RAF COLLEGE CRANWELL "College 100 Memories"



A Summary of College Items - Chapter 6 Evolution of Flight - A Cranwellian Perspective

Prologue

If ever you are required to research something on the heritage of the RAF College - it could be looking up details of a relative who might have been trained at the College, or it could be a more complex review of specific trends throughout its 100 year history - inevitably you will be encouraged to explore the Library's holding of College Journals.

In addition to many other records held within the College and other, third party archives, these journals contain a wealth of information on the milestones, the events and the thinking that underpinned College operations. They are essential reading for anyone who wishes to gain an understanding of how the College evolved and took on the challenges that confronted the world's oldest air training academy throughout its marvellous history.

As its contribution to "College 100" - the celebration of 100 years of officer training at the RAF College - the Cranwellian Historical Society created a suite of albums intended to capture RAF Cranwell's heritage, one album for each year of the College's existence and containing authentic extracts from the College Journals.

One of six chapters that portray 100 selected topics - 'memories' per se - this album draws on chronological Journal extracts in an attempt to summarise life at the College throughout its history, from a variety of perspectives. They are extracts of the original articles in the Journals and so their accuracy is dependent on the authors of the day; the dates in each slide title indicate each article's date of origin.

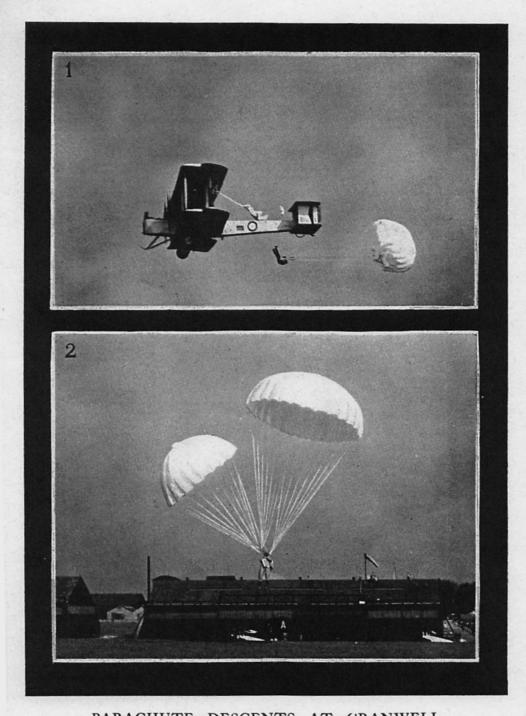
We hope "College 100 Memories" gives you an enjoyable insight into life at the College between 1920 and 2010. Happy reading.

Memories that Symbolise 100 Years of Flight

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Autumn 1926 - Parachuting Articles (1)



PARACHUTE DESCENTS AT CRANWELL.

- (1) Two Pull offs.
- (2) Main and Reserve Parachutes opened.

Autumn 1933 - Parachuting Articles (2)

PARACHUTING AS A CAREER

BY JOHN TRANUM.

I BEGAN parachuting from necessity. About thirteen years ago I went from my native land to America to find a career in aviation. Fortune soon favoured me and one day I was flying over the beautiful Santé Barbara Mountains, feeling very pleased with myself. Suddenly I heard a sizzling sound, followed at once by the unpleasant sight of a billow of smoke and flame issuing from my engine.

I thought that I was doomed until I realized that I had got a parachute with me; in fact, the object of the flight was to convey this parachute to a pilot at Santé Barbara field. In a second I jumped out and landed safely, amazed by the experience. I had imagined dropping through the air as a terrible experience, but it was quite pleasant.

From that moment I decided to become a parachutist, and as soon as I could afford the equipment I looked round to make a living from it. I went to a film studio and offered my services for any air stunt that they liked to name.

The casting director said that he wanted an aeroplane taken up, fired, and the pilot to escape by parachute. I asked five hundred dollars for the feat, and after he got over his surprise we came to terms. The aeroplane -an old Nieuport-was well sprayed with petrol and I took it up to 7,000 feet. Here I released my safety belt and set fire to the plane with a special fuse match.

Contrary to expectations, there was a loud "whoof" followed by a brilliant firework display, which showered me with burning drops of petrol. I got out and dropped and the roaring Nieuport came after me, but I managed to miss it and bring my first film job to a happy ending.

After that I was never short of film work, which varied from serious jumps to the grotesque. For example, to advertise a new summer resort I had to jump dressed in a frock-coat, grey topper and monocle, and land on the lawn of a principal hotel, then make a majestic entry into the foyer, with my parachute stowed away in my suitcase.

I also came down once on a beach dressed in white flannels with a string of beads round my neck, playing on a guitar-all for the purpose of advertising an Hawaiian orchestra. I have never believed in attempting foolhardy stunts with parachutes, but it is difficult to live up to ideals when one's living is involved. Big fees have been responsible for some of my aerial excesses.

Perhaps the silliest thing I did was to ride a motor-cycle over a Californian cliff 200 feet deep, which is a short distance for operating a parachute effectively. Three of my predecessors had lost their lives over the feat. But somehow I came through safely, although it was an ordeal.

I have often wanted to drop off the Eiffel Tower in Paris, and one day I had taken up a position ready to jump from there, but as I stepped forward



My velocity at that moment was 119 m.p.h., the maximum velocity of a falling body when it enters the vertical path, but during my dive my velocity had touched 140 m.p.h.

It is difficult to describe the shock of opening which I felt. One's body seemed to be mangled, but that feeling only lasted a second and I was soon comfortably floating down to earth. I landed safely close to a tree about five miles from the aerodrome, where I sat for a few minutes recovering from slight exhaustion or the reaction.

The observers of the drop proved my fall to be 17,250 feet and not 17,500 feet as I thought, but I could safely have continued for another thousand. However, I was sufficiently beyond the record so I remain contented.

There is a usefulness in a drop of this nature. First it proves that an airman can rely upon his parachute to withstand the shock after he has fallen a long distance. Secondly, it proves that he can have faith in himself to withstand such a drop without losing consciousness or being otherwise rendered incapable of opening his parachute.

In war the fighting pilot inevitably will be faced with the contingency of jumping for his life at great altitudes, so I can suggest that such a jump as mine is a comforting lesson.

As for the parachute, the type I used is designed to bear a shock load of 200 lb. moving at any speed up to 400 miles per hour. The rest of its performance will be known to my readers. It opens in 1 3-5th seconds, and one descends at the rate of 21 feet per second.

Spring 1929 - Autogyros (1)

THE AUTOGYRO.

By Flight-Lieut. C. E. W. Lockyer.

A COMPLETE account of the properties of the autogyro would be likely to prove dull reading, since it would involve the introduction of a good deal of mathematics. Consequently, it is my intention in this article to confine the subject-matter to simple explanations of the salient points in which this type of aircraft differs from the aeroplane.

Before launching this attempt, it is of interest to recall the genesis of this remarkable departure from conventional methods of heavier-than-air locomotion. It was not the outcome of a mere desire for novelty, but of the bitter personal experiences of the inventor, Senor Juan de la Cierva, in his early essays with aeroplanes. "The possibilities of losing flying speed and the uncertainties of landing," wrote Cierva, "are the only faults with which we can reproach the aeroplane." It was with the specific idea of attempting to remove these disabilities of the aeroplane, "to find a flying machine with stability entirely independent of its speed," that he began his experiments on the windmill type which has developed into the autogyro of to-day. Whatever other limitations may exist, or be inherent in the design, the inventor has certainly achieved his aim in so far as it is set out above.

Whether the gyrations of a descending sycamore seed or some other such simple phenomenon played the inspiring part of Newton's apple, is not known. The essence of the idea, however, has been simply stated, as follows: "If we wish to reduce the lowest speed of an aeroplane," that is, mitigate the inconveniences to which Cierva refers, "we increase its area or use some device for increasing the stalling angle; slot, or flap or change of section: generally the area is increased. Cierva, instead of adding area, adds speed by virtue of the rotation of his comparatively small sustaining surfaces"; thereby making it possible for the translation of the aircraft as a whole to be slow. It transpires, and this is the gift of the gods in this particular device, that the hinged rotary sustaining elements operate roughly at constant mean lift co-efficient and speed. The result is that stalling, in the sense of the breakdown of flow, has been eliminated.

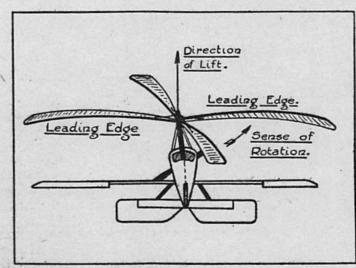
Once committed to the windmill species, Cierva encountered the first and obvious difficulty, the asymmetry of forces arising from the blades moving in the same sense as the general motion of the aircraft, on the one side, and, on the other, in a sense opposite to the general motion. His first attempt at a solution was to employ two rotor systems, one above the other, turning in opposite senses. Unfortunately, it was found that the lower one, owing to interference between the two, revolved at only two-thirds of the speed of the top one, and the difficulty could not be overcome in this way. It was at this stage of his researches that the most notable conception occurred to him, that of employing a single windmill, and articulating the blades at their roots. The idea underlying this modification was that the greater relative air speed of elements of the advancing blades might be compensated by a smaller relative incidence. For, where the thrust moment would be large in the case of an advancing blade rigidly attached to a central spindle, a hinged blade rises and so causes a reduction of its effective angle of incidence and of its thrust. Thus, in the case of hinged blades rotating clockwise as viewed by the pilot from below, the starboard blades will be rising and the port blades falling.

Articulation of the blades swept away most of the mechanical difficulties: since, with articulated blades, the total reaction on each blade, that is the resultant of all air and inertia forces, must pass through the hinge pin. Gyroscopic couples which would be of the severest nature in a rigid system, cannot be transmitted through the flexible attachments of the blades, as these are practically on the axis of the shaft. Therefore, we have a resultant force here as distinct from the precessional couple associated with gyroscopic motion

While we deal with the mechanical aspect of the rotor, reference should be made to two other mechanical features of its design.

To avoid torsional stresses in the blades themselves, through travel of centre of pressure, and to allow of the use of a single spar, a symmetrical

Fig. I.



section, usually Göttingen 429, has been employed. Again, the blades have a section, concave downwards in the axial plane, designed so that the resultant force at each point is along the blade; thus the single longeron of steel tube is practically in pure tension, allowing of the most advantageous use of material in the spar.

Next, we may consider some of the aerodynamic features. There is nothing mysterious about the aerodynamics of the autogyro, though there are certainly curious phenomena, such as the practically constant rate of rotation at all forward speeds once a certain rate of rotation has been exceeded; and such loose expressions as that the autogyro stalls at high speed in contradistinction to an aeroplane, which stalls at low, do not involve any new ideas of fluid flow. The expression merely means that with increasing speeds the retreating blades will become less and less efficient, for parts of them will then be moving backwards relatively to the air; that is, the trailing, instead of the leading, edge of the blade is meeting the relative air current, and the aerodynamic conditions are obviously very inefficient. Thus the loose

Spring 1929 - Autogyros (2)

expression does not imply any sudden loss of lift due to a breakdown of the air flow as in the aeroplane at its stalling angle.

A good deal has been written "why the autogyro rotates in the sense in which it actually does"; for it is in the opposite sense to that in which it would if dropped from rest with the shaft vertical. In fact, Don Juan's windmill rotates in the opposite sense to those at which his famous countryman, Don Quixote, tilted. Now, it is fairly obvious that, if the windmill is at rest and is subjected to an air current perpendicular to the shaft, the port blades of the rotor shown in Fig. 1 would, since their trailing edges are presented to the air stream, have a higher drag than the starboard, and rotation would start in the sense shown. This corresponds with the condition of level flight. It is not easy to give a simple explanation why this sense of rotation is stable for conditions of flight intermediate to level flight and vertical descent, and recourse must be had to analysis of the direction of the

Sense of Rotation.

Threat.

Contribugal Force.

Pliage. Neight.

Fig. II.

resultant force on the blade elements; which analysis, incidentally, shows why the pitch angle of the blades must be small. In autogyros this angle is about 2 degrees.

In referring earlier to some of the mechanical features, mention was made of the flapping of the blades in flight, and of the downward concavity of the blades, akin to the droop of the leaves of a palm (Fig. 1). These two features deserve further examination, aerodynamically.

Since the hinged blades cannot transmit any moment about their hinges, there must be a general upward inclination of the blades, the magnitude of this depending on the curvature, weight, and moment of inertia of the blades. In fact, the upward inclination is necessary to obtain a balance about the hinge of a blade of the moments due to the thrust, the weight, and the centrifugal force (Fig. 2), for much the same reasons as an aeroplane has its inner wing lower than the outer on a turn. This angle is independent of the angle of incidence of the windmill, and is approximately 6 degrees. As I mentioned earlier, however, the blades have not a uniform coning angle throughout a rotation, but, in the case discussed, the starboard blades rise as they advance and the port blades will, of course, fall. This motion is

equivalent to a tilt of the plane of rotation backwards, the lowest point being downwind. In addition to this, which is a velocity effect, there is a dihedral effect owing to the general upward inclination, by virtue of which the thrust tends to be high in front and low at the back. By the same argument as before, the blades will rise in front and fall at the back, thus the plane of rotation will be tilted laterally as well as fore and aft. The new plane of rotation will have its lowest point somewhere in the first quadrant measured from the downwind position.

The fore-and-aft tilt produces no asymmetry in the direction of flight; the sideways tilt does, and requires compensation. Since the lateral tilt depends on dihedral effect, it can be modified by adjusting the downward curvature of the blades, as the outer parts of the blades will thus be inclined at a smaller angle to the plane normal to the shaft of the windmill. The asymmetry of forces due to this dihedral can by this means be reduced to small proportions; and, to allow for the remaining side force, the shaft of the windmill is tilted laterally to suit some mean angle of incidence, the base being to starboard for the sense of rotation considered here.

In conclusion, reference should be made to the performance of the autogyro compared with that of an aeroplane of the same weight and horsepower. Certainly, up to the present, the former has not shown up favourably as regards speed and climb. Whether this will always be so is still a subject of controversy, and it should be borne in mind that the autogyro is still in its infancy. One of the arguments put forward to demonstrate why the autogyro can never be as efficient as an aeroplane of the same weight and horse-power is that, in going from "A" to "B," the sustaining surfaces of the former trace out a spiral path, whereas those of the latter travel in a direct straight line. But the argument is not so simple as that. An aeroplane flying at top speed carries more area than it needs, because it requires that area to fly at low speeds. In an autogyro, the area is much less, the extra speed of the lifting surfaces, by virtue of their rotation, compensating for this at low speeds. The body, in each case, travels at the normal speed, and the increased work is in respect only of a small fraction of the total. Moreover, the better aspect ratio of the autogyro supporting surfaces has to be taken into account. So that it may still be premature to give a verdict, and, in view of the ability of the autogyro to land more slowly, pull up more quickly after landing, and to remain stable at large angles of incidence, it seems well worth while to investigate the possibilities of improving its speed, climb and take-off.

Spring 1927 - Early Flights (1)

FLYING IN THE EARLY DAYS.

By C. G. GREY, Editor of The Aeroplane.

There is always a certain grim satisfaction in having been a pioneer of anything, especially in the way of pioneering new territory, or a new means of locomotion, or even a new religion. There is a certain joy about the job that one never captures in later stages of development. Metaphorically speaking there are always pioneers who are burnt at the stake or hanged or crucified or shot at dawn for sticking out for their own opinions. And of the pioneers who escape evil fates some few make vast fortunes and the rest of the survivors have always the satisfaction of being able to say, "I told you so."

But the worst sort of survivor is the fellow who will insist on saying, "Things are not what they were in my day." He is generally of the type who was so beautifully told off by the late Sir Frank Burnand when he was Editor of Punch. Some unkindly critic said to him, "Ah, Burnand, Punch isn't what it used to be," and Burnand replied simply, "No, my boy, it never was."

Therefore, one is not going to claim that aviation is not what it used to be or that our pilots are not what they used to be. Some of us old stagers, remembering our friends who were "star turn" pilots in the dark ages of aviation, are apt to forget what a lot of infernally bad pilots there were in those days and how much easier it was to shine as a "star" when there were so few other "stars" to set up rival scintillations.

The fact of the matter is that the pilots to-day are every bit as good as ever they were, so far as pluck and skill are concerned, but it is considerably more difficult for them to stand out from the rest, largely because the all-round level of flying has been so immensely raised by improvements in the machines themselves and in the engines and in the system of training.

Nevertheless, it is just as well that the younger generation of pilots should get some idea of what the old hands were able to do. Therefore, without going back to 1908, which is really the "Year One" of aviation, although Orville Wright actually made his first flight on December 17th, 1903, one proposes to discourse for a while, without any particular method, on certain early performances with aeroplanes.

For practical purposes, the history of aviation is divided into three parts, the period before the war, 1914-18, the period of the war, and the period since the war. Many people will tell you that the war period was the making of aviation. As a matter of fact, the probability is that if there had been no war aviation would have made considerably more progress.

It was not much of a war, anyhow. It only lasted for four years, and plenty of wars have lasted longer than that. Quite a number of nations were concerned in it. But the amount of territory which actually saw any fighting was comparatively small in relation to the area of the so-called civilized communities of the world, or compared with the territory covered by, say, the Napoleonic Wars or the Thirty Years' War or even the wars of Cæsar, and Alexander, and Cyrus (plus our old friend, Xenophon).

A good many people were killed in the course of the war. But their number was a small percentage of the total population of the countries to which they belonged. And anyhow more people died of influenza in the Winter of 1918-19 than were killed or died of wounds between August 1914 and November 1918.

The money cost of the war was fairly large. But it probably did not do as much financial harm to any of the nations involved as has been done by the various strikes and trade disputes since the war. And, though it disturbed the military balance of power in Europe it has hardly disturbed the industrial balance of the world at all—except that the United States have gone still further ahead of Europe.

The only benefit aviation got out of the war was that we learned just what men and material will stand. But we might have learned even that just as well without the war, for looping-the-loop and upside-down flying were quite popular pastimes in 1913.

Where the war did harm to aviation was that, speed and climb being most desirable things for war machines, we achieved performance by the stupid process of simply building bigger and bigger engines and cramming more and more power into the machines. We learned a certain amount about streamlines and a good deal about the strength of materials, but really very little about aerodynamics.

As a matter of fact, in the eight years since the Armistice the Germans have learned more about aerodynamics than anybody else, merely because they were forced by the Treaty of Versailles to give up using big powerful engines and had to go all out for efficiency to get the best results out of the small engines which they were allowed to use.

Why the period before the war is so particularly interesting is that we had no high-powered engines of any kind—our biggest was 100 h.p.—we knew precious little about streamlining and rather less about wing sections. And yet we used to get amazingly good results, taking them all round.

In the month of April, 1913, there was an epidemic of long-distance flying in France, a number of pilots competing for the prize put up by Monsieur Michelin, the great tyre manufacturer, for the longest flight made in a day. The results of these flights were shown graphically in *The Aeroplane* on May 8th, 1913—just before the paper was two years old.

In order to teach our authorities at home a lesson, the distances covered in those one-day flights were shown as the radii of circles measured from London as the starting point instead of from the actual starting points. These showed that Guillaux, the winner, would have reached Breslau or Florence, or Barcelona, or Christiania; that Gilbert, the second, would have gone beyond Dresden; and that Daucourt, the third, would have got to Berlin. Three others would have gone beyond Hanover. The obvious lesson was that German bombers could reach us. And they did, less than two years later. In the same issue a table, which is reproduced on page 8, was published, giving particulars of the machines and engines used and the starting and stopping places of the various flights.

Even to-day, with our engines of anything between 300 and 450 h.p., a flight of five hundred miles in the day is quite a considerable performance. Pilots who are accustomed to such machines will therefore be able to judge the better the value of a flight of 770 miles in the day with a little 60 h.p. Clerget.

