39, p. 155.) (75/46 Germany.)

In all technical gyroscopic problems, the gyroscope is connected with certain masses which are either part of the instrument or necessary for the support of the gyro. In order to allow for this coupling, the ordinary equation of the gyroscopic motion must be supplemented by a set taking into account the oscillations.

As an example, a single gyroscope suspended in gimbals has three degrees of freedom and in the case of a rigid axis it may carry out two kinds of oscillations: A rapid oscillation in nutation and a slow oscillation in precession. If the shaft is elastic, two further kinds of oscillation are possible and both the nutation and precession are affected.

The greater accuracy required of modern gyroscopic instruments requires these effects to be considered, as otherwise objectionable resonance phenomena may arise.

In the discussion, the introduction of an "apparent" directional couple and an "apparent" moment of inertia in the calculation are recommended. The precession frequency is calculated from the true directional couple and the apparent moment of inertia, whilst the frequency in nutation follows from considerations of the "apparent" directional couple and the true moment of inertia. By the introduction of these concepts the mathematical equations are considerably simplified.

The Application of Complex Mathematics to Gyroscope Theory. (L. Stellmacher, Z.V.D.I., Vol. 83, No. 6, 11/2/39, p. 155.) (75/47 Germany.)

When investigating small stable motions carried out by a gyroscopic system about a position of equilibrium, the problem is simplified by introducing the complex co-ordinates $\alpha + i\beta = z$ when α and β are the angles which the axis of the system makes with the true vertical. The simplification is especially marked in all cases when the gyroscopes are symmetrically suspended with regard to their two degrees of freedom and are subjected to symmetrical moments about the two corresponding axes.

The method can, however, also be applied if a small departure from symmetry exists and is especially useful in all problems involving coupling and damping.

In the discussion, it was pointed out that in the case of two-dimensional problems, the position locus as well as the time should also be expressed in complex form.

Since the functional relationship and integration of two complex functions has already received considerable attention, it is often possible to integrate differential equations and thus obtain a solution to a gyroscopic problem which could only be solved with great difficulty if real co-ordinates are employed.

A Mechanical Harmonic Synthesizer-Analyser. (S. L. Brown, J. Frank. Inst., Vol. 228, No. 6, Dec., 1939, pp. 675-694.) (75/48 U.S.A.)

A harmonic synthesizer is described that has thirty harmonic elements (fifteen sine components and fifteen cosine components) that operate simultaneously, and the sum of the thirty sinusoidal movements is recorded by a tracing point (pencil) on a drawing board that is driven uniformly past the pencil point.

Analysis is accomplished by setting the amplitudes of the thirty elements to values that are determined from the values of selected ordinates from the curve to be analysed and the harmonic components of this curve are determined from selected ordinates of the auxiliary curve that is traced by the machine. Thirty-two equi-spaced ordinates from the curve to be analysed furnish sufficient data whereby analysis is accomplished by a single trace of the machine, that includes fifteen harmonic components (fifteen sine components and fifteen cosine components), or sixty-four equi-spaced ordinates may be taken from the curve and the analysis will include thirty-one harmonic components that are obtained from two traces made by the machine (odd harmonics are determined from one auxiliary curve and even harmonics from the other curve); or, one hundred and twenty ordinates may be selected from the curve and the analysis is extended to fifty-nine harmonic components by tracing four auxiliary curves with the machine.

Industrial Research in 1939. (W. A. Hamor, Industrial and Engineering Chemistry (News Edition), Vol. 18, No. 1, 10/2/40, pp. 1-13.) (75/49 U.S.A.)

In 1939 over 30,000 scientists and engineers with about half that number of assistants and clerical grades were engaged in research in the U.S.A., the total expenditure being of the order of 200 million dollars. The principal results were achieved in organic chemistry, moulding fuels, textile fibres and plastics. The latter have received much attention by the military authorities and the following applications, definite and potential, of these new products are noted:—

(1) Laminated plastics for aircraft construction.
(2) Guide lines, made of cast resins, on aircraft carriers.
(3) Luminescent resins.
(4) Tinted cellulose acetate windows for A.R.P. of gum stocks made from cellulose acetate and fabric filled phenolic resins.
(5) Shaped cellulose acetate sheet as a chute for conveying ammunition belts from ammunition boxes to machine guns on aircraft.
(6) Phenolic resins for mouthpieces and containers for gas masks.
(7) Use of Koroseal plastics in gas masks as a protection against mustard gas.
(8) Use of phenolic resins in the construction of the noses of A.A. shells.
(9) Possible use of synthetic textile Nylon as a parachute material.

The Testing of Loud Speakers. (R. Vermeulin, Philips Tech. Rev., Dec., 1939, pp. 354-363.) (75/50 Great Britain.)

To judge the quality, and to compare different loud speakers, it is desirable to make use of quantitative data, such as the distortion and the frequency characteristics. Methods used in the Philips laboratory for rapid determination of these factors are described; the fundamental problem of the conditions under which the measurements on the loud speaker must take place is also discussed. Measurement of the direct sound alone as well as measurement of the total sound radiation are considered; a measurement in which a certain combination of direct and indirect sound is used as a basis.

Report on Circuit Design for Low Frequency Radio Ranges. (D. M. Stuart, Civil Aeronautics Authority, Report No. 8, 1939.) (75/51 U.S.A.)

This report presents a discussion of the circuit theory involved in the design of the radio range coupling system, and a description of the equipment employed in the latest type of radio range station. Particular emphasis is laid upon the theory of the coupling system because it is the most important part of the entire equipment, and also because its function is perhaps the least understood by those who do not have direct contact with the problems of radio range operation. Some of the theoretical work is new as far as the literature on the subject is concerned, and the results are presented here for the first time in published form.