Probably actually the best flight of the lot was Seguin's flight of 528 miles in the day on a Farman box-kite with a Gnome engine. Unfortunately the table does not record the power of the engine, but one believes that it was an 80 h.p. Gnome of the old type, before the Monosoupape, which still survives in our Avro training machines, had come into use.

Guillaux' Clément-Bayard monoplane was one of the prettiest little things that had been produced up to that date, and the fuselage, at any rate, had not at all a bad streamline, although the speed of the machine was killed by a cumbersome undercarriage and an immense mass of piano-wire bracing above and below the wings. Séguin's machine, on the other hand, was an enormous Farman box-kite which was simply a forest of struts with a whole entanglement of wires in between. And its speed cannot have been more than about fifty miles an hour. The distance was covered with the help of a following wind and by sheer endurance on the part of the pilot and passenger.

How much improvement was made in the following year may be judged by the series of flights made by German pilots during the month before the outbreak of war in 1914. Linnekögl, on a Rumpler, put the height record to 21,450 feet; Oelerich, on a D.F.W., raised it to 25,750 feet. Landmann put the duration record up to 21 hr. 20 min., and Boehm raised it to 24 hr. 10 min.—both on the same Albatros. And Suyelack flew non-stop with a passenger on a Rumpler from Berlin to the Turkish frontier, just 1,000 miles. Which shows why German aviators did so well in the early days of the war.

Spring 1927 - Early Flights (2)

						tance.	Stopping
Pilot.	Date.	Machine.	Engine.	From-To.	Km.	Miles.	Places.
Guillaux	April 27	Clement Bayard (Mono)	60 Clerget	Biarritz— Kollum	1255	770‡	Bordeaux Villacoublay, Ath.
Gilbert	April 24	Morane-Saulnier	63 Le Rhone	Paris— Salamanca	1040	646	Vittoria
Daucourt	April 16	Borel (Mono)	50 Gnome	Paris-Berlin	950	590	Liège, Hanove
Brindejonc des Moulinais	April 29	Morane-Saulnier (Mono)	Gnome	Villacoublay— Quakenbruck†	900	559	Liège.
Seguin*	April 26	Farman (Bi)	Gnome	Marseilles— Namur	850	528	Dijon, Mourmelon, Brocire— l'Allaud
Audemars	April 26	Morane-Saulnier	Gnome	Paris-Hanover	640	396	Mannheim
Vedrines	April 30	Morane-Saulnier	-	Lyon—Rouen	480	298	Nevers, Villa- coublay
Hamel*	April 17	Bleriot (Mono)	80 Gnome	Dover-Cologne	-	290§	
Letort	April 26	Hanriot-Ponnier	50 Le Rhone	Villacoublay— Visé	450	279	<u></u>
Schemmel	April 30	Ruchonnet (Mono)	70 Gnome	Vidamée— Nuerbwerg	400	248	Retstore
Marty	April 30	Caudron (Bi)	roo Anzani	Le Crotoy— Dusseldorf	380	236	Arten

Spring 1927 - Early Flights (3)

What the machines were like on which people used to fly in the very early days may be judged by one of the stock jokes at Eastchurch when the first four officers who were allowed to fly officially by the Admiralty were learning in 1911, on box-kites built by Short Bros. to the order of Mr. Frank McClean

(now Lieut.-Col. Sir Francis) and lent by him to the Senior Service.

The late Horace Short, the head of the firm, was really a first-class engineer. He had, in fact, had a very big hand in producing the Parsons turbine, which is now used on practically all high-speed sea-going ships. Consequently, he was determined that his aeroplanes should be strong, if nothing else. And, as in those days we knew nothing about metal construction and were hazy about wing sections and so forth, Horace Short's great idea was to make sure that the spars used in the thin wing sections of the period were adequately braced. So naturally the old Short box-kite was one vast mass of piano-wire.

So the legend arose that all the Short machines were subjected to "The Thrush Test." The idea was that, if Horace Short had any doubt about the strength of his machines, he used to catch a thrush, a bird which abounded on the aerodrome, put it in the pilot's seat of the machine, and then, if it escaped, that was taken as evidence that there were not enough wires, so he used to put some more in. Anyhow, thrush or no thrush, the fact remains

that the Short machines never did break.

Incidentally, there is a good deal of interest in noting that these first four officers were Lieut. A. M. Longmore, R.N., Lieut. C. R. Samson, R.N., Lieut. E. L. Gerrard, R.M.L.I., all now Air Commodores, and Lieut. R. Gregory, R.N., who died only a year or so ago as a Lieutenant-Commander, R.N., in command of a destroyer on the China station. Such are the vagaries of fate among pioneers, for at the beginning poor Gregory was the senior officer and much the best pilot of the four. The fact that the three surviving officers still fly regularly shows how ridiculous is the idea that a man can only

fly for a few years at a stretch.

Here one may note that in 1912 the Short brothers began experimenting with aeroplanes mounted on floats instead of wheels. The first flights on these machines were made by Lieuts. Longmore and Samson. From those early efforts are descended all the float seaplanes of to-day, for Mr. C. R. Fairey, chief of the Fairey Aviation Company, whose IIIDs do most of the work of the Fleet Air Arm, was himself with Short Bros. at that time, in charge of the workshops and of the early seaplane experiments. And to-day Mr. Oswald Short, the survivor of the partnership, is doing equally interesting pioneer work with metal floats and metal hulls for flying-boats. The floats used by Sir Alan Cobham in his Australian flight, and those used in the pioneer survey work done by Mr. Kemp and Mr. Raynham of the Air Survey Company in the Far East, and those on the machine which is opening the experimental service between Khartoum and Uganda are all his products.

Nearly all the flying in those days was done with the old 50 h.p. Gnome, an engine which could hardly have given more than about 35 h.p. actually on the airscrew, so somehow or another the aeroplanes of those early days cannot have been so frightfully inefficient. The big box-kites were deadly slow, but there were at that period a number of little tractor machines which put up a remarkably good performance with even smaller engines than

the Gnome.

Some of these machines are quite interesting to compare with the light aeroplanes about which we hear so much in these days. During 1913-14,

when the late Richard R. Gates and Mr. Bernard Isaac were running the aerodrome at Hendon, and bringing 20,000 or 30,000 people there every week-end, there were numbers of these comparatively small machines in use.

The British Caudron Company, an offshoot of the French firm which still exists, and some of the privately-owned schools at Hendon, had Caudron biplanes with 35 h.p. Anzani engines, and the British Deperdussin Company, the chief of which was the late John Porte, then a retired Lieutenant, R.N., had some small Deperdussin monoplanes which also performed amazingly well

with Anzani engines of 35, 45 and 60 h.p.

Late in the war, John Porte became Lieutenant-Colonel, R.A.F., commanding the seaplane station at Felixstowe, and there he produced the famous "F" type flying-boats. He himself had, in 1913, a Deperdussin monoplane with a 100 h.p. radial Anzani, which had a speed of well over a hundred miles an hour. That big Deperdussin was rather a remarkable machine, for it was taken over by the Royal Naval Air Service at the beginning of the war and was flown quite regularly here, and also round about Dunkirk, by R.N.A.S. pilots, and was not finally crashed till somewhere in 1916.

Having said so much about the beginning of Naval Aviation one must add a few notes about the beginning of military flying. Actually the pioneer of this side of the Service was Capt. J. D. B. Fulton, R.F.A., a very brilliant Gunner officer who, having been awarded by the War Office certain sums in cash for improvements in guns, proceeded to invest the money in one of the very early type Blériot monoplanes, on which he learned to fly at Larkhill, now the R.A.F. Balloon School, and the smallest unit in the Air Force.

He built himself a shed there and later was joined by Mr. G. B. Cockburn, one of the earliest British aviators, who a year afterwards gave up some six months of his time, free of all cost, to teaching the four first naval aviators to fly. The Bristol Company came along soon after and built alongside the

first real aeroplane sheds on Salisbury Plain.

Just about when Capt. Fulton began flying, the old Balloon Company of the Royal Engineers was turned into the Air Battalion, R.E., which acquired a few strange aeroplanes, such as one of the earliest Wrights (which never flew) and some primæval Farmans. No. I Company of the Air Battalion was Kites and Balloons, and the aeroplane people were ultimately sent to form a separate Aeroplane Company under Capt. Fulton at Larkhill. And that was where the Royal Flying Corps really had its beginning.

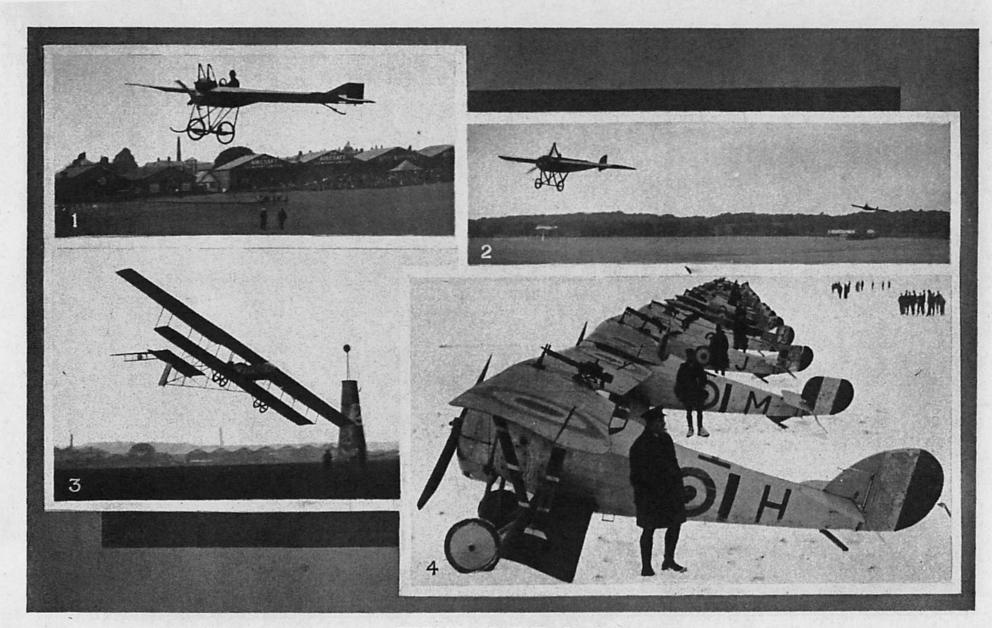
Some idea of how the pilots used to fly may be gathered from the fact that their great ambition was to fly from Larkhill over Stonehenge and back, only a matter of four or five miles. There is a fairly deep hollow between Larkhill and Stonehenge, and the prevailing south-west wind, blowing over the ridge on which Stonehenge is situated, always blew the machines down into the hollow. So the legend grew that the spirits of the Druids prevented the sacrilegious aircraft from flying over their temple. Then one day Mr. Cockburn, on his Farman, being forced down into the hollow, alighted on a sheep, which was hewn asunder by the airscrew. The machine was hauled back to the sheds and a new airscrew was fitted, and the very next flight it sailed gaily over Stonehenge and returned safely.

Probably the new screw happened to be more efficient than the old one, or the wind happened to be in a different direction, or something. But, naturally, the legend was elaborated by the argument that the Druids, having been propitiated by the sacrifice of the sheep, had consented to remove

Stonehenge from the list of prohibited areas.

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Spring 1927 - Early Flights (4)



THINGS OF THE PAST.

- (1) Walter Brock at Hendon in 1914 on a Deperdussin, with a 35 H.P. Anzani engine.
- (2) Reginald Carr at Hendon on a Morane, with a 50 H.P. Gnome engine, in 1914.
- (3) A Henry Farman at Hendon, with an 80 H.P. Gnome engine, in 1914.
- (4) A Squadron of the R.F.C. in France in the Winter of 1917-18, on Nieuports, with 110 H.P. Le Rhone engines.

Spring 1927 - Early Flights (5)



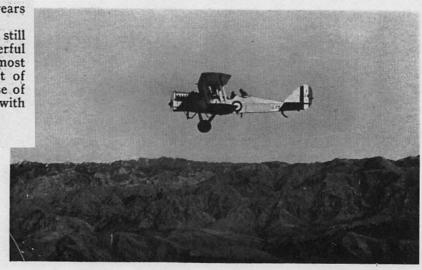
A PATHAN SEPOY OF THE TOCHI SCOUTS IN THE POST AT MIRAN SHAH, WAZIRISTAN.

When one considers that in those days nothing was known about stress calculations, and that people had the haziest ideas about side areas and control surfaces, the marvel is that any of the pilots of the period have survived. But somehow the people who built those machines had pretty good engineering instincts and, by the kindness of Fate, when things broke they generally broke near the ground or actually on the ground. The death-rate in proportion to the miles flown must have been high. Nobody dared to work it out in figures. But in some mysterious way people managed to avoid being killed. And the curious thing is that very few of the best pilots of the period did get killed.

curious thing is that very few of the best pilots of the period did get killed.

Anyhow, junior Lieutenants, R.N., and subalterns and junior Captains in the Army who were flying in those days, are still flying as Air Vice-Marshals and Group Captains to-day. Probably some of them regret now and then that flying in these days is not as exciting as it used to be fifteen or more years ago, and lacks the charm of uncertainty.

However, they can console themselves with the idea that there is still plenty of pioneering to be done. Although we have to-day the most powerful Air Force in the world, in spite of the fact that it is not by any means the most numerous, the development of new types of machines and the prospect of having to fight the next war under conditions entirely different from those of the last war indicate that there is still plenty of work to be done by men with active minds and the old pioneering spirit.



A D.H. 9.A., 60 SQUADRON, FLYING OVER THE KOHAT PASS COUNTRY, N.W. FRONTIER.

Spring 1928 - Air Combat WW1 (1a)

AIR FIGHTING.

Some Experiences during the War, 1914-1918.

By Wing-Comdr. W. S. Douglas, M.C., D.F.C. (Continued from page 93, Autumn Number.)

The Battle of Cambrai.

Towards the end of October, 1917, we were transferred to the 13th Wing, which at that time was co-operating with the Fourth Army. The object of our transfer was to strengthen the air forces that were to be employed in the Battle of Cambrai. In November the surprise attack on Cambrai was launched. The rôle of No. 84 Squadron throughout the battle was the protection, by means of offensive patrols, of our low-flying and contact patrol machines. The weather was most unfavourable for flying-a succession of fogs, mists and drizzle. It was impossible to work in larger formations than a flight: sometimes it was only possible to send out pilots singly or in pairs. This would seem to belie the theory that I have already propounded—that the day of the individualist in air fighting was at this time on the wane. But I do not deny that there will always be exceptional circumstances of weather or of war when a fighting pilot will be called upon to fight on his own and unsupported. A considerable amount of fighting took place during the battle, as the enemy put up numbers of contact patrol and reconnaissance machines supported by fighters. Owing to the weather conditions we fought at a very low altitude—any height between 300 and 2,000 feet—never higher. We succeeded in shooting down five or six enemy aircraft without loss to ourselves -the first fruits of our arduous apprenticeship on the Menin-Roulers Road.

Spring, 1918.

After a month's comparative inactivity due to adverse weather conditions, we were sent south in the new year to the 22nd Wing. The new Fifth Army had just been formed under the command of General Gough, and had taken over from the French a section of front to the east of Peronne. The 22nd Wing, to which we were transferred, had been sent to co-operate with the

Fifth Army.

From January until March we were employed entirely on high offensive patrols. Our Wing Commander (Lieut.-Col. Holt) was a great believer in the policy of carrying out strong offensive patrols, even at the expense of leaving the line practically unprotected during certain hours of the day. We therefore usually worked as a complete squadron, i.e., three flight formations in close co-operation. We were able thus to evolve by experiment the tactical procedure suitable to a squadron flying in formation. The final solution arrived at was as follows: The leader of the whole squadron is the leader of the lowest flight (call it "A" Flight). About 500 feet above "A" Flight, and 300 to 400 yards away, behind and to a flank is the second flight (call it "B" Flight). The duty of "B" Flight is to follow closely and conform to the movements of "A" Flight. It does not attack on its own initiative—the initiative lies absolutely in the hands of the squadron patrol leader, i.e., the leader of "A" Flight. This somewhat rigid formalism was found to be necessary owing to the tendency of the following flights to be drawn away into subsidiary combats, leaving the squadron leader unsupported. If the latter attacks, "B" Flight does one of two things: it either reinforces "A"

Flight, if the enemy is sufficiently numerous to make this worth while; or else it flies directly over the top of "A" Flight, and affords protection to "A" Flight against enemy fighters attacking from above. The third flight ("C" Flight) is the covering force: it flies as high as possible, and a mile or so behind and to the flank of "A" Flight. The leader follows "A" Flight at a distance, and has orders never to come down to the assistance of "A" and "B" Flights except in great emergency. The mere fact that "C" Flight is circling high up over the combat is usually sufficient to prevent any but a very strong enemy formation from attacking the two lower flights.

During this period (January to March, 1918), the experiment of causing two or more squadrons to work in close co-operation was tried. At first, two or three squadrons were sent out flying in one large formation, different squadrons at different heights, e.g., a squadron of Camels at 15,000 feet, a squadron of S.Es. at 16,000-17,000 feet, and a squadron of Bristol Fighters at 18,000-19,000 feet. This was not very successful, however, as it was found to be extremely difficult to bring the enemy to battle. As soon as this large formation crossed the lines, his fighting patrols drew off east, and continued to fly east as long as they were followed. Then, when our formation turned west again, the enemy would turn also, and hang around the rear and flanks

of our formation, firing at long range and picking off stragglers. Another plan was therefore tried. Three squadrons were instructed to fly by widely different routes to a certain point about fifteen miles east of the lines, and to meet at that point (it was actually a German aerodrome) at a certain specified time. They were then to make a drive in concert from east to west, and attempt to catch in a net any enemy fighting patrols between them and the lines. By this time, the enemy was "getting wise" to the fact that we were increasing the size of our fighting patrols: moreover, although we did not know this, he had concentrated a large number of squadrons in the area which we patrolled, in preparation for his big offensive on March 21st. He was also probably nervous lest we had heard of the impending attack, and that there was some ulterior motive in our big "drives." At any rate, he opposed our concentration on the three occasions that we attempted this manœuvre with a concentration of about an equal number of his own fighters. On all three occasions a big mêlée (or "dog fight," as it was called) took place, in which we accounted for a number of enemy aeroplanes. On the other hand, as the fighting took place fifteen or twenty miles east of the lines, our casualties were fairly severe; for, in the mêlée, pilots tended to lose formation, and often had to return to our lines independently with perhaps a damaged machine or failing engine.

I am certain, however, that this is the best method of carrying out a strong offensive patrol in which several squadrons partake: i.e., for two or three or more squadrons to be instructed to meet at a certain time and at a certain place (over, say, a large enemy aerodrome), coming from different directions; then to combine and make a big sweep back towards the trench line or theatre of land operations. This method gives the best chance of surprising a small number of enemy aeroplanes with a large concentration of fighters.

The Great Retreat (March, 1918).

On March 21st the great German offensive was launched, the brunt of which fell at first on the Fifth Army with which we were working. We soon

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got our first taste of moving warfare; for within a week we were compelled to evacuate three aerodromes—first Flez (about eight miles west of St. Quentin), then Roye, then Vert Galant. At Flez and Roye we actually came under desultory shell fire.

Our efforts were, of course, entirely directed to the assistance of our hard-pressed infantry. All aeroplanes and pilots were concentrated on lowflying attacks against the advancing enemy. An enormous amount of useful work was done by the R.A.F., the value of which was somewhat obscured at the time by the swift rush of events. Many very gallant deeds were done by our low-flying aircraft, of which only the scantiest records were kept: we had little time for writing up our achievements. Insufficient credit, I think, has been given to the Air Force for its share in staying the German advance on Amiens. We were working under difficulties: we changed our aerodrome every other day; it was impossible to carry out any but the slightest repairs to machines and engines; our machines stood out in the rain for days at a time. But both pilots and mechanics, inspired by the importance of the occasion, worked themselves to a standstill. A source of encouragement to the pilots was that for the first time in their experience they were presented with perfect ground targets-troops marching in fours along the roads, batteries and ammunition wagons moving across the open. One could thus see plainly what one was attacking; and, what is more, see the effect of one's bombs and gun fire. Troops would scatter into the fields, leaving men lying prostrate in the road; wagons and horses would be thrown into confusion and overturned. One pilot overturned a German general's car into a ditch. One felt that one was directly helping to stop the enemy's victorious advance. It was found, too, that in this war of movement the fire directed at one from the ground was sporadic and innocuous. The only efficient ground defence against low-flying aircraft is a concentration of several machine guns into an antiaircraft battery. The enemy was too occupied to do this; or perhaps his machine guns were too busily employed with ground targets. In any case, it is obviously difficult for such batteries to operate when on the march; and to be really effective they need to be well entrenched. We therefore found that not only were ground targets easier to see and hit, but that we were little troubled by the enemy's anti-aircraft defences; so that, tragic as was the great retreat to other arms, to the Air Force, as far as my experience goes, it was something of a picnic. During the whole of that strenuous fortnight, No. 84 Squadron suffered only one casualty: and that was the result of an air combat.

We found that with the S.E. (as I have said before, it had an excellent "zoom") the best method of attacking ground targets was to fly out over the enemy at 1,200-1,500 feet; a height at which anti-aircraft guns find an aeroplane a fast-moving and difficult target, machine guns are not very effective, and from which one can scan a wide stretch of country in search of a suitable target. The target selected, one proceeded to dive at it not too steeply, but flying down on it from a distance with engine full on. On coming within range, one opened fire; at about 200 feet released one's bombs, and immediately "zoomed" hard, probably turning at the same time. The speed of one's dive being probably 150 to 180 miles an hour, one's "zoom" took one back to about 1,000 feet. One could then repeat the performance, if necessary. With practice, pilots were able to drop their bombs by this method with great accuracy.

Air Fighting (Summer, 1918)—Offensive Patrols and Escorts.

When the German advance was stayed to the east of Amiens, we settled down at Bertangles (some four miles north of Amiens). There we remained until September, when the advance of our armies swept us eastward in its wake. From April until August we were employed entirely on offensive

patrols, escorts to bomb raids and balloon attacks.

Offensive patrols were now regularly carried out by the squadron working in squadron formation. Only when weather conditions made the manipulation of so large a formation difficult or impossible did we deviate from this practice; on these occasions one flight would be sent out with a roving commission. Occasionally a large patrol, made up of two or three squadrons, would make a drive some distance into enemy territory. A good combination was found to be a squadron of S.Es., flying at 15,000-17,000 feet, supported by a squadron of Bristol Fighters at about 18,000 feet. The Bristol Fighters, being not only good in attack but in defence, could thus protect the rear of the whole formation.

We occasionally were detailed to act as escorts to bomb raids, but it was found that a judicious arrangement of offensive patrols not only affords adequate protection for the bombers, but leaves the fighting squadrons free to attack the enemy fighters as and how they like, under conditions chosen by themselves. A fighting squadron on escort duty is like a boxer trying to fight with one hand tied behind his back: he cannot accept the opportunities of attacking his opponent that present themselves, because his one free hand is constantly employed in defending himself. Similarly, a fighting squadron on escort duty cannot attack the enemy formations that it encounters because, if it did so, the bombers, proceeding on their course, would soon be out of sight, and would thus be left unprotected. All that the fighting squadron can do is to wait until the enemy attacks, and then to parry the blow. Moreover, a bombing formation, if composed of aeroplanes with a good performance, of pilots who can fly in close formation, and of observers who can shoot straight, can fight a very successful defensive action against even superior numbers of enemy fighters.

Balloon Attacks.

For some time past, we have been trying to discover the best method of destroying hostile balloons. It was at first found to be a most difficult undertaking; but gradually the secret of success yielded itself to experiment.

The first difficulty encountered was that of actually setting the balloon on fire. Time after time pilots, their machine guns loaded with nothing but tracer ammunition, would dive on a balloon and see their tracer going right into the envelope; and yet the balloon refused to burn. It was then discovered:—

(a) That to shoot down a balloon with tracer it was essential to go right up close to it, fifty yards or less. At longer range, however good the shooting, the balloon rarely, if ever, caught fire.

(b) That one had to consult the weather conditions. If it was raining or the atmosphere was moist, it was almost impossible to fire the balloon, although one could put it temporarily out of action by holing and so deflating it.

(c) That a proportion of three or four tracer to one ordinary round was sufficient to ensure success.

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Again, if one dived straight down on to a balloon from a height, as the balloon was hauled lower and lower so one's angle of dive became steeper: in the end, one's dive often became so steep that not only was good shooting difficult, but, owing to the speed of one's descent, one was in effective range of the target (i.e., fifty yards) for an exceedingly brief space of time. It was therefore found to be best to dive steeply to a point about half a mile from the balloon and on a level with it; then to flatten out, and go straight at the balloon with all the added velocity gained in one's dive; at 200 yards' range one took a sighting shot with one's Vickers and at fifty yards opened with one's Lewis gun. One carried straight on to within about twenty yards of the balloon, firing all the time, hopped over it, and "zoomed" away.

It was difficult to ensure that, when a suitable opportunity of attacking a balloon presented itself, pilots had a Lewis drum available filled with tracer in a suitable proportion. I therefore made all pilots carry with them a special drum for balloon attacks, clearly marked as such. If the patrol leader decided to attack balloons, he made a signal with Véry lights: pilots then put the

special drum on their Lewis guns.

The balloon observers often got away in their parachutes. This was not satisfactory, as a balloon can be replaced for a few hundred pounds; the raison d'être of a balloon is the observer, and he it is that one should put out of action if possible. One would see the observer, as one approached, crouching like a monkey on the edge of the basket, clinging to the rigging, ready to jump. Beauchamp-Proctor, who made a speciality of balloon attacks and burnt sixteen of them, made a practice of shooting at the observer at long range as he approached, and then switching on to the envelope when the range become close. Being a first-rate shot, he would in this way first topple the observer back into the basket, and then, before he could extricate himself, set fire to the balloon over his head.

By such methods our attacks became more and more successful. But we were always liable to be interfered with by hostile fighting patrols; for, as it was usually necessary to go down to 1,500 feet or under to get at the balloons, every enemy fighter in the sky was above one, and so had the power of attack. We therefore had to devise a system of security. This was done by an adaptation of the squadron formation as employed on offensive patrols. "A" Flight (i.e., the lowest and leading flight) was made up of five experienced pilots, who could be trusted to shoot straight and fend for themselves. This was the striking force. "B" and "C" Flights (i.e., the higher and following flights) were simply a covering force. The whole formation crossed the lines at about 10,000 feet, as though engaged on an ordinary offensive patrol. "A" Flight then dived straight for the balloons, spreading out fanwise. By previous arrangement, each of the five pilots attacked a separate balloon, provided there were a sufficient number. "B" Flight dived in the wake of "A" Flight to about 5,000 feet, then flattened out, and flew out slightly east of the balloon line. Its duty was to protect the pilots actually engaged in attacking the balloons. "C" Flight came down to 8,000-9,000 feet and, keeping slightly to the west of the balloon line, afforded protection to "B" Flight. It was found to be preferable for "A" Flight not to rendezvous after the attack, but for each pilot to make the best of his way independently back to our lines. They were followed and protected as far as possible by "B" Flight. It was, I think, asking too much of human nature to require pilots to rendezvous at, say, 1,500 feet

over the enemy balloon line, under fire from numerous batteries of machine guns, when five minutes of low flying would take them back to our lines.

This method of carrying out a balloon attack proved eminently successful. The whole operation took about ten minutes from the time the lines were crossed until the pilots were safe again over friendly territory. On one day in September, by employing the tactics outlined above, we destroyed five balloons in the morning (Beauchamp-Proctor shot down two, one after the other), and four in the afternoon, i.e., nine in one day. All were confirmed as going down in flames by our anti-aircraft gunners. We lost one pilot, who was shot down from the ground.

The Great Advance (August to November, 1918).

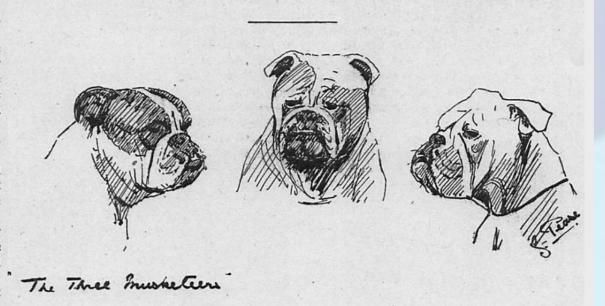
In August, 1918, our armies commenced the great attack on the Western Front that was destined to end the war. During the ensuing advance, No. 84 Squadron was engaged on a variety of tasks—high offensive patrols, balloon attacks, low-flying attacks on the retreating enemy, and even, during a spell of foggy weather, low reconnaissance of the enemy's positions.

The system of offensive patrols altered but little during these last months of the war. It tended to become stereotyped—perhaps too much so. Formations tended to increase in size, and it was a far more frequent occurrence for two or three fighting squadrons to combine in one large operation.

Our experience of low flying during the advance was much the same as during the retreat in the previous March: targets were easy to see and to hit, while the enemy's anti-aircraft defences were somewhat disorganized by the movement of his armies. There is no doubt that the demoralization of the enemy brought about by the constant attacks of low-flying aircraft was an important factor in the final victory of our arms.

On November 11th, 1918, the Armistice was signed.

(THE END.)



2010 - Combat Ops (2a)

Combat Operations: The Asymmetric Advantage of Air Power

Air Chief Marshal Sir Stephen Dalton, Chief of the Air Staff - Extract from the RUSI Lord Trenchard Memorial Lecture 2009

The Royal United Services Institute continues to stimulate debate in the Defence and Security arena. This is a particularly important role at the present time when, arguably, we are approaching a genuinely strategic crossroads in the design of our future Defence Policy and Military requirements. It will be critical that we really raise the absolutely essential focus on our current 'Main Effort' in Afghanistan and take a long hard look at our national security levels of ambition and requirements. If this results in a fundamental revision of our notion of Britain's place in the world then, inevitably, there will be significant implications for the size, shape and structure of our armed forces; but, we should not overlook the significant role that those armed forces are currently playing in defending and promoting the security of this country, our values and our interests, in their broadest sense, as an integral part of our current operations. You will not be surprised to hear that I intend to return to this theme through the rest of this talk. As the relatively new Chief of the Air Staff, one of my real concerns is that while public support for the armed forces is as high as I have ever known it to be, witness the marvellous public turnout in Uxbridge for the Home-coming Parade for 63 Sqn Royal Air Force Regiment last month. Nor should we underplay for a moment the consistently humbling support from the people of Wootten Bassett. However, despite this marvellous moral and physical support, the genuinely informed understanding of the role of the military in contemporary society is worryingly low, and this is particularly challenging for the Royal Air Force. In Afghanistan, for example, without RAF aircrew flying our Chinook, and shortly Merlin as well, support helicopters, and transport aircraft in and through some of the most demanding environmental conditions faced by any military forces anywhere in the world, and in the face of the constant threat of being shot at by the same insurgents who threaten the Land Forces, without those very brave and highly skilled aviators, more often than not, the equally brave and courageous soldiers and marines would not be able to pass the start line. This issue is important; if it's symptomatic of a more general lack of understanding in the public - and a consequent undervaluing - of the absolutely key role that air power plays, in its many guises, in all roles of military and security operations. And this matters, because air power is equally fundamental to success in the full gamut of military operations from

counter-insurgency operations, whether they be historic such as in Malaya in the 1960s, Northern Ireland during the troubles there, or on Operation Herrick today in Afghanistan; effective airpower is essential to all scales of medium or high-end warfighting. Often it has been and will continue to be the advantageous asymmetry that air power has given the UK and our allies that has been the determinant in giving the force or the coalition the battle, nay war winning capability and advantage. Our combat operations over the last two decades demonstrate how air power has consistently evolved; it has been adaptive and it has developed. But where are we today, as the consequence of those lessons from our recent history and what are the drivers that are shaping our current thinking and decision-making? And equally importantly, what defines our immediate future requirements as well as our longer-term insurance premium - well that is, of course, the focus of the forthcoming Strategic Defence Review, a requirement on which all the major political parties agree. Whatever, the resulting conclusions, one thing is certain, and that is that we will want and need to unlock the fullest potential of air and space power in the coming years and deliver affordable and agile capability as part of this country's joint defence and security forces - and that is of course wherever they are deployed, whatever the nature of future operations, whenever they're needed. But to do this effectively and add to our asymmetric advantage over potential adversaries - whether they be state or non-state - we will need to invest significantly in putting 'real meat on the bones' of our National Network Enabled Capability.

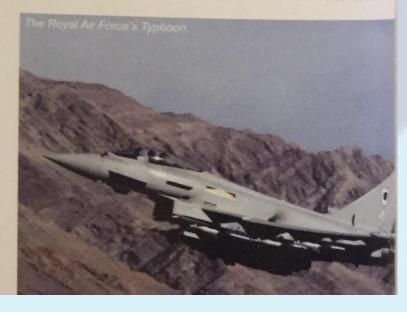
Now the themes that go through this – agility, capability, and asymmetric advantage – will run through everything I say today, and they are an integral part of my vision for the Royal Air Force. But for reasons that will become clear, I'm also going to emphasise another characteristic. Amongst other significant anniversaries, 2009 marks Charles Darwin's 200th birthday. You recall that he observed that:

'It is not the strongest of the species that survives, nor the most intelligent. It is the one that is most adaptable to change.' Consequently, I believe that adaptability – in our organisation, people and equipment – is the key to ensuring that the RAF

continues to make the critical air power contribution to the UK's defence mission, as the strategic environment evolves over the coming years.

Recent Operations

So let me turn to what contemporary events show us about military requirements. It's worth reminding ourselves that over the last twenty years, the RAF has been continuously involved in combat operations across the entire spectrum of conflict. We have conducted top-end warfighting against technologically capable opponents - where we have had to fight hard for that critical and fundamental requirement in any military operation that of control of the air. We have had to find ways to overcome sophisticated, integrated air defence systems - on at least four occasions in that time: during the Gulf War of 1991, in the Balkans in 1995 and again in 1998 and, as recently as six years ago, in the Iraq war of 2003. To use a military term, we have then 'transformed in contact' with our adversaries, to switch to intense counter-insurgency operations in Iraq and Afghanistan. At the other end of the scale, we spent eleven years flying low intensity - but highly cost-effective - air-policing of the no-fly zones over Iraq, interspersed with timely focussed interdiction operations without the need for major long-lead time and costly deployments or reinforcements. At the same time we conducted



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numerous, rapidly arising, humanitarian relief operations such as that in Somalia and Sri Lanka and military interventions, such as Sierra Leone and East Timor. Throughout this period, we have continued to deploy significant force elements to cover permanent commitments, notably the air defence of the United Kingdom, support to the Strategic Deterrent and overseas in the Falkland Islands. So the RAF has been very busy – and continuously over a very long period. But what are the broader implications of this experience?

The first point to make is that the development of military aviation, supported by emerging technology, means that air power has been consistently developing and maturing over the last twenty years in particular, and can now make the critical, precise and designed impact that theorists such as Douhet, Mitchell - and, of course, Lord Trenchard - have envisaged since the dawn of aviation. Western air forces can now deliver precise, proportionate firepower with extremely high levels of assurance, in virtually all weather conditions. This means that in conventional, forceon-force encounters, air power may have primacy in the joint campaign, with the land component effectively 'fixing' the enemy to be neutralised from the air. We saw the genesis of this in the Gulf War of 1991, when largely unseen and unreported, the air campaign neutered the fifth largest army in the world and, in so doing, set the conditions for that army to be utterly defeated in a land battle that lasted just 100 hours. This was of course at an absolutely minimal cost in coalition casualties. By the time of the Iraq War of 2003, modern air power was decisive, and, according to a recent RAND study, with over seventy-five per cent of the 20,000 major military engagements being primarily prosecuted by air power. The implications are profound. In the first place, as the then CGS announced, the Army has been able to plan its transformation into a uniform and lighter brigade structure, because of its 'increased confidence of delivery of effects from

The resulting breaking up by The Army of its traditional armoured and mechanised brigades is something that we would do well to remember in future discussions about force structures across the whole of defence, because, in essence a cheque has been written that air power must ultimately retain the ability to cash and pay to UK Land Forces on behalf of The Nation. More fundamentally, our adversaries have also recognised the asymmetric advantage of air power — witness the significant effect

that even the overflight or noise of a fast-jet or helicopter has on Taliban fighters as just one example, and this has driven them of course to develop their own asymmetric strategies to try and negate it. In this sense, understanding air power is critical, if we are to understand how - and why - the nature of conflict itself is changing and evolving. While air power has proved to be the dominant force in conventional warfare during recent operations, it has also provided the key enabling capabilities, particularly of course in support of the land component, in irregular and counterinsurgency warfare. The mobility, ISTAR capability and heavy firepower support delivered by air power are absolutely essential, not least in minimising the footprint on the ground. As Colin Gray has put it: 'Airpower is about mobility and power projection. It is about bringing fire to bear on the enemy, be he far or near; about inserting and extracting friendly troops; about surveillance and reconnaissance, and other forms of intelligence gathering; about supply and its movement.

However, because our opponents understand the importance of air power, they will contest our control of the air with every possible means at their disposal. In the Balkans and the two Iraq wars, sophisticated air defence systems were employed against us, but even if our enemies lack an air force, they will still use shoulder-launched missiles and small arms to attack our air transport aircraft and helicopters. They will set booby-traps at known landing sites and attempt to mortar or rocket our aircraft on the ground. All of these tactics have been adopted by the Taliban in Afghanistan and, in this context, force protection and the role of the RAF Regiment is as much a part of the battle for control of the air as more familiar and 'traditional' capabilities, such as the offensive and defensive counter-air operations that were flown in the two Gulf Wars. If all else fails, the enemy will seek to neutralise our asymmetric advantage by using propaganda to attempt to influence the media, putting pressure on our freedom to exploit air power capabilities to the full; again, this ploy has been used in



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Afghanistan, where one of the most significant challenges that we currently face - particularly as our land forces are so reliant on air support - is to make sure that we can counter the allegations that the majority of civilian casualties are caused by air attack. We all deeply regret innocent civilian casualties in war, but the growing perception that all civilian casualties are caused by air delivered weapons is far from the truth. Where mistakes are made, then lessons must be learned and procedures amended. However, we need to guard against immediately assuming that every allegation is substantive. The allegations are often unfounded, whilst the media will seek to sensationalise all occasions, we have to be far more agile and proactive in demonstrating the discretion and proportionality that is used whenever air weapons are employed. Such decisions are founded on the sensitivity and discipline of the airmen and airwomen involved at every step of the targeting process, and I am always impressed by the quality and resolve of our airmen who are involved in targeting and aviation, often under extreme pressure.

I suggest that this very brief review of our operations over the last twenty years reveals two defining characteristics above all others: first, their variety, and second, their unpredictability. As we have seen, the RAF has operated across the entire spectrum of conflict, transitioning from top-end warfighting to low-intensity air policing and back again, before switching to intense counterinsurgency operations. Few of these operations were envisaged beforehand, and some, such as the 1991 Gulf War, represented real strategic shocks. To my mind, this only reinforces the need for us to continue - within sensible resource constraints - to retain as balanced a force capability as possible, so that we can field relevant capabilities to confront the requirements of today's 'Main Effort' in Afghanistan, yet retain the ability to adapt to the future contingencies that we know will be difficult to predict. This principle is understood across the political domain. The Secretary of State has already announced that he intends to sponsor a full and open discussion on the future defence requirements based on the forthcoming Green Paper and how it identifies the short, medium and long-term potential needs of the UK's foreign and security policies and ambitions.

Equally, the Shadow Secretary of State, Liam Fox recently said: 'of course, the main challenge here is between equipping our forces to succeed in our current conflicts without failing to prepare for any future contingencies', and, although the National Security Strategy

rightly emphasises the primacy of current operations, it also notes the requirement to: 'to invest in a broad range of capabilities for the long term'. This is important, because there is a perception that future wars will only be fought, as Rupert Smith has put it, 'amongst the people', with Western military interventions being limited to failing or failed states, where the opposition will be confined to ill-armed militias, criminal gangs and terrorist groups, and the overriding requirement is for 'boots on the ground' to provide stability and security. A development of this line of thinking of course is Frank Hoffman's conception of 'hybrid warfare', where low-tech terrorist tactics are mixed with higher-tech capabilities, often obtained through a state-sponsor. It has been argued that as these are the wars that are being fought now, they are the only wars likely to be fought by the West in the future and that we should, therefore, dispense with 'irrelevant' high-tech, 'Cold War', equipment. This is a somewhat futile discussion. Although the emphasis may have changed, there is nothing particularly new, or radically different, about the contemporary operating environment; and insurgencies are as old as warfare itself and mixing conventional and unconventional capabilities as 'hybrid warfare' is a strategy that has been adopted across history, from the Boer farmers of the High Veldt in South Africa at the beginning of the last century through to Hizbullah in Southern Lebanon at the beginning of this century.

These sorts of conflicts will undoubtedly continue, and may even proliferate, but highly credible trends analysis and many important strategic thinkers predict that the days of state-on-state conflict are also far from over. Many of the likely future sources of

conflict, such as competition for water and energy resources and the impact of climate change, can only be resolved at the level of sovereign states and their interaction within the international system. Russia's willingness to use force on the margins of Europe itself, in Georgia last year, is a good indication that 'conventional' warfare is still very much a fact of international life and of course it's important to remember the four inter-state conflicts I've mentioned that the British armed forces have been involved in over the last twenty years. This demonstrates the essential uncertainty of the strategic environment and reinforces my conviction

Joint Helicopter Command's AH-64 Apache.

to stake the RAF's future on the belief that we will not have to fight a foe with access to high-technology, conventional military capabilities at any time in the foreseeable future. Our recent history suggests that this would be a very dangerous assumption indeed. This leads me directly to the question of legacy, or 'Cold War', weapons systems. I've made it clear why I believe we need an air force with a balance of capabilities, and this may be particularly true as we transition from a period of undisputed American hegemony to a more multi-polar world, where we may have to operate in unfamiliar or unexpected coalitions, and possibly without the same level of access to US combat power that we have assumed and benefited from in the past. But there are some very unhelpful misconceptions about exactly what 'a balanced force' really means. The key is adaptability and, if we get this right, we're not necessarily in an 'either-or' situation, where force elements can only be used for conventional warfighting and not irregular warfare, or indeed, vice versa. The relevance of a piece of equipment is determined by the capability it enables and how adaptable it is to future operational needs, not just by its date of procurement and whether it was planned before or after the fall of the Berlin Wall.

For example, the soldier with a rifle in his hand is a Cold War weapon system whose equipment and training has been adapted to ensure that he is absolutely relevant and capable in current conflicts; equally, multi-role Tornado – which entered service in 1982 as a strike aircraft, optimised for low-level use in Europe against the Warsaw Pact – has been readily adapted for highly



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effective use across the widest spectrum of operations from intense warfighting in Bosnia, Kosovo and Iraq, through low-cost, low-intensity but highly effective deterring, air policing, precise attack and reconnaissance operations over Iraq from 1992-2003, right through to its current counter-insurgency deployment to Afghanistan this year.

This level of adaptability is provided by the Tornado's innate design and configuration concept, which highlights the dangers of relying on more limited, niche capabilities, narrowly configured for one type of warfare. For example, it has been argued that a small, turbo-prop, aircraft would provide a cheap attack capability in Afghanistan. But its utility, and arguably survivability, would be markedly reduced in comparison with fast jets, such as the Tornado and Typhoon, because of increased vulnerability to less sophisticated enemy weapon systems, their reduced speed would limit response across the battlespace, and their more limited weaponry options and payload would reduce the deliverable effect at the precise time and place they were most needed. More importantly though, any such aircraft could not be used in other sorts of conflict with any confidence in their survival, such as when our Tornados and Harriers were called upon to operate against highly effective and integrated air defence systems in the Balkans and Iraq. Our relatively small size means that we simply cannot afford to implement specialised procurement strategies that establish force elements that are appropriate only for one sort of operation; the risk is that we end up equipped to fight the last operation or war and not the next.

Importantly, in this debate, the Typhoon is providing huge and adaptable capability today. As one of the world's leading fighter aircraft, it guarantees our ability to control our own skies; last year, for example, our quick reaction fighter-force was scrambled on just under one hundred occasions to intercept unidentified aircraft entering the UK's airspace including, within recent weeks, renewed incursions by Russian bomber and maritime aircraft. But the Typhoon also has an impressive and expanding, precision ground attack capability that is utterly relevant to current counter-insurgency operations and, just like the Tornado, also has the ability to use its sensors to provide, high resolution, full motion imagery of action on the ground, data-linked to troops in the field, providing a critical, real-time, ISTAR capability as well. The interest that is being shown in Typhoon by other air forces around the world indicates its value: they realise that this

level of capability is essential, when states such as China and Russia are exporting very capable, fifth generation fighter aircraft and sophisticated, 'double-digit' SAMs across the globe, often to states and albeit, indirectly, in the case of shoulder-launched SAMs to non-state organisations representing a tangible threat to future global security and our freedom of movement in potential hotspots in which UK forces may have to operate.

The Strategic Environment

I've spent some time discussing the implications of our recent operational history, and offering some thoughts about how this background highlights some key characteristics and requirements for shaping our future capabilities and force structure. However, defence clearly doesn't exist in a vacuum so let me turn to some of the broader challenges currently facing us. While it's tempting to think that we're living through uniquely difficult and demanding

times, this particular occasion today reminds me vividly of the problems that faced Lord Trenchard in 1919 and which were so well captured nearly thirty years later when Air Chief Marshal The Lord Tedder wrote: "We British are often accused of preparing for the last war, or even the last but one war. The rate of technical development is now so rapid, and the effects of changes in techniques so far reaching, that it may well be fatal to lag behind. For our own security we must think in terms of modern war. The last war is not modern it is out of date!"

We are not in the same parlous situation now, but defence in general is facing some compelling strategic questions and drivers. I would suggest that there are two factors in particular that will have a profound impact in the years ahead: The first is the pressure imposed by our involvement in Afghanistan and the legacy of what – for the RAF at least – was nineteen years of unbroken combat operations in Iraq. Quite rightly, our main effort today is in support of current operations in Afghanistan and this remains our overriding priority and largely drives our contemporary planning and activities. This is a 'war', a comprehensive campaign that we cannot afford to lose: for reasons of our national security that is,



and because of the potential impact on our national standing and credibility across the globe, not least, because of the implications for the future role and employment of NATO and other coalitions of 'the Willing'.

The consequences of failure for the credibility and reputation of the United Kingdom's armed forces and indeed, on the perceived utility of military force as a lever of national and international power, should also not be underestimated. One of the deeper, and potentially more troubling, implications of our experience in Iraq and Afghanistan is their impact on a generation of the populous that may now be convinced that military operations are prohibitively expensive in every sense: politically, financially and in human terms. The press and public reaction to the casualties suffered during Operation Panther's Claw in July and August this year, and the media focus on Wootton Bassett, and the continuing actual and potential impact of coroners' inquests all illustrate the point amply. But I remain convinced that there will always be occasions when military force is the appropriate tool, if not indeed the only option, to deal with particular crises and that - whatever their preferences and prejudices - future decision-makers will

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have no choice but to use it in certain circumstances. Therefore, it is the duty of all of us involved in defence - and again, I am conscious of the role that RUSI plays here - to engage with opinion formers and decision makers more generally - to help to build their understanding of the military lever, so that they can provide a more compelling explanation to the public of the rationale - and legitimacy - for the use of force when it is appropriate. This is the only way that we can begin to repair the relationship between that familiar Clausewitzian trinity of the government, the people and the military, and re-build the popular consent that will be necessary for future interventions. As the military, we have our part to play in ensuring that we continue to adapt, so that we can provide the most relevant and useful defence and security capability as a policy tool. Here, air power is particularly important, because if - and this is absolutely critical - if and only if we can continue to secure and maintain control of the air whenever and wherever the Government commit the armed forces, we will have the freedom to offer different options to our leaders. In some circumstances, these may include alternatives to the deployment of major land forces,

and the political commitment, and cost in blood and treasure that this will always result. We should not forget, for example, that the air policing of no-fly zones over Iraq by the USAF and RAF, and for part of this time the French Air Force, neutered Saddam's regime as a regional threat for eleven years, without the loss of a single Coalition life, and at the combined relatively low cost of less than a one billion dollars a year. Even where a significant presence is required on the ground, air power can act as a force multiplier to dramatically reduce our exposure within the construct of a joint campaign. General Karl Eikenberry, the Commander Combined Forces Command Afghanistan in 2007, made exactly this point when he wrote: 'Without air and space power, 500 to 600,000 troops would be needed in Afghanistan to achieve the same effects as the 40,000 soldiers, sailors and airmen we have there today. Air and space power provides the asymmetric advantage over

the Taliban such that no matter where they choose to fight, coalition forces can bring to bear overwhelming firepower in a matter of minutes. Moreover, putting 500 to 600,000 troops into the country may achieve the same military effect, but it could have a negative impact on the population; such numbers could appear as an occupying force, rather than a security assistance force. In short, there is no substitute for effective air and space power.'

This last point is of course particularly key. Ideally, the 'boots on the ground' required in counter-insurgency operations will eventually be provided by indigenous suitably trained forces, as these will be more sensitive to local conditions and often more culturally acceptable than foreign forces who may be portrayed and perceived as occupiers or invaders. Air power can be used to provide the supporting, high-end, technological capabilities, such as ISTAR and combat air that are more difficult and take longer for local security forces to develop. The second strategic driver currently challenging defence is, of course, the economic downturn and its social and political consequences. Although there are encouraging signs that the economy may be bottoming-out, the

long-term impact on the national exchequer has been significant and defence spending will have to compete with other government departments in what the shadow chancellor, George Osborne has described as an 'age of austerity'. While I would not wish to second-guess the outcome of any future comprehensive spending review, most analysts predict that whole government spending will have to fall in real terms by about 10% in the six years to 2016/17. Whatever political choices are made in the future, it is clear that defence will need to take account of the consequences of a fiscal squeeze, and this means that some extremely difficult decisions will have to be made.

We now have the opportunity to engage in a debate - which I firmly believe must be as wide-ranging as possible - to define what the United Kingdom's future role in the world should be what contribution defence should make and what resources the Nation is prepared to commit to delivering this vision. We must also continue to resource the absolutely critical insurance policy - the so-called standing defence tasks - that underpin the first priority of any government, that of protecting its people. Only then can we sensibly determine the size, shape and structure of our forces. RUSI has already made an important contribution in this vital area through the ongoing programme of conferences its running to address exactly these issues. However, I believe that this discussion is too significant to be confined just to the military. policy-makers, media commentators and academics; it must be held in the wider public too. There will be some critical questions that we cannot afford to shy away from. These range from the future scale, readiness and nature of military forces over the net ten years or so that the nation is prepared to train, deploy and sustain, through the affordability of some of our planned major defence procurements, to our role in multinational operations and the nature of our defence relationships with both the US and Europe. We also need an honest assessment of what constitutes the 'credible military threshold' that is required to give us the leve of influence in various forums that we believe is critical to the UKS right to have a seat at the particular international tables.

Imagination and innovation will be needed to maximise the capabilities that can be provided. For example, the radical partnering arrangements with industry that we have adopted to support our aircraft fleets are on track to yield some billion pounds worth of savings over the next five years. This demonstrates what can be done with a real will to embrace

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change and a genuinely innovative approach, but implementing this degree of revolutionary change has not been simple or easy, either in terms of our people, our processes and our potential ability to respond to unforeseen requirements and as someone once said, 'events, dear boy, events'! This may mean that we have to accept having fewer fleets of aircraft, vehicles and ships and using some of them, such as our larger Air Transport aircraft, in what might academically be judged inefficiently at times. However, the major cost driver in equipment terms is the through-life costs and that means that having fewer individual fleets is much more cost-effective than salami slicing each fleet. I would hope - and expect therefore - that there will be a similar appetite for decisions, some of which will be painful but necessary, across the rest of UK defence, if we are to wring the most out of every last defence pound. Similarly, our Future Strategic Tanker and Transport Aircraft programme is another ground-breaking, world-leading initiative, which aims to deliver affordable capability through a joint military-civilian enterprise that will share spare capacity with the civilian sector, necessitating operation by a mix of service and reservist personnel. Again, there is a whole raft of issues that will need to be addressed as the programme is implemented, but - as I've emphasised already - we must be prepared to continue to adapt, if we are to deliver critical relevant capabilities that otherwise would simply not be affordable. I believe that a truly comprehensive defence review must also consider the wider military contribution to the security of the UK homeland, especially within the context of the National Security Strategy. At this stage, with a nod to Lord Trenchard again, I should point out that it was the threat of air attack, at that time on Great Britain, which ultimately led to the formation of the Royal Air Force as an independent service, following the publication of the Smuts Report some ninety-one years ago. This still remains our raison d'etre - albeit, no longer exclusively in the UK - and I've already mentioned the activities of our Typhoons on quick reaction alert both in the UK and, later this week, they will be beginning this task in the Falkland Islands. While maintaining the integrity of the United Kingdom's airspace will continue to be our most important task, not least during the London Olympics in 2012, I believe that there are other - and broader - ways in which the RAF can play a meaningful part in homeland security, notwithstanding the cultural, legal, historic and constitutional constraints that will have to be overcome.

The Pre-eminence of Information: the only Certainty of an Uncertain Future

I've made it clear why air power matters to defence, and explained how a capable air force, with a balanced spread of capabilities, is essential in providing the United Kingdom's armed forces with an edge in combat operations not just in war-fighting but across the entire spectrum of operations from deterrence to conflict. I've also highlighted some of the strategic factors that may affect the delivery of this capability. I'd now like to drill down into a little more detail, by offering some thoughts about how we can secure, enhance and exploit this asymmetric advantage that air power can deliver. As I've explained, air power is capable of, and must be prepared to, provide a broad spectrum of military response options to counter potential state and non-state adversaries, who are themselves are likely to be equally agile, adaptive and innovative in often unexpected ways. Consequently, we must be able to take advantage of fleeting opportunities, and future combat success will depend almost entirely on our ability to make effective decisions, at pace, in an uncertain and complex environment. Network Enabled Capability - NEC - is by now a far from new concept; in fact, it has almost become a cliché, but I will suggest that it remains the key to securing air power's and our broader military and security advantage in the future.

The provision of accurate and timely information has always been critical to the success of any military activity. Although in itself, this cannot guarantee victory, history suggests that victory is impossible without it. Equally, information overload, where commanders are deluged with information, but starved of real knowledge, must be avoided. We have made some promising progress in both these areas. In Afghanistan, investment in information and communications technologies has enabled air command and control mechanisms to be developed that have permitted us to employ kinetic and non-kinetic effects at a high tempo, and across all levels of the operation. This has allowed us to be much more flexible in the way that we use capabilities so that, for example, what were previously considered to be purely strategic assets, such as NIMROD R1 SIGINT aircraft, have often been employed to support tactical engagements right down to platoon, or even section, level.

However, while these networks have provided situational awareness, the complexity of the situation on the ground, where clan and family allegiances mean that each village may require

a campaign in its own right to secure, means that commanders increasingly require shared situational understanding. Moving from awareness to understanding implies knowledge of motivations, fears and perceptions as much as force dispositions, capabilities and intentions; this cannot be achieved purely through the technical collection of intelligence, but requires a much more comprehensive fusion of information from all sources. I believe that the RAF is uniquely well-placed to take centre-stage in this process, because we have operated in a 4-dimensional battlespace for many decades, where NEC, and information management, have always been a key feature.

This means that our people are steeped in a tradition which promotes an intuitive and instinctive awareness of the importance of information, the potential of networks, and an understanding of their operation. This week is, of course, the anniversary of the Battle of Britain and next year will see the seventieth anniversary of that battle, and of the vindication of Fighter Command's integrated air defence system - itself based on a networked concept dating back to 1917. This critical system of systems remains a classic example of the way that data - from Radio-Direction Finding (radar) stations and Observer Corps posts - was collected, filtered, fused, analysed and disseminated, in this case using a network of land-lines and ground-to-air radio. The result was to enable air command and control and efficient battlespace management through shared situational awareness, providing battle-winning even war turning decision superiority for Dowding and Park the two principal RAF commanders - and their battle staff. Of course our current Air Defence Ground Environment is a lineal successor of the 1940 system, but has been many times upgraded. During the early stages of Operation Enduring Freedom, the RAF was involved in the first attempt in history to create a truly comprehensive and persistent Intelligence, Surveillance and Reconnaissance (ISR) umbrella, providing an 'unblinking eye' capable of detecting all enemy activity. This was formed by a constellation of overlapping, multispectral, manned and unmanned air and space-based sensors, including our own E3-D, NIMROD R1 and Canberra PR9 reconnaissance aircraft at the time.

The RAF has built on this experience by developing our potential to exploit NEC. As I speak to you today, RAF REAPER unmanned aircraft, while ostensibly engaged in the direct tactical support of land forces using secure data and video links twixt soldier and pilot operator, are also at the same time being cued onto emerging

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threats by wider search assets such as the ASTOR system or NIMROD surveillance aircraft: the analogy here is searchlight to flashlight to spotlight. This sort of integration increases the utility of particular systems and the potential of other systems such as the soon-to-be-introduced Watchkeeper to contribute to this operational level knowledge is significant here.

It is exactly this kind of evolutionary approach that we are developing to meet contemporary challenges, not least in increasing our contribution to the counter-IED battle, which you will be only too aware is a real focus for current work inside and outside Ministry of Defence (MoD). Coalition and RAF air platforms are being increasingly integrated and cross-cued to down-link, process and disseminate vital information including change-detection imagery, Full Motion Video and near-real time radar data on a common bearer for easy access. This shared information is enhancing responsiveness today and has much more promise, so that officers can use this tool not only to respond to what is happening, but also as importantly by involving air-minded individuals in planning, for example, convoy missions.

This illustrates that the importance of NEC for the RAF is not just in the development of enabling networks, or the interconnected application of air power per se – I've described how we've already been operating in this manner for many years now. Rather, it's in the potential that it now provides for us to fully integrate and synchronise our capabilities and activities, at speed, in the Joint environment, with other government departments and agencies and with coalition members to achieve a shared understanding.

With its ability to be stealthy when required, the Joint Combat Aircraft will be able to conduct air-to-air, air-to-ground, close air support and ISTAR missions in passive or heavily defended airspace. The need to deliver air power support to tactical ground assets against a fleeting target will be instantaneously evident and rapidly coordinated, with mission changes to Air Tasking Orders replicated across the joint battle-space and immediately available for visualisation on the Common Operating Picture. The latest imagery, derived from say land-controlled tactical UAVs will be readily available, on and via the air tactical network, to the JCA cockpit and weapons system. This will enable fleeting and constantly moving targets to be found, re-acquired and tracked whilst threats are simultaneously avoided and suppressed. With positive target identification established, this does of course

require a degree of coordination with an efficient joint targeting process for the aircraft to be authorised to engage when the pilot assesses that ROE collateral damage constraints have been mitigated. Follow-up battle damage assessment conducted by airborne sensors will be made available in near-real time for assessment by the command chain.

This sort of scenario is well within the limits of what is pragmatically possible in the near-term future, and illustrates how an evolutionary NEC approach can unlock the true potential of air power to deliver an agile and adaptable asymmetric advantage in combat. However, there is one note of caution that I should sound: as our reliance on networks increases so, clearly, does our susceptibility to both Computer Network Attack (CNA) and Exploitation (CNE). Indeed, in a world where information is becoming a capability in its own right, it could quickly become a critical vulnerability. This threat is dynamic and proliferating, and the RAF is taking it very seriously. Working with the MoD Chief Information Officer and his counterparts in other Government Departments, we are already operating a Computer Network Defence (CND) capability in parallel with the successful delivery of NEC, identifying and addressing threats as early as possible during the capability process. Cyber warfare is a reality today and we must invest appropriately if we are to continue to be able to build and rely on our networks and computer based decision matrices.

Conclusion

I've covered a lot of ground, from the strategic drivers and the context provided by our recent operational experiences right down to some of the tactical detail. Much of this, and the rest of our current thinking about the employment of air power, is encapsulated in the new edition of AP3000 – British Air and Space Doctrine. This substantial new edition will be launched formally here at RUSI in the next few weeks, but it's already available online, at the RAF and the RAF Centre for Air Power Studies websites. This new edition aims to demystify air power by describing it in simple, jargon-free language, explaining its utility in terms of just four key roles: control of the air; air mobility and lift; intelligence and situational awareness; and attack. The emphasis is on how air power can contribute as part of a comprehensive, inter-agency, approach to operations, set within a framework of Joint Action.

While the new edition of AP3000 codifies a change in emphasic it's apparent to me that the principles that underpin the RAFe delivery of the UK's air power were equally evident in Lord Trenchard's day. We often forget that his vision was for an independent air force, rooted in the concept of expeditionary warfare and the inherent jointness of air operations, stemming from his experience of the Western Front, and that he was very eager to embrace new technology as it emerged. Above all else, he had a deep-seated belief that the RAF's success would depend on its people. In all these respects, as I hope I've made clear, little has changed. The outstanding and highly courageous performance of RAF personnel, particularly those aircrew flying Royal Air Force Support Helicopters such as the Chinook and RAF Hercules aircraft and RAF Regiment Gunners working on the ground to provide the essential force protection specialist capability at the precious and critical airheads, bear witness to this everyday in Afghanistan. If the RAF is to continue to deliver an asymmetric advantage to the United Kingdom's combat and security operations, it needs to continue to be able to 'cash that cheque that Defence has signed it up to' and to be able to deliver the necessary air power in the future. To that end it is vital that the Royal Air Force continues to be capable, cost-effective and adaptable. But it can only do this, if it recruits, trains and retains physically and morally strong men and women with the innale courage and agility to adapt to a dangerous, complex and dynamic environment, especially as the information domain becomes increasingly pervasive.

The tradition established by Trenchard means that the RAF is culturally and technically adept, and that our people are intuitively comfortable working in the 'information space'. This, I believe, will be central to our success in the future, as we prepare to adapt to the new challenges that will face us, including cyber threats.

The last nineteen years of continuous combat operations has seen the RAF transform while 'in contact' with adversaries. Although it may be a smaller air force than the one that I joined, its ability to deliver battle-winning asymmetric combat air power has never been greater. I am proud and deeply honoured to lead an air force that is far more capable, combat-experienced and cost-effective across the whole structure than it has relatively been perhaps at any time in its history and certainly since the end of the Second World War.

Spring 1929 - Airship Articles (1a)

LANDING LARGE AIRSHIPS AT A MOORING TOWER.

By SODN.-LEADER R. S. BOOTH, A.F.C.

THE question of long distance communication by means of lighter-than-air craft has received considerable attention since the war, and in 1924 the present airship programme was commenced with the object of building two airships, each of five million cubic feet capacity, to demonstrate the capabilities of this type of aircraft when operating over distances still beyond the commercial capabilities of aeroplanes or seaplanes.

The operation of these ships to India, via Egypt and across the Atlantic to America or Canada, has received general attention in the Press, and it is common knowledge that bases have already been built at Ismailia and Karachi, and that another base is under construction at Montreal.

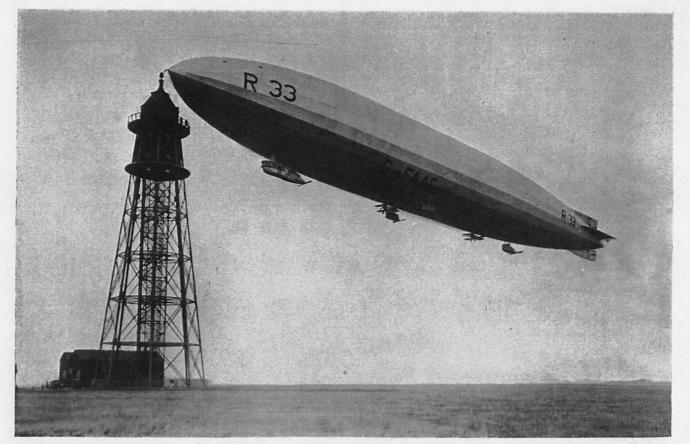
The ships are expected to fly early in 1929; so that perhaps a general description of handling this type of aircraft, which has a total weight of about 150 tons, with overall dimensions of 720 feet by 130 feet, will be of interest.

From the earliest days of airships one of the greatest difficulties has been handling them on the ground, and many methods have been devised to enable ships to be moored out in the open, or to be handled into sheds under adverse weather conditions. The most obvious solution of the difficulty is to make sheds which will revolve, either by building them on a floating raft or on a gigantic turntable. Both these systems were tried in Germany before the war—a floating shed on Lake Constance, in which the earlier Zeppelins were built, and a revolving shed at Biesdorf, which was built in 1911. Another double-revolving shed was built early in the war at the most important North Sea airship station, and it is interesting to note that the two ships housed in this shed were the only two from this station which were able to accompany the German Fleet on the extended patrol which terminated with the Battle of Jufland.

It will, however, readily be understood that this type of shed is too costly for general use, and it also has the disadvantage that large landing parties are still required to land and manœuvre the ship on the landing ground. In the war this objection was not of much importance, as man power was cheap, but after the war it was realized, especially in this country, which is handicapped with some of the worst flying weather in the world, that other systems must be devised if airships were to become a commercial success.

Suggestions have ranged from elephants to caterpillars—the former to be recruited from all the wandering fairs in the country, the latter to be of the mechanical species. All systems of handling ships on the ground have, however, the same disadvantage, and that is the enormous force required to hold the ship when broadside to the wind. It can be done by using landing parties up to seven or eight hundred men or by mechanical means, but the ship's hull is then hardly strong enough to stand the strain, and also in very strong winds the ship tends to lie over on her lee side, as the handling guys are attached to the bottom of the envelope or hull.

During the war successful experiments were carried out with the smallest non-rigids moored to short masts, but as it was found that these ships could readily be moored out in valleys or on the lee side of high trees, the results were never utilized on Service stations.



R 33 AT THE CARDINGTON TOWER.

Photo: Royal Airship Works Cardinetor

Spring 1929 - Airship Articles (1b)

After the war, it was decided to modify the design of R 36 and complete her as a passenger-carrying ship, and it was then realized that some mooring system must be devised to which the ship could be attached, and from which

the ship could leave without the use of a large number of men.

Considerable work was done on this problem, and as a result a temporary mooring mast was built at Pulham. Compared with the new mooring tower at Cardington, it was rather a crude affair, but the results obtained in 1921 with R 33 were satisfactory. This ship remained at the mast continuously from February to July, in winds up to sixty miles an hour, and also made numerous flights from and to the mast in winds up to thirty miles an hour. During this period one gas bag was changed and one engine was also changed when actually on the mast. If these experiments had not achieved such success, it is certain that the present programme would never have received parliamentary support, and it is also doubtful whether America would have interested herself in this type of craft.

The photograph shows the elaborate mast or, to give it its correct designation, tower, which has been erected at Cardington. I shall now give a general description of the tower at Cardington, and follow it with a descrip-

tion of landing and leaving a tower by an airship.

The tower itself consists of a rigid steel framework 200 feet high, equipped at the top with two platforms and a conical-shaped tower head. The lower platform is for the landing searchlights, and the upper one to work all controls used in landing the ship, and also for the passengers and crew to embark to and disembark from the airship. At the extreme top of the tower will be noticed a projecting arm, which is mounted on gimbals, allowing it to swing to thirty degrees from the vertical in any direction. The arm is hollow, and is fitted with a female cone on top, into which the cone on the ship's bow eventually fits, being secured by three spring-loaded stops.

The arm is also made telescopic to obviate any shock when hauling the ship in, and it can finally be centralized and locked in the vertical position by a system of wires inside the tower head, operated by a motor on the lower part of the telescopic arm. On the control platform are the distant controls for the winch motors, which are situated in the hut at the foot of the tower. These winches are steam-driven, and can haul up to 15 tons with a speed varying from dead slow to 50 feet a minute at full load, and 500 feet a minute

under normal conditions when the load would be about 5 tons.

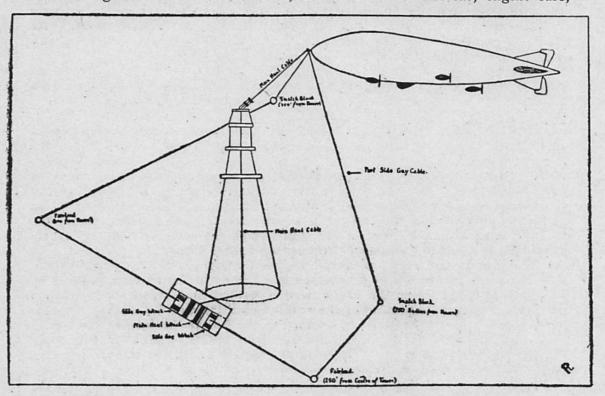
Fuel, water and gas mains are installed in the tower for re-fuelling the ship when moored, and a lift able to carry twelve passengers is available for the convenience of the passengers, tower and ship's crew.

For the attachment of the yaw guys, twenty-four mooring points are placed at equal intervals on the circumference of a circle with radius 750 feet from the base of the tower. Two of these blocks are selected, dependent on the direction of the wind when the ship is about to be landed.

On receiving word that the ship is returning to her base and will land at a certain time, the officer in charge of the tower must make all preparations for her reception. Steam must be raised in the boilers about an hour before the ship is expected, and then the ground wires laid out, depending on the direction of the wind. The main wire is first led from the main winch, up the tower, through the telescopic arm and down on to the landing ground, directly to leeward, the last 100 feet being flaked on the ground about 800 feet from the tower. The side guys, or yaw guys, are taken from the two

side guy winches and led through snatch blocks on either side, and sixty degrees away from the position of the main wire, back to the foot of the tower. The tower is now ready to receive the ship, and the mooring tower officer stations himself on the control platform, together with the three winch operators and a signalman. On the ground are four riggers ready to connect the ground wires to the ship's wires, and in the winch house three engineers standing by the steam winches and one man watch-keeping on the boilers

While all these preparations are being made on the ground, the crew of the airship are also busy. Half an hour before she is due to arrive at the base, the crew are ordered to landing stations, which means that every man or board goes to his correct station, either in the control car, engine cars,



at special positions along the keel or to the mooring winches in the bow of the ship.

Before the actual landing is made, the ship must be in correct trim and equilibrium. This can be judged roughly by the feel on the elevator wheel, but to get accurate results all engines must be slowed down until the ship is almost stationary in the air. The captain of the ship then estimates how light or heavy the ship is, and, taking the temperature of the ground into consideration, he adjusts the equilibrium and, at the same time, the trim of the ship by releasing water ballast or valving gas. The temperature on the ground is important, as if the ship descends into a warm belt of air she will suddenly lose a considerable amount of lift, and conversely she will become very light if landing into a stratum of cold air. The amount of this gain or loss of lift due to temperature changes is approximately one-third of a ton per

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degree Fahrenheit for a ship the size of R 100 or R 101. If landing during the heat of the day with detached clouds in the sky great care is necessary, as the lift of the ship changes considerably when the sun is suddenly obscured by clouds. In this case the gas in the ship rapidly loses super-heat, and as this super-heat may represent anything up to five tons of lift, it is obvious that its sudden loss at a critical moment may seriously embarrass the captain of the ship. For this reason the most convenient times for landing are at dawn or dusk, or during the night when atmospheric conditions are almost

When the ship is "ballasted up" in correct fore and aft trim and slightly light, course is set towards the mooring tower, and the height coxswain is instructed to bring her down gradually to 1,000 feet. One mile short of the tower, which is being approached up wind, word is passed to the duty coxswain at the mooring point to ease out the main wire to within 100 feet of the end. This wire is about 900 feet long, and is kept reeled on a winch in the bow of the ship. It is payed out through the mooring cone attached to the ship, which can be seen in the photograph of R 33 securing to the Cardington

The ship is now slowly approaching the tower, with the main wire hanging from her nose. If there is little wind two engines are probably running slow astern, and only the after engine is being used to give her

The height coxswain can now bring the ship down to 900 feet, and the steering coxswain keeps her steady on the tower. The speed of the ship is eased off a little more by slowing down the after engine, and, if necessary, by running the wing cars astern, until the ship is stationary over the landing mark which shows the position of the mooring tower wire. The last 100 feet of the main wire is then let go to give the men on the ground some slack in case the ship veers off to one side or the other, and they connect the two wires by a snatch-coupling on the tower wire, signalling that the wires are connected to the ship and tower head.

About half a ton of ballast is now dropped from the bow of the ship to make her trim slightly down by the stern, and also light enough to rise up on the end of the single wire. When this wire tautens the captain of the ship adjusts the trim and equilibrium to his satisfaction, and then signals to the tower that the ship is all ready to haul down. If the ship rises up too fast on the single wire, no jerk is brought on the ship's bow as the main winch is set free to veer, and it can then be braked gradually to bring the ship to rest, and at the same time the long bight of wire, which weighs about threequarters of a ton, helps to bring the ship up gradually.

As the ship is being hauled down on the single wire, she must be kept head to wind by the steering coxswain, and also about five degrees down by the stern by the height coxswain. If there is a wind, dynamic lift, due to the angle of trim, is added to the static lift, and ensures that she is not carried

down towards the tower by any gust of wind.

The yaw guys are paid out from the ship as she is being hauled down, these wires being about 700 feet long and stowed on winches close to the main mooring wire winch in the bow of the ship. As soon as they touch the ground the main winch is stopped, and the yaw guys connected up by snatchcouplings to the ground yaw guys. These guys are then hauled taut so that the nose of the ship is at the apex of a pyramid formed by the three wires.

If using thre eseparate winches for hauling in the ship, it is most important that the yaw guys should be kept taut the whole time, as if the main wire has the strain and the yaw guys are slack the ship may swing from side

to side, bringing up with a jerk on each yaw guy in turn.

While being hauled in, the captain of the ship is responsible for the trim and equilibrium, and he can stop the evolution at any moment, if he considers

it necessary, by pre-arranged signals from the control car.

When the ship is within about 50 feet of the tower head, the main winch is stopped, and the yaw guys, which it will be remembered are 120 degrees apart, are hauled down until the mark which indicates the distance from the tower head to the anchorage comes to the yaw guy snatch block. These two wires prevent the ship moving sideways or over-riding the tower, and as the stern is still being kept down there is no up and down movement, even in a gusty wind. When the yaw guys are down to the mark, the main wire can be hauled in slowly until the ship's cone engages the cone at the top of the telescopic arm. As soon as contact is made, the ship's cone is securely held by three spring-loaded stops, which engage in a groove cut in the ship's cone.

The telescopic arm can now be centralized and locked in the "in" position, which ends the evolution of landing to the tower. The ship wires are then unrove from the tower winches and reeled up on the bow winches, leaving the ship free to move round the tower head with any change

of wind direction.

The ships now under construction will be fitted with a hatchway in the bow, and a convenient gangway, which will then be lowered down to the rail round the tower-control platform to allow the passengers and crew to disembark, their equivalent weight being taken on board by filling up the water-ballast tanks in the vicinity of the passenger accommodation.

The system of landing just described is known as the three-winch method. The same result can be obtained by using two winches, or even one. With two winches the yaw guys are connected to what may be termed a floating wire triangle on the ground. The two yaw guys are led through the ground anchorages to snatch blocks at two corners of this triangle, the third corner is fixed to an anchorage directly to leeward of the tower. The wire round this triangle is connected to one winch, with the result that both yaw guys are hauled in simultaneously. If the ship swings from one side to the other the whole triangle moves over the ground, which prevents any jerk on the bow structure and, at the same time, the ground friction tends to stop the swing. This movement becomes less and less as the triangle grows smaller until when the yaw guys are down to their marks, all the triangle blocks are together, so that any side movement is impossible. A modification to this system has been worked out, whereby all three wires are interconnected, and all worked by one winch. With the ship some distance from the tower head, the apex of the wire pyramid can move freely in any direction, all wires remaining taut; but, as the ship approaches the tower, the system tautens gradually, until the yaw guys are down to their marks, when they are held by a limit wire. The winch then hauls direct on the main wire, and the ship's cone is brought into the tower cone.

Both these systems have obvious advantages over the three-winch system, as they eliminate any possibility of putting sudden strains on the bow structure, and with the single-winch method the ship is moored almost automatically by the single winch once the yaw guys are connected.

When moored at the tower, watchkeepers are always on board to keep the ship in correct trim by taking on board or releasing ballast. On a calm day this is a constant anxiety due to the rapid change in lift, so to assist the watchkeepers ballast weights are slung in the ship at three or four points. Each of these weights can be varied to weigh between a half and one ton, and with the ship horizontal two of them are on the ground and two just clear. Any small change of lift is, therefore, taken by these weights, and ample warning is given to the watchkeepers that a change of lift is taking place.

In bad weather one complete watch is always on board, and a second watch remains in the vicinity of the tower in case it should be considered necessary to slip. This should only be necessary under rare circumstances, and a good indication that conditions are becoming dangerous can be obtained from the electrical strain gauges fitted in the bow structure. These strain gauges will register in the control car, in a position which will be under the eye of the officer of the watch, the actual stress imposed on the bow structure.

Slipping from the tower is a very simple operation, and it can be done in any wind. As soon as the crew are on board and the engines warmed up, the ballast weights are slipped from the ground. The ship is then trimmed down by the stern and about half a ton light as shown by the gauge fitted to ship's cone attachment. While this is being done the tower crew secure the ship by a pendant from the ship's cone down to the telescopic arm to a slip in the tower turret. This pendant is then hauled taut, and the spring-loaded stops in the tower cone, which hold the ship, are screwed back. At a given signal from the ship the slip is released and the ship rises away from the tower, her engines being started up when she is clear.

From this short description of landing at a mooring tower it will be seen how comparatively simple the evolution is compared with landing on the ground, and it is on this simplicity that the future of airships depends. There is every reason to hope that the new towers now erected will come up to expectations; and the trials of the new ships next year will be watched with intense interest by all those who have seriously considered the problems of

imperial air communications.

AN AWARD FOR GALLANTRY AT DIGBY.

H.M. THE KING has approved the award of the Medal of the Military Division of the Order of the British Empire to 363339 L.A.C. W. Arnold, for

conspicuous gallantry displayed at Digby Aerodrome on June 20th, 1928.

Arnold was a passenger with F./Lieut. J. Marsden in a machine which was wrecked on landing and immediately caught fire. Arnold extricated himself from the burning wreckage, and, although fully aware of the grave risk he was taking, re-entered the flames and succeeded in dragging the pilot, who was unconscious and very seriously injured, to a position of safety. Arnold suffered burns to his face, neck, and hands, and his prompt and courageous action undoubtedly saved the pilot's life, since the burning petrol spread rapidly and rendered any subsequent approach to the wreckage

We send congratulations to L.A.C. Arnold and to F./Lieut. Marsden. It

is good news that they are both restored to health.

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LIGHTER-THAN-AIR CRAFT.

By Major C. C. Turner, A.F.R.AE.S.

In the matter of airships, Great Britain has been trying to run before she could walk. In 1924, after a period of stagnation, the Government decided on a programme providing for the building of two airships of unprecedented size, at the same time neglecting provision for keeping airship personnel in training. The reason for this was a necessity to restrict expenditure, but at the same time to experiment with ships of enormous hull capacity. With a small increase in linear dimensions there is a big increase in volume, and airship theory assumes that structural advantages and increased useful load can thereby be secured.

There were many critics of this policy, but it was framed in consultation with airship experts, who, pointing out its one weakness, nevertheless were

confident of a success which would vindicate lighter-than-air craft.

The disaster to the R₃8 in England, followed shortly by the loss of the "Shenandoah" in the United States, had made a deep impression on the public, and when the two biggest airships in the world, the R₁00 and the R₁01, were being prepared for their launching there was in existence in the public mind something like a "disaster complex," and this had been further stimulated by the outspoken forebodings of Mr. E. F. Spanner. Even the friends of the airship feared that any slight mishap would have an extremely damaging effect, whilst a disaster of any magnitude might be expected to "kill airships for ever." In short, in this department there was a state of nervous tension, and at the same time an intense desire to vindicate airships by spectacular displays. The temptations contingent on this "atmosphere" were for long steadfastly resisted, but I think it is apparent that resistance gradually wore down. I do not propose to analyse this factor in the situation any more closely.

Yet I think it is essential to our proper understanding of a very important question that we should realize that, so far from British airship experts having been greatly privileged by the opportunity given to them to realize their dreams of very big airships, in which could be embodied features upon which they placed the utmost reliance, they were, in point of fact, from the first labouring under handicaps and burdened by responsibilities which could only have been sustained by super-men. Under stress of financial straits, and gravely wounded by the disaster to R38 with its heavy toll of Americans and Britons, we vacillated, scrapped airships, vacillated again, and allowed airship personnel to disperse; we then demanded of a small body of experts that they should bridge a great gulf by building airships twice as big as any ever made, and that without opportunity for operational practice they should navigate those ships. Thus a train of cause and effect was laid which bore its bitter fruit in the dreadful disaster to R101. Has this country taken the lesson to heart? Will it ever learn the lesson?

The airship is not dead. Despite disasters, more money is now being spent on airships than at any time except during the Great War. More scientific and engineering talent is being put into bigger ships then ever. Are we to suppose that the United States and Germany are staking so much on a

hopeless project? It stands out conspicuously that airships have at least a very plausible case. Great Britain failed by losing faith and courage in adversity eight and ten years ago. The danger is that she may be making the

same mistake now, and whenever Britain is false to her tradition of indomitable and unwavering courage and resolution she pays a heavy penalty.

We have got to carry on with airships, and although the present programme of experiment and of resumed flights in R100 was the utmost that any Government could adopt at the moment, the country must make up its mind, and that very soon indeed, that this is but a brief temporary measure

and that more serious work on a larger scale must follow.

We cannot help ourselves. The United States and Germany are going ahead. If it were merely a matter of defence in the military sense we might, relying on a belief that there will be no more war, stand by, or make a gesture for peace. Very little is it a matter of defence, however, and very much is it a matter of commercial development which we cannot afford to neglect. What I would urge then is that we regard the present programme as a brief temporary expedient, and that we prepare ourselves for a general advance after a few months, not waiting for our friendly rivals to get too far ahead, and very definitely not again imposing an impossible task on our airship personnel, expecting them to work miracles and retrieve a situation brought about by our lack of courage and spirit.

In this connection I am convinced that Capt. F. N. Boothby's suggestion of an Airship School should immediately be adopted, to analyse the lessons to be learned and to ensure their application in the future. Such a school did, in effect, exist at Pulham at the time the late Air-Commodore Maitland was in control. It was ruthlessly and wastefully scrapped at a time of

cowardly panic.

Under the burden of disasters we have lost sight of the fact that British airships have a very good record, and few people realize what a great amount of airship work was done during the war. The following figures of hours in the air and distance travelled by airships speak for themselves:—

					Hours.	Miles Flown
1915	•••	•••	•••	•••	1,496	41,675
1916	•••	•••	•••	•••	8,296	229,187
1917	•••	•~	•••	•••	22,389	579,185
1918	•••	•••	•••	•••.	56,536	1,395,763

That was in war time; and the casualty rate for that period, including losses due to enemy action, shows an average of one fatality for every 42,548 miles flown.

It is sometimes alleged that airships absorb a disproportionate amount of man-power, but the wartime figures disprove this, and these figures would be greatly improved at the present time owing to the use of the mooring tower.

Men employed per hours flown:—Airships, 1.62; aeroplanes, 3.52. Hours flown per man employed:—Airships, 1.04; aeroplanes, 0.40.

Average duration of patrol:—Airships, 6 hrs. 17 min.; aeroplanes, 2 hrs. 2 min.

Casualties to airship personnel: -239.

Fatalities due to enemy action and flying accidents: -48.

A great many more airships have been built and a great deal more work done with them than most people realize. But by comparison with aeroplanes, which are so much cheaper and easier to build, and which have a far more rapid typal development, airships represent a much more costly undertaking. The few disasters which have befallen them have been more terrible than any aeroplane accidents, and the resultant set-back the more

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serious. It is not unnatural that many voices should be raised in protest. Many of us who have lost whole companies of friends in these disasters are tempted to heed these protests, to which weight is added by pressure to avoid the spending of money on anything which does not buy immediate necessities, although one would think increased employment and the prospect of a busy industry are among our paramount necessities.

But we cannot evade our responsibilities in this matter. We cannot stand by idly while America and Germany build. And apart from that consideration, we are face to face with a Naval situation which demands that something shall be done to compensate for cruiser shortage. So seriously has our cruiser programme been cut down that the Navy is faced by a situation in which it may no longer be able to carry out its recognized duties. It is acknowledged that aircraft must be brought into the breach, and there are solid grounds for believing that airships for many years, and possibly always, will be far more suited to such duties than flying boats.

It may be objected that airships have proved so vulnerable in war that they may safely be ignored in this respect. Against that view it should be stated that such naval duties as those referred to would never expose an airship to aeroplane attack, whilst peace-time naval activities, which are very important to civilization, to security on the high seas, and in the repression of brigandage and piracy, are also to be considered. Surely, too, we cannot ignore the fact that the United States is building airships which, heavily armed, inflated with a non-combustible gas, and equipped as aeroplane carriers, are designed as powerful instruments of war.

Where, then, do airships stand at the present time technically? What is the answer to the fear that every airship built is likely at any moment to go up in flames?

It is claimed that the report on the disaster to Rioi clearly shows there was no inherent fault in the design of that ship. Here I would like to remark that the finding of the Court of Inquiry, although presented in an almost convincing way, and although led up to by an investigation admirably conducted, does not settle beyond question the cause of the disaster. There are alternative possibilities, although these also would not condemn airships in

One of the possibilities has been mentioned by Air-Commodore E. A. Masterman, R.A.F. (Ret.), who refers to the incident on the day of the R.A.F. Display last year, when Rioi was compelled to discharge eleven tons of ballast. Air-Commodore Masterman questions the decision that the disaster at Beauvais was due to a loss of gas forward, for the Chief Coxswain went aff a few seconds before the final dive, and from this it may be inferred that the officers on deck were under the impression that the elevator control had failed. "Had he known of a loss of gas forward he would move everybody aft as quickly as possible so as to frim the ship." The opinion is expressed, therefore, that there was a repetition of the trouble which had occurred on Display day, and further that there is no conclusive evidence that the airship was not at the time much lower than 1,000 to 1,500 feet.

Again, the assumption that the airship was down by the head is open to a possible explanation which may be of value, whether it applies in this case or not, to future airship operation. The contingency which I will now mention was, I believe, first explained by Mr. Griffith Brewer. To understand it we must consider the case of a very long airship making slow

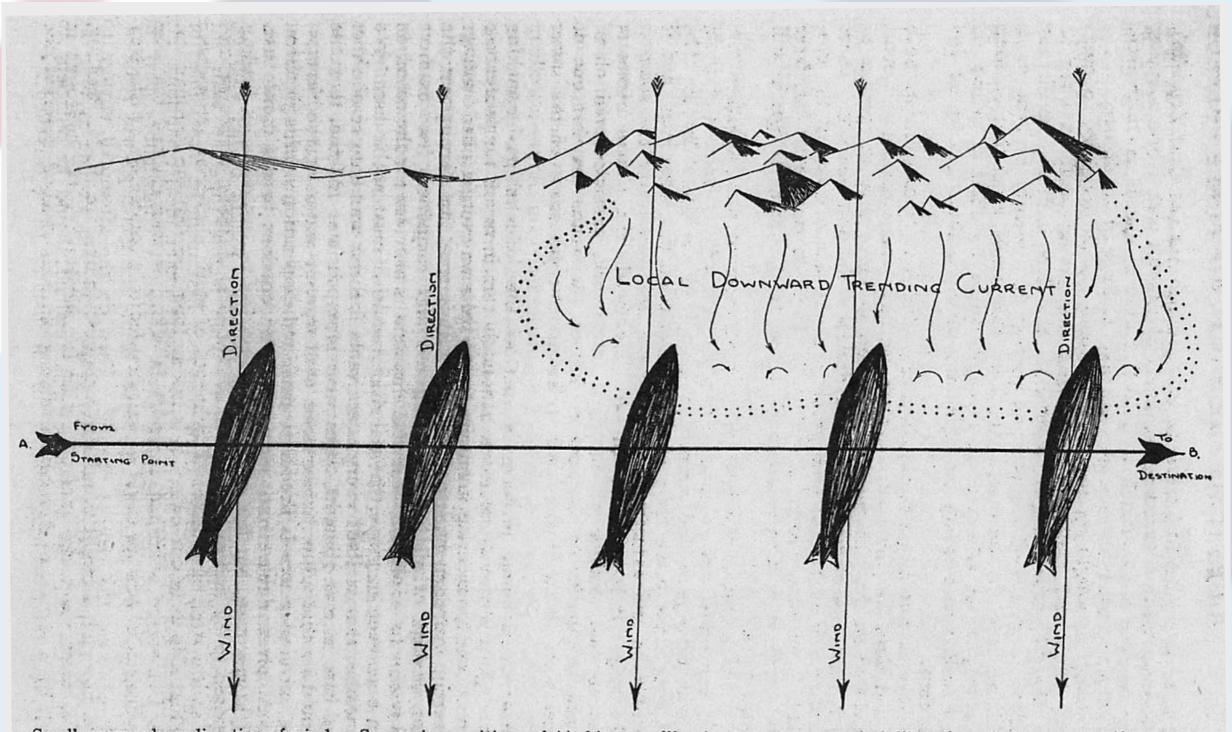
travel-speed with a heavy wind abeam, compelled thereby to move in a crabwise manner like a ferryboat crossing a swift stream. Supposing in such a case the very long airship enters a region where there is a slight downward component in the wind over a limited fixed area: the air always moving, but the region where it has a downward component remaining constant. The down-draught need only be a very gentle one for the theory now being considered. It might be of so slight a character as to have been ignored by those who, for the purpose of the inquiry, examined the Beauvais region. We know a certain amount about the behaviour of currents deflected by ground irregularities; that is to say, we know about the more definite and conspicuous currents, but it is by no means sure that we can at any moment draw an accurate chart of currents at all altitudes in a region, shall we say, roughly north-east of Beauvais ridge and extending four or five miles therefrom. And there are other causes of downward currents than hills. Over woods and lakes balloonists always feel a tendency to descend.

Now a very long airship travelling south, but with her bows pointed S.W. by W., or approximately thereto, might easily for a considerable time have her nose in the down-draught while the rest of her was clear. Those on board would have no knowledge of so slight a current which, however, would hold the head of the ship down. She might be clear for a few seconds, or the control would operate and bring her level; but down by the head she would go again, giving the impression either of failure of elevator control or of loss of gas forward.

These doubts are mentioned not because they affect the main argument of this article, but because it is necessary that every possible condition of airship travel should be considered. By facing all possible and conceivable risks, success may eventually be attained. By ignoring any one of them disaster is courted. Thus, the rain trap on the hulls of the R100 and R101-a brilliant idea which will certainly increase the performance of airships by making it possible to take on board fresh ballast in the form of rain-water, so that on many occasions airships will go out of their way to get into a shower may in certain circumstances prove an embarrassment. In very heavy rain the weight of water which would be collected might amount to two or three tons in a few minutes. It is true that the apparatus provides for the retention of only the desired quantity of fresh ballast, whilst excess can be discharged through the usual water ballast discharge vents. But it stands to reason that in such a case nice and instant adjustment is impossible, and that it would be difficult to avoid either a too rapid discharge of water or the reverse. Probably only experience is needed to perfect the operation of this excellent system. At present there have been very few occasions to put it into use.

Rioi was heavily handicapped by the excessive weight of her engines, which averaged about 8½ lb. per h.p. This factor, together with the weight put into her structure, from the very first made it impossible for her to carry out a great Empire voyage except under ideal conditions. It led to the making of modifications which played a contributory part in the final disaster. For example, the space round the gas bags was reduced, and this increased the risk of chafing. Then on the attempted voyage to Egypt it was found necessary to keep below a certain altitude as long as possible in order that the amount of gas retained should be sufficient to ensure carrying the load long enough for the distance to be travelled.

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Small arrows show direction of wind. Successive positions of Airship travelling in a strong cross-wind, like a ferry boat over a swift stream.

Dotted area is a fixed local downward-trending current.

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Both Rioi and Rioo had fabric trouble (as also has the Graf Zeppelin), and this is undoubtedly a besetting weakness of airships with fabric covering which will be even more difficult to guard against as speeds are increased. Fabric trouble, it must be remembered, may easily lead to disaster.

But saving of weight on the engines would enable designers to overcome both fabric and gas-bag trouble, and this saving could at once be secured. The "Condor" engine, with which the Rioo is fitted, has already been adapted for heavy-oil compression-ignition at a weight of little more than 2½ lb. per h.p. In the case of the Rioo this would mean that on long voyages a very great saving in fuel-weight would be effected, whilst on the Rioi it would have meant the lightening of the dead weight by no less than eight tons.

It must be admitted that the attainment of the great framework strength of R100 and R101 has involved a certain sacrifice, and although it cannot be doubted that on this item weight could now be saved without sacrifice of strength, it cannot be claimed that either design is the best possible. There is no doubt that in airships of such great girth the size of some of the gasbags entails a problem which has not to be faced in smaller or slenderer ships. In short, it is hardly too much to say that airship design is still in the melting-pot.

In the United States the interesting experiment of metal-sheathed airships is being made, and a small airship has carried out successful trials lasting about three years and comprising more than 500 hours' flying. The designers have made plans for a very big airship on the same lines, and if their calculations and assumptions are correct this may prove the solution of the difficulty. It is too early to say. Meanwhile the United States is committed to two airships of the rigid framework, fabric-covered class, each to have a capacity of 6,500,000 cubic feet. It stands out that one of the critical tests of these ships will relate to the durability of the outer cover.

Another outstanding problem is that of the kind of gas used for buoyancy. Quite obviously, unless an absolutely certain means for preventing fire outbreak, and for securing immunity from explosion even in a bad landing, be discovered, hydrogen must not be used. It is true that throughout the history of airships of all kinds, leaving out war casualties, few disasters have been due to explosion, but the disasters which have culminated in explosion have been so grave that the risk of another must not be run. We must remember that in R101 every conceivable fire risk and danger of short circuiting had, it was thought, been overcome. It was claimed that the airship could go through a thunderstorm with scarcely any danger; although, of course, an airship avoids thunderstorms, and does not go through them. The Rioi, driven down from some cause or another, would have been damaged in any case, but her complete destruction by explosion on landing was supposed to be impossible. After all, the Graf Zeppelin makes ground landings as a matter of routine. Discharges of static electricity are secured safely in that ship as in our own. It is not so long ago that the Aeronautical Research Committee published a report in which it was claimed that the use of hydrogen in airships could be safeguarded in a completely satisfactory

Here, however, I ought to refer to a suggestion by Capt. F. N. Boothby, R.N., who some years ago evolved a plan for surrounding the hydrogen in an airship by a sheath of non-combustible gas. This method deserves the

very closest attention, for, although it would involve an extra load, it is claimed that the sacrifice of useful lift due to it would be far less than that incurred by inflating the airship with helium instead of hydrogen.

In the American airships helium is to be used, and Dr. Eckener also proposes to use it in the new big Zeppelin to be built at Friedrichshafen.

Helium is non-inflammable gas, found chiefly in the United States. It is heavier than hydrogen, and its lift is less by about 7 per cent., a very serious drawback, which in the case of R100 would mean a reduction of the gross lift by about 10 tons, a reduction which would put that airship completely out of consideration as a commercial vehicle. The use of helium would, however, make it possible to dispense with some of the ante-fire provision and equipment, and would also permit of modifications in the design by which greater speed would be secured, and thereby fuel-saving.

Helium, however, is a very expensive gas, and must be conserved far more carefully in the operation of the airship than is hydrogen. Valving must be reduced to a minimum. Considerable experience of its use has, however, been obtained in the United States, and it is enough to state that all future American airships are to be helium-filled.

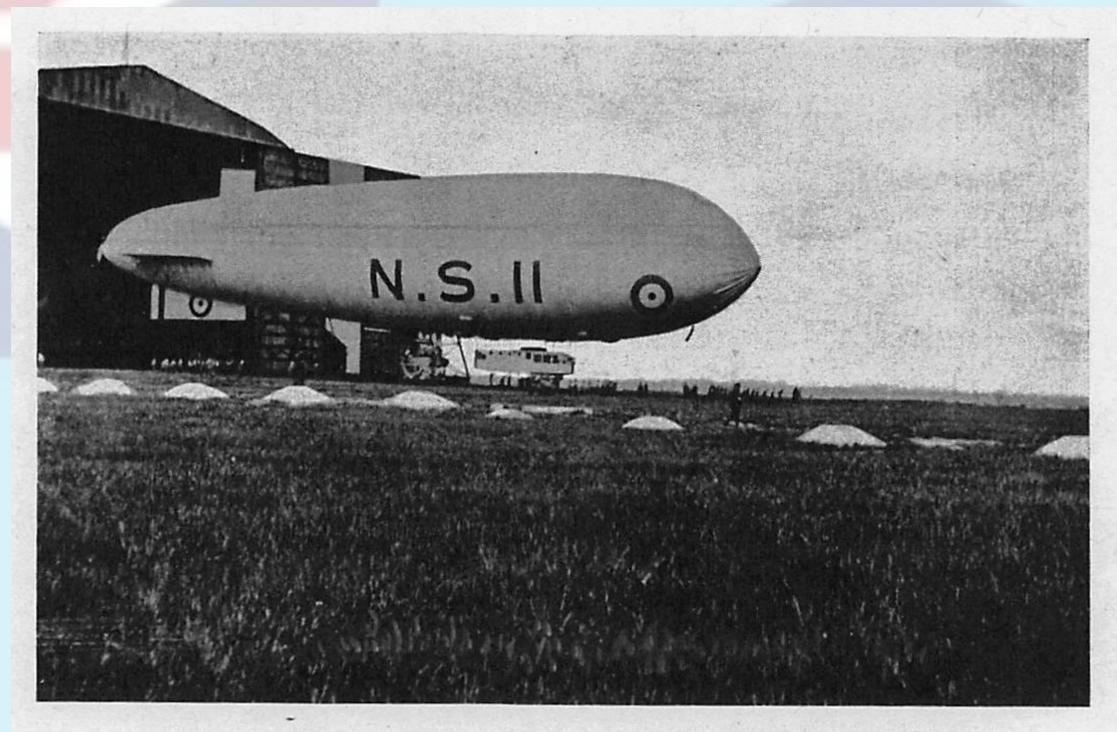
The supplies of helium are sufficient, it is claimed, for 1,000 to 2,000 super-airships, whilst additional sources in various parts of the world are from time to time reported. If we decide to use helium we should at present have to get it from the United States, and the quoted price is 40 dollars per 1,000 cubic feet, including cost of transport. That heavy cost, combined with its handicap in the matter of lift, is sufficient reason for examining very closely the idea of surrounding hydrogen with a sheath of non-inflammable gas.

Airships are still very much in the picture. The shipping companies have for long given serious attention to them, for they suggest the employment of high-speed mail and passenger craft which would replace the very costly high-speed liner, and enable the companies to employ as surface craft vessels of moderate speed, which are highly profitable. At present the high-speed ocean liner is partly paid for out of the profits of the traffic which is content with moderate speed.

As compared with heavier-than-air craft, we must always remember that airships have the advantage of much greater range. They are the only class of aircraft with which regular ocean services can yet be contemplated, for it will certainly be many years before flying boats can undertake a regular service both ways across the North Atlantic, whilst no matter how successful the designs of big flying boats prove, it will always be an unavoidable circumstance of aircraft that a useful and paying load has to be sacrificed to range, and that for heavier-than-air aircraft 500-miles stages are likely always to be the maximum economical stages. Of course, craft can be built for very special services in which stages of 1,000 miles may be flown, extravagantly, yet in certain circumstances necessary; but such services will be exceptional, and if aviation is to depend upon them it will never be a great transport industry.

In short, the world needs airships very badly, and I rather think that that being the case it will, in the end, have them.

Autumn 1932 - Airship Articles (3)



[Photo: W. K. Morton & Sons, Ltd., Sleaford.

AIRSHIP N.S.II LEAVING ITS SHED, CRANWELL.

March 1951 - Airship Articles (4)

JOURNAL OF THE ROYAL AIR FORCE COLLEGE

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JOURNAL OF THE ROYAL AIR FORCE COLLEGE

THE AIRSHIP "BOURNEMOUTH"

By Squadron Leader T. York-Moore

AFTER a lapse of twenty years an airship is once again making an appearance in England: a small, non-rigid airship is being constructed in Bournemouth. The venture was started in 1946 by a small band of enthusiasts and construction of the ship began in 1949. "The Airship Club" has been formed to take care of the work and to operate the ship, and has over two hundred members to date.

The small airship had originally an ordinary observation kite-balloon envelope of the "R" type, but this has now been lengthened by six sections to 108 feet and an approximate capacity of 45,000 cubic feet. Hydrogen will be used, as it is not possible as yet to obtain the necessary supplies of helium. Under the best conditions the gross lift will be about 3,150 lb.

There are two "air-balloonets" fitted inside the envelope and inflated by an air-scoop and suitable fabric ducts, which collect air from the propeller slip-stream and lead it to the balloonets. They serve the purpose of keeping up the small pressure (20-30 mm. of water) of the gas and thus keeping the shape of the envelope, upon which the whole efficiency of the airship depends. A simple "non-return" valve of fabric covers each entry hole into the balloonets, and there is a simple "butterfly-valve" box on top of the air-scoop. The balloonets have hand-operated and automatic valves on the underside and to the rear, and another half-way up the side for slow deflation (or normal) purposes. The gas valves "blow off" at 35-mm. pressure and the air valves at 33 mm. The airship is kept in trim during flight by means of these air balloonets. There are three stabilizing fins, with two elevators and one rudder, which are easily erected and dismounted.

For normal deflation, and in case of an excessive and quick rise in pressure in the envelope during flight, there is an upper gas valve about half-way up the port side, operated by the pilot. In a case of real emergency arising (in the air or on the ground) the airship has a "ripping panel." This is a narrow panel about twelve feet long which can be torn off, allowing the gas to escape very rapidly. On no account must other valves (top or bottom) be opened when this is done—the reason being that any air sucked into the envelope while gas is escaping will produce a highly explosive mixture.

The specially designed car will be far superior in comfort, and for observation purposes, to the S.S. "Zero" airships of the First World War. These latter ships were excellent in nearly every way, but had one failing, that of restricted visibility ahead. There is now complete visibility ahead as well as to the sides and rear. The car is slung from the envelope by means of ten main suspension wires which are coupled to the car fittings with quick-release clips. The opposite ends of the rigging are attached to large "eta" patches, which in turn are stuck on to the envelope with ordinary rubber solution. It is estimated that a pull of over one ton is necessary to pull one of these patches off the envelope.

The control wires to the rudder and elevators run along the top of the car for easy maintenance and inspection, and are worked by hand wheels, fitted with friction brakes to make for easier and finer control in flight, and to lessen the strain on both the pilot and the coxswain when any bumps are encountered. This was a normal fitting to the

elevator wheel in all the small ships during the 1914-18 war, and was found very satisfactory.

It is hoped to be able to fix a "castor" type landing wheel under the car, as this will simplify conditions of mooring-out, ground handling, take-off and landing. The last two are not, however, dependent on a wheel, as the "car-handling" party will see that the underframe does not get damaged on the ground. The castor wheel will depend on the available lift justifying its attachment, but a substitute can be found by using a larger "ground" one, which would be removed before take-off and replaced after landing.

The data and dimensions of the ship are as follows:

Car.—Length, 15 ft.; width, 4 ft.; height, 6 ft.

Engine.—75 h.p. British Salmson radial engine.

Propeller.—Four-bladed, 5.75-ft. diameter; wooden.

Envelope.—Length, 108 ft.; largest diameter, 27 ft.; over-all height above ground,

Gas.—Hydrogen, volume = 45,000 cu. ft. add owner you'll abmoulted add on the

Balloonet Height. -3,200 ft. approx. and bas are one to (1218 of to 1818 of 1818)

Speed.—Maximum, 40-42 m.p.h.; cruising, 30 m.p.h.

At the time of writing it is not possible to give the rates of climb or descent. It is hoped, however, subject to the controls and air-blower system, that they will compare favourably with the old S.S. "Zero" class of airships of the 1914-18 war, i.e., climb, 1,000 feet in 45 seconds; descent, 1,000 feet in 30 seconds. These speeds are only for short periods and are considerably less in a normal flight.

In designing the airship "Bournemouth," care has been taken to ensure the greatest possible safety, good all-round visibility, ready accessibility of the engine in flight, reasonable room for the five passengers, easy entrance and exit from the car, ease of refilling the petrol tank in flight, and controls arranged so that one person can fly the ship if necessary. The training of club members as airship pilots was also borne in mind when the ship was designed. All precautions are being taken against fire as well, and fire-fighting equipment is fitted.

When inflated and in use the airship will be kept moored-out in the shelter of high trees in suitable sites according to prevailing weather conditions. This is a perfectly safe method, and was widely employed in the First World War. It has been improved in present times in America by the use of portable mooring masts. These have been used for years with advertising and other ships.

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Spring 1930 - Formation Flying (1a)

FORMATION FLYING.

By D. A. B.

This article deals entirely with Formation Flying as a spectacular display and

not as a means to an end on active service.

The first essential when learning to fly in formation is that a pilot should realize the correct position for his aeroplane to occupy relatively to that of the leader. In this respect, a beginner generally tends to fly in a position such as that represented by aeroplanes "X" and "Y" in Fig. 1. Such a position has a number of disadvantages. It necessitates flying in the leader's slip-stream, makes it more difficult for the leader to watch his formation, and in cases of emergency increases the danger of collision.

Another characteristic common to most beginners is that they are far too disinclined to use the throttle lever sufficiently and try to keep station without varying the revolutions of the engine, which immediately makes a simple

operation difficult.

Once the above points are realized, a pilot should, with practice, very

quickly become accustomed to ordinary formation flying.

I am now going to mention a few facts about various manœuvres that should be of assistance to pilots attempting these manœuvres for the first time in formation. I assume in each case, unless otherwise stated, a "V" formation of three aeroplanes.

TAKE-OFF.

The most common fault in a formation take-off is the straggling of the

following aeroplanes.

Provided a formation be properly led, this can be avoided by keeping engines running as fast as possible, without letting the aeroplanes actually move forward, while waiting to take off. Then immediately the leader's aeroplane starts moving, a small further opening of the throttles will cause a corresponding movement of the remaining aeroplanes. From that point on, the throttles should be used as for normal formation flying.

When taking off, the leader should open his engine up very gradually at

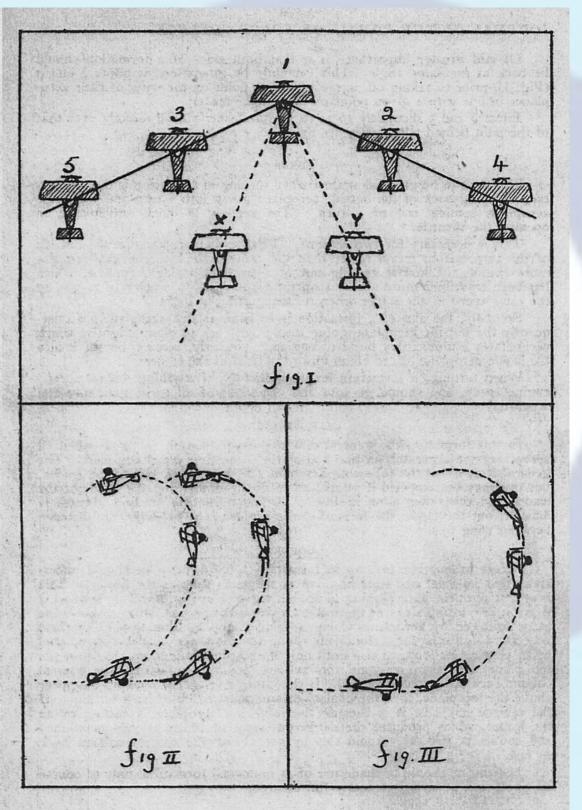
first and should never use full throttle.

LANDING.

In order that all aeroplanes in a formation may touch the ground simultaneously, it is essential that towards the latter portion of the approach the following aeroplanes get down to the level of their leader. If this is not done, they will touch the ground after the leader, which, apart from looking unfinished, results in the rear aeroplanes overshooting. This is because the deceleration of an aeroplane on the ground after landing is much greater than that of one in the air prior to landing. A leader should always keep a small amount of engine on during an approach, and by watching his formation after landing he may be able to assist them by judicious use of his throttle. This, however, should not be necessary.

STRAIGHT FLYING.

To ensure that a formation is symmetrical, the pilot, or pilots where there are more than three, on one side of the formation (generally the right) should be made responsible for distance, and pilots on the other side should fly so as to be line abreast with their opposite numbers.



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Spring 1930 - Formation Flying (1b)

Of still greater importance is it that both sides of a formation should lie back at the same angle. This can only be guaranteed if pilots 2 and 3 (Fig. 1), prior to taking off, agree to keep a point on the wing of their aeroplanes in line with a given point on that of the leader.

Pilots 4 and 5 should fly so as to see the leader's head directly over that of the pilot behind whom they are flying.

TURNS.

The fault to be guarded against when turning in formation is the momentary dropping back of the outside aeroplane going into a turn and the inside aeroplane coming out of a turn. The remedy is quick anticipation in opening the throttle.

This is necessary for two reasons. Firstly, the aeroplane on the outside of the turn has to travel faster than the others, and consequently requires more engine. Likewise coming out of a turn the inside aeroplane, which has been travelling more slowly than the leader, has to accelerate to get up the same speed as the leader when resuming straight flight.

Secondly, the aim of a formation is to bank as one aeroplane. Consequently the outside aeroplane going into a turn has to climb slightly, which necessitates a momentary burst of engine. Similarly, coming out of a turn the inside aeroplane has to climb up to the level of the leader.

When turning, a formation leader should fly, if anything, below normal engine speed, and should go into and come out of all turns gradually and accurately.

LINE ABREAST.

In this formation the general difficulty experienced is to know when all aeroplanes are accurately in line and at the same time equally spaced. The general fault is for the following aeroplanes to hang back behind the leader, but this may be remedied if pilots aim to fly so as to bring the heads of the leader and the other pilot in line. Accurate spacing in line abreast is difficult, but the closer the formation the simpler is it to judge the distance between wing tips.

LOOPING.

Before attempting to loop in formation a following pilot should understand that he must not start his loop at the same time as the leader. This is at first sight the natural thing to do, but a glance at Fig. 2 will show to what it leads, i.e., losing sight of the leader, which is dangerous. Fig. 3 shows the paths followed by aeroplanes doing a correct loop in formation. The best way to do this is for a following pilot to allow the leader's aeroplane, when starting its loop, to rise until only its bottom plane is visible below his top plane, and then maintain this relative position by easing the control column back at the correct speed. If the leader's aeroplane tends to disappear above the top plane, then the control column must be eased back farther. If the reverse happens, it is because the following aeroplane is cutting in on the leader, which produces the dangerous state of affairs already mentioned and shown in Fig. 2. Avoid this by not easing the control column back so fast.

The engine should be made use of as in normal formation, only of course all pilots will be flying at nearly full throttle.

BUNTING.

The same principle holds good for a formation bunt as a loop. A following pilot must not start his bunt until after the leader. A greater distance should be left between aeroplanes when bunting in formation, as there is no means of regulating the relative speeds of follower and leader; except when engines that will run inverted are used, in which case it is safe to bunt in close formation.

SLOW ROLL.

This manœuvre can never be carried out in really close formation, as each pilot in turn loses sight of the leader's aeroplane. The difficulty of locating the leader again when in the inverted position is simplified if the rear aeroplanes go into the roll slightly above the level of the leader.

Another important point is that all aeroplanes do the same kind of roll and that the following pilots, when compelled to lose sight of the leader, pick up a point on the horizon on which to complete the blind portion of the roll, thus ensuring that they keep the same line as the leader.

In practice it is found difficult to get all aeroplanes to start the roll simultaneously. If, however, the leader banks his aeroplane in the opposite direction, prior to starting the roll, it will enable the other pilots to anticipate the start of the roll proper.

HALF-LOOP.

This is a particularly good method of assuming the inverted position when in formation. It is better than by means of half a slow roll, because, owing to pilots not losing sight of the leader during the manœuvre, they can fly

Care must be taken, however, on top of the loop, as all aeroplanes are momentarily very near to stalling-point with a consequent decrease in control.

INVERTED FLYING.

Straight flying in formation inverted is not difficult once a pilot becomes accustomed to looking at and formating on the leader. Speaking generally, one experiences anew all the difficulties encountered when first learning to fly in formation. The actual time that can be spent in practising inverted formation flying is very limited, for obvious reasons, with the result that no pilot gets enough experience to be really proficient.

The use of elevators and rudder is quite automatic inverted, but it is not easy at first to decide which way to bank in order to turn quickly either towards or away from the leader.

When flying inverted in line-ahead, in order to ensure turning at the same rate as the leader it is necessary to keep the nose pointing at a definite point with respect to the leader's aeroplane. If a following aeroplane wishes to gain distance, the nose must be aimed farther forward towards the leader's cockpit, and, if tending to overshoot, should be allowed to drop back behind the leading aeroplane.

This latter point is a good example of something which a pilot does quite subconsciously when flying normally requiring a definite concentration when flying inverted.

I have as yet said little about the formation leader, whereas, without doubt, he is the most important factor in a formation. His obligations are many. In addition to executing every manœuvre accurately, he must continually watch his formation, assist them where possible, and be ready to do

the right thing in case of emergency. Add to this his responsibility for signals, timing, placing, showmanship, and one sees that his task is as difficult as it is responsible. Most important of all, he should be gifted with that personality which automatically inspires complete confidence in his followers.

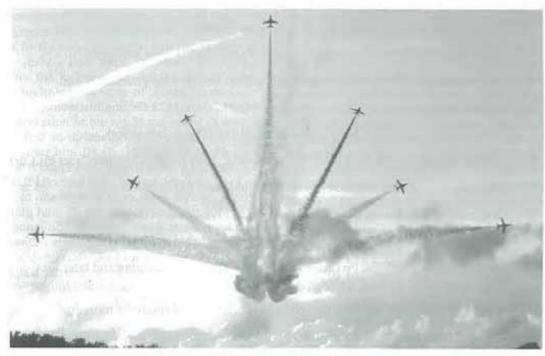
Much more might be written about this very interesting side of flying, but space does not permit. If, however, this article proves, even to the smallest degree, as entertaining to its readers as participation in the subject, to which it relates, is to the pilot, then the valuable space which it occupies will not be wholly wasted.

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March 1997 - Red Arrows 1996 (2a)

THIS IS OUR LIFE!

Sqn Ldr A Cunnane, Red Arrows' PRO



Vixen Break at sunset

1996 has been quite a year for the Red Arrows what with one thing and another. Never before can the Team have had such a high profile, and to cap it all I have been asked to write for the prestigious Royal Air Force College Journal. As it happens, the deadline for copy neatly coincides with the completion of the latest Red Arrows' event and publication will be well after the embargo date for publicizing the event.

I refer, of course, to 'This is Your Life', recorded in the magnificent setting of College Hall Dining Room on 23 September 1996. Although the Subject was the then Leader of the Red Arrows, Squadron Leader John Rands OBE, the programme was intended to be a tribute to all members of the Team and also was meant to show off the Royal Air Force in a positive light to a television audience of about 10 million. We were all privileged to have the Chief of the Air Staff, Air Chief Marshal Sir Michael Graydon, on the set and the personal message he carried

from our Commandant-in-Chief, Her Majesty Queen Elizabeth The Queen Mother, was a great honour for the entire Team.



"I don't believe it!!" This is your life John Rands 23 September 1996

But let's get things in order. After the decision to close Scampton had been announced in Westminster, a great deal of work was done to find a new home for the Team. Rumours were rife. A local newspaper in Cornwall rang to ask if it was true that the Team was moving to St Mawgan; another newspaper in Elgin asked if it were true that we were going to Lossiemouth. The faithful fans of the Team in the Cirencester area wrote to say that they would be delighted to welcome the Reds back to Kemble. An executive of a wellknown civilian airport in the south west, much frequented by the Red Arrows, offered his airfield. In fact, just about every RAF airfield in the UK was considered and everyone was rejected for one reason or another. For a while it looked as though the Team might be homeless.

At last, it was announced that the Team would move to Marham. Shortly afterwards that move was put on hold for at least 2 years for operational reasons. Time was now getting very short. The run down of Scampton was well advanced. Eventually, it was disclosed that the Team would move to Cranwell as an interim move for 2 to 3 years until Marham became available. However, because of congestion in the Cranwell and nearby Barkston Heath circuits, and the fact that the Coningsby climb out and let down lanes pass close to Cranwell's overhead, it was also announced that the Reds would continue to practice overhead Scampton.

The Red Arrows went to South Africa and back in September and October 1995 to help the SAAF celebrate their Seventy-Fifth Birthday. The last aircraft movements at Scampton, or so we thought at the time, were on 23 November 1995 and the media gathered in force to see that historic airfield close down. First out that day were The Red Arrows who departed for Malaysia where they took part in an international air show called LIMA 95 on the holiday island of Langkawi. The Reds were followed by their support Hercules and almost immediately afterwards the Station Commander flew the Station Chipmunk out to Newton. I should have known better than to organize a press facility for the last aircraft flying out. But more of that later.

1996 started with the Red Arrows separated from their aircraft by some 9,000 miles - and that has never happened before. The Hawks were bedded down in a hangar at the RAAF Base Butterworth in north western Malaysia and the Australians promised not to play with them. The Red Arrows' pilots and ground crew had flown home, business class, by civilian airlines to spend Christmas and the New Year with their families. Perhaps this is a good point to mention that all the 1995/96 winter tours and the June 1996 visit to Indonesia were funded by what we came to call our 'Pot of Gold'; over £3 million contributed by 16 British defence-related companies who all thought it worth their while to pay for having the privilege of the Red Arrows appearing on their exhibition stands at the various air shows.

Throughout that winter there was considerable doubt whether the Red Arrows were based at Scampton or Cranwell. Scampton had closed officially, but there was nowhere for the Team to go at Cranwell. Actually it did not matter very much (to the Red Arrows) because what was left of RAF Scampton was by then under the command of Station Commander RAF Cranwell. The 1995 official End of Season Guest Night, which has to be arranged months in advance, was held in Cambridge because of the doubt about where the Team would be in late October. Cambridge was deemed to be midway between Scampton and Marham and still convenient for the many guests who travel to the Dinner from the London area.

In early January the Reds and Blues boarded another comfortable 747 to fly back out to the Far East to be reunited with their aircraft. I came to Cranwell to do some work but could not find an office so instead I flew out to Singapore to do advance PR for the Team. After a few days flying out of Butterworth to regain currency, the Red Arrows pressed on to Australia where they displayed in spectacular fashion in Canberra and over Sydney Harbour Bridge - the latter on Australia Day in front of an estimated audience of 1.2 million folk, Dedicated PRO though I am, I cannot claim that the entire crowd came out especially to see the Red Arrows, but see them they did and we claimed that as an all-time world record for any aviation event. On the way back from Australia, the Team called in at Bandar Seri Bagawan and Manila to give public displays before large and ecstatic crowds before settling down in Singapore for 10 days or so displaying at Asian Aerospace 1996.

The Team arrived at Cranwell on 20 February - exactly on schedule of course - and that marked the official end of the 1995 display season. The 2

March 1997 - Red Arrows 1996 (2b)

for it yourself! Indications are that this other site has never even heard of the Royal Air Force Aerobatic Team and current legal advice given to us is that there is probably nothing we can do to prevent the authors using the Red Arrows' name even though it is registered as a trade mark.

There were two 'spectaculars' in early June, both given blanket coverage by the media. The first was a fly-past with Concorde over London's Heathrow airport on 2 June to celebrate the airport's Fiftieth Anniversary. The second was on 8 June over Wembley Stadium to mark the opening of a football competition called Euro 96. Perhaps it is just as well the Red Arrows were not scheduled to fly-past over the final. The television audience for the opening ceremony, potentially 400 million according to the organizers, had a much better view of the fly-past than those in the arena who were able to catch just a glimpse of the Hawks with their red, white and blue trails as they flashed over the rather small skyport in the centre of the arena.

Later the same month the Team set out again on what was becoming a well-worn route to the Far East. This time the destination was Jakarta and the event was the first Indonesian Air Show for 10 years. As it happens, the last time the Red Arrows displayed in Jakarta was in 1986 at the first Indonesian Air Show. Dr Habibie, the Minister for Technology and the Organizer of both Indonesian Air Shows, said at a grand reception in honour of the Red Arrows in the presence of Michael Portillo



Red Arrows over Soekarno-Hatta International Airport Jakarta - Jun '96

the Defence Secretary, that Jakarta Air Shows would in future be held every year and that he had already put in a bid for the Red Arrows for 1997. I am not sure how welcome that snippet of news was because it is a long, tiring journey to Indonesia by Hawk and this year it kept the Team out of the UK for about 4 weeks at the height of the European display season and led to the cancellation of a number of shows including, sadly, the Waddington Air Days and several shows in Italy.

The Red Arrows have continued to support charities in many parts of the UK through the medium of the Team's own charity, the Red Arrows' Trust. Over £20,000 was disbursed during 1996 up to the end of August and upwards of £15,000 more was expected to be allocated in the remaining months of the year. The money comes in from the sale of Red Arrows' approved souvenirs and the use of the Red Arrows' trademarks and logos on approved merchandise. including the highly popular Red Arrows' virtual reality flight simulator. The nice thing about the Trust is that the pilots themselves have a large say in how the money is to be used. In September 1996, a Dutch company released an excellent CD-ROM of Red Arrows' photographs and 1997 should, hopefully, see the release of a multi-media encyclopaedic CD-ROM, including everything anyone could possibly wish to know about the Red Arrows plus a virtual reality game based on real air-to-air footage which will allow players to choose which position in the Team they wish to fly.

In August there was a most welcome visit by 4 Russian officers including the Russian Knights aerobatic team Leader, Lieutenant Colonel Aleksander Vladimirovich Lichkun, and Deputy Leader, Lieutenant Colonel Vladimir Alekseivich Kovalskiv. These same 4 officers had visited the Team at Scampton in 1991. The 1990 Red Arrows had met them all in Kiev the year before during the Red Arrows' foray behind the Iron Curtain. This time the Russians came by civil airline since their team activity is temporarily suspended following a tragic accident at Cam Ranh Bay, Vietnam, as the Knights were returning home from LIMA 95 in Malaysia. Four display pilots were killed when 3 of the SU-27 aircraft flew into the ground whilst formating on the starboard wing of their support IL-76 transport during a descent through cloud. The pilots in the 2 aircraft on the port wing, Colonels Lichkun and Kovalskiy, survived to tell the story

and visit the Red Arrows. The purpose of the Cranwell visit was to learn more about the logistics of operating an aerobatic team world-wide and where better to come for that purpose? Naturally, the Russians took the opportunity to fly with the Reds and accompanied the Team to displays in the West Country where they helped on the ground dispensing Red Arrows' brochures and stickers.

So, as I write this, the Thirty-Second Season of the Red Arrows has come to a close and 3132 displays have now been flown since the first one in May 1965. The Fourteenth Leader, Squadron Leader Simon Meade, is already with us understudying John Rands, and the 3 new pilots, numbers 103 to 105, have already been having a look around. The Red Arrows will certainly reach new heights in the 1997 Season. The arrival of Simon at 6ft 1in, Red 2 Ian Smith at 6ft 3in, Red 3 Gary Waterfall at 6ft 3in and Red 5 Andy Cubin, a mere 5ft 11in, brings the average height of the Team to 6ft 1in - helped enormously by Second Line Engineer Dick Burns who tops out at 6ft 5in and hindered by a certain pilot who is but 5ft 8½in.

At Scampton in recent years we had upwards of 3,000 visitors a year. Admittedly many went primarily to see Nigger's Grave and pay a nostalgic

visit to the Dam Busters' former home, but nevertheless every visitor bar none also wanted to see and visit the Red Arrows. We cannot cope with anything like those numbers in our present accommodation at Cranwell. The First Line Ground Crew are still cramped into tiny Portakabins. The HQ element is now reasonably furnished and we have a new coffee bar, an essential piece of work that has to be done whenever a squadron moves home. This one was generously donated and installed by a relative of one of the Reds. The building itself is still far too small in which to entertain all the visitors who wish to see the Team on home ground; we have nowhere to display the hundreds of trophies and other awards presented to the Team over 32 years. And what are we to do with our visitors while the Team is practising overhead at Scampton? Speaking personally, I do not miss standing out in the wind and the rain talking to visitors but somehow watching the flying on live video is not quite the same.

During 1996 countless ordinary people around the world, as well as the media and other air forces, have acclaimed the Red Arrows as being the premier aerobatic team in the World. What a pity we do not have a Headquarters and Visitors' Centre to match.



The 1996 Red Arrows Team

Autumn 1938 - Rotary Wing Aircraft (1a)

ROTATIVE WING AIRCRAFT

By T. V. WELSH.

It has been said that the essence of invention is not so much thinking of something new as forgetting something old. This appears to be true of rotative wing progress. The modern rotor has little relation to the lifting screw as this was thought of centuries ago. On the other hand, one of the latest rotative wing types, the F-W helicopter, is not unlike certain fanciful pictures of the past. The constant-speed airscrew driven by a 600-h.p. engine mounted in a suitable aeroplane demonstrates one aspect of the lifting power which the old investigators dreamed about. The modern rotor consists of aerofoils, articulated and controlled and individually stable. The single-blade Everel airscrew is a novelty which lies betwixt and between, for its blade is hinged to allow various "coning" angles with associated change of incidence and so provides an automatic constant-speed effect without direct control.

Adequate rotor control has become the modern criterion. Sheer thrust, or lift, once the main problem, has dwindled in importance compared with problems of stability and control of lifting blades in a rotor. There are four outstanding examples of rotative wing aircraft in Europe to-day which illustrate the latest phase of progress. They are all experimental and only one or two exist in each case. Between them they provide evidence that practical types will be developed and that an old ideal will be fully realized.

A brief survey of the curious progress of rotative wing development may assist a better understanding of the present position. For the aeroplane was actually the last proposal for obtaining artificial flight. Flapping wings were the first approach until it was realized that lift was difficult to obtain by such means. Aerial screws were next considered, incidentally, long before marine screws were thought of. As early as A.D. 1500 Leonardo da Vinci experimented with paper screws, and a sketch has been found in his notebooks of an aerial screw machine with a diameter of ninety-six feet, to be built of iron and bamboo framework, covered with linen cloth, thoroughly starched. A less scientific description exists of what, in about 1760, a learned French mathematician called a pterophore, with two screws, one to lift and the other to propel: a man was to be seated in a chair attached to the apparatus to provide the necessary power to rotate these screws, through gearing. This may or may not have been a vision of something analogous to modern autorotative aircraft, but there do exist aeroplanes at the present time in Germany in which the airscrew is driven by man-power through some form of geared mechanism. The first known model with aerial screws was exhibited before the French Academy of Sciences in 1784. From that time onward there were numberless further proposals and experiments, many quite fantastic, but others based on a genuine spirit of research. Many great names find mention in the old records.

Finally, flight was achieved with the aeroplane. In the face of this reality it was obvious that the long tradition of somewhat futile academic investigation should be broken, but a few serious experimenters still believed in the possibilities of lift independent of forward speed. Results, unfortunately, were unconvincing, but there were scientists in the early years of this century who had progressed far beyond the simple screw and had arrived at the idea of articulated vanes as well as the practical distinction between powered rotation and autorotation. They recognized that each presents merely a limiting aspect of the same fundamental problem. Even the principle of control by altering the plane of rotation due to tilting of the

hub had been proposed.

Something of this is at the root of all the rotative wing success that came later, after the Great War had established the aeroplane in modern life through intensive effort and the expenditure of unlimited money for well-defined requirements. The late Señor de la Cierva had the courage and ability to make a magnificent simplification and to break away from the unreality of an old and long tradition. His autogiro was the first practical rotative wing aircraft in history. He did not concern himself with solving problems of stability and control of lifting vanes turned by enginepower, but mounted a freely rotating rotor on a modified aeroplane at such an angle that, given initial revolutions, it would "windmill" and keep on turning when towed through the air, and so provide a lifting system equivalent to the aeroplane wing. A minimum amount of normal aeroplane structure was retained for orthodox control. Since a rotor would revolve equally with the relative airflow when sinking as when drawn forward by a propeller, a measure of lift remained independent of forward speed. Thus after an engine failure it was possible to parachute to earth in safety. Practical requirements reintroduced the idea of driving a rotor by enginepower, if only to give the necessary initial revolutions. A drive from the engine turning the airscrew was adopted and was used up to the moment of the procedure for take-off, which was then the same as for an aeroplane.

The "wingless" Autogiro came next when practical means to alter the plane of rotor rotation were evolved. Auxiliary plane surfaces were abandoned since direct control with "the hanging stick" was sufficient for every flying manœuvre. This method was standardized in the famous C.30 Autogiro, known in the Service as the Rota. Direct control must not be confused with lift control, which came later and which accounts for the more spectacular rotative wing successes of to-day. Lift control varies the amount of lift or thrust; control of the plane of rotation alters the direction of thrust. A gyroplane (such as the autogiro) is balanced between the thrust of the rotor and airscrew thrust, which intersect at the centre of gravity. Changes of throttle position and control movements give rise in flight to a pendulum effect of fuselage relative to rotor which feels quite different from normal aeroplane movements with respect to C.G. This hint of differing principles may help to explain something of the experienced pilot's lack of enthusiasm for gyroplanes. The safety of depending upon a continuously running bearing had been proved by thousands of hours in the air, but there was a feeling that the advantages of rotative wing aircraft did not compensate for their disadvantages. Their advantages in-

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cluded non-stalling and ultra-slow landing properties, and simple control. On the other hand, take-off was not invariably short and there were moments of instability, especially in high, squally wind, just at the take-off and immediately after landing; useful load and speed were less than in the equivalent aeroplane. Gyroplanes demanded, and did not always receive, more precise handling, based upon adequate experience in varying wind conditions. This is worthy of mention before dealing with the latest phase of development which has removed nearly all the old disadvantages because a measure of success was nevertheless achieved which did not secure the

recognition it deserved.

Coming, then, to the present situation, the most important achievement is lift control. This has introduced the possibility of direct take-off, known as "the impulsive helicopter start." It has also made possible the removal of lift and therefore of instability under certain conditions. Before his tragic death, Señor de la Cierva saw his "jumping" autogiro give the first public demonstration of the new effect. There were, however, other investigators in the field at this stage of development. New methods and refinements became current. Helicopter experiments had been continuously taking place without marked progress, but there were indications of coming success; on the whole, there was relief in many minds that the gyroplane could, at last, do all that was really necessary so that helicopters could remain a pious wish. While work was proceeding with the autodynamic autogiros (Cierva and Weir types), the Hafner A.R.III helped to complete the picture with its thoroughly convincing "towering" take-off and its unusual controllability in the air. Only a few experts realized that gyroplanes and helicopters were really coming much closer together.

Interest now centres, in fact, on the remarkable Focke-Achgelis helicopter which, in recent months, has astonished the general public and experts alike with indoor demonstrations, hovering and backward flight, excellent controllability and straightforward construction. It consists of a nearly normal fuselage with a 160-h.p. engine in the nose, provided with a fan for cooling purposes only: the engine drives two horizontal rotors mounted on outboard pylons which produce both lift and forward or backward movement of the aircraft according to their attitude: the rotors revolve in opposite directions to cancel out torque. Full details of the method of control are not available, but it is probable that the pitch of the rotor is controlled by the amount of torque transmitted to it and that there is some independent means of tilting the rotors fore and aft, together or differentially. There is provision for autorotation, but it is uncertain whether its control is then so efficient. With driven rotors, control appears both accurate and sensitive. Records put up to the Fédération Aéronautique Internationale include: height, about 8,000 feet; endurance, one hour and twenty minutes; speed, over more than ten miles, 81 m.p.h.; distance, direct, about 10 miles, and in a closed circuit nearly 60 miles. Professor Focke's previous association with the Focke-Wulf Company of Bremen is well known, and his intervention and achievement with rotative wings have had a profound effect.

The records set up by the Breguet-Dorand helicopter, not long before, were quite eclipsed. These included: height, about 500 feet; endurance, about one hour; speed, about 40 m.p.h.; distance, in a closed circuit, about 30 miles. This strange machine weighs about two tons and is powered by a 360-h.p. Hispano engine. Two two-blade rotors, rotating coaxially in opposite senses, cancel out torque. The blades are relatively stiff and are provided with an articulation near the mid-length to relieve bending stresses, but difficulties appear to have arisen due to one blade cutting the other in half as they passed each other in banked turns. The mechanical complications of the control and drive appear to be considerable, but this performance is important. Mr. Breguet is also well known as a successful designer and manufacturer of aeroplanes, but he was working on helicopters as long ago as 1903. His return to this research is, therefore, significant. He has lectured about the problems of a very large transatlantic passenger-carrying helicopter having two coaxial three-blade rotors driven by four engines totalling 3,600 h.p. He prophesies speeds of over 300 m.p.h.

The autodynamic principle of lift control as demonstrated in recent autogiros is based on an inclined drag-hinge arrangement of the blades whereby negative angles are produced by application of torque; when torque is removed the angles become positive and so do not exceed a setting suitable for autorotation. Apart from refinements, the tilting control re-

mains much as before.

The Hafner Gyroplane is an experimental aircraft designed to demonstrate a system of rotor construction and control developed out of original research with single-rotor helicopters. The A.R.III, Mk. II, weighs 900 lb. and is powered by an 84-h.p. Pobjoy Niagara III engine; it is a single-seater with a speed range of 12 to 120 m.p.h., rate of climb of 1,100 feet a minute, direct take-off and landing (no run); it can describe a circle in flight of 40 feet radius and can remain stationary in the air in a ten-mile-an-hour wind. "No flying machine ever built, aeroplane or autogiro, is so manœuvrable as the Hafner Gyroplane, for in effect the whole of the sustaining member is also control surface, infinitely and instantly responsive" (Major C. C. Turner, aviation correspondent, Daily Telegraph, London, 14th May, 1937).

In most autorotative types some form of blade articulation has been used to allow the blades to flap and thus stabilize the rotor by balancing out unequal lifts. This has presented certain problems, since heavy centrifugal loads introduced friction into the joints and considerable leverage was necessary to move the hub against this friction. It was realized that if the blades could be "feathered," their angle might be reduced during the initial spinning of the rotor, in order to reach higher revolutions than those required for normal flight. The energy so stored could be converted into lift by increasing the angle of the blades. This would enable the machine to take off without running along the ground. High centrifugal loads, however, combined with small angular movements, made "feathering" impracticable for any form of thrust bearing.

In the Hafner system, centrifugal loads are taken from the blade to the

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hub by an internal steel tie rod which is sufficiently flexible to twist for "feathering" and acts as a spring to return the blade to its normal setting. This enables the rotor to be mounted on a rigid axle, thus eliminating the complications and heavy control load involved in tilting, since the "feathering" of the blades may be used not only to permit the energy-assisted take-off, but also for controlling the plane of rotation in flight. To achieve this, the angular settings of the three blades are controlled by levers at their roots. These levers are ball-jointed to a three-armed spider mounted on a spindle in the centre of the hub. When this spindle is tilted by the control column it pushes the levers down on one side, reducing blade angle, and raises them on the other, increasing blade angle. Thus the plane of rotation is varied and the aircraft banks, dives, or climbs accordingly. Another control, the lift lever, is used to raise or lower this same spindle, to alter the blade angles equally. Lift can thus be introduced, varied or removed at will, for direct take-offs, during flight (to suit varying conditions and speeds of flight), and on landing. In addition to controlling the blades in this way, the spider and levers also stabilize them individually in their rotary path. This limits the range of "flap," required to balance out the changes in lift as they revolve, and causes them to fly at the best angle to the airflow. The special blade construction employed, which is stiff at the root to resist bending when the blades are at rest, yet is thin and flexible over the outer portion, permitting a narrow chord relative to its length, enables a larger diameter of rotor to be used for a given size of aircraft than is possible by conventional methods. The Hafner system thus provides, in combination, a rotor with greatly improved flying characteristics and an accurate and sensitive control.

Thus, the world to-day possesses direct take-off gyroplanes and helicopters. The arrival of a practical helicopter does not, however, detract from the importance of gyroplanes. Every helicopter must function as a gyroplane if there is engine failure or when throttled back, and it must also be controllable in this condition. It is not clear that controlled autorotation is highly developed in existing helicopters. With reference to future possibilities, any twin-rotor helicopter would seem to suffer from disadvantages such as high drag and rotor diameters, for given gross weights, being limited by constructional considerations. The logical ideal is the singlerotor helicopter; a general absence of drag and the forward attitude of a single horizontal screw suggest great possibilities for aerodynamic efficiency of a high order; the advantages of vertical ascent and descent are retained and the construction can be amphibian where this involves difficulties with gyroplanes; such helicopters would be comparatively silent. This type will obviously develop from gyroplanes. Of the two mentioned here, the rigid axle in the Hafner system enables the entire control method to be considered power-driven rotors and, indeed, was developed on those lines.

Certain standard types should develop now from all this experimental success. Based on results with the Hafner system it is clear that gyroplanes should be satisfactory at least up to 3,000 lb. gross weight (with rotor diameters of about 50 feet): these would have a speed range of 20 to 120 m.p.h., endurance of three hours, direct take-off and landing performance;

control exact and sensitive over the whole range; ceiling, about 15,000 feet. A civil cabin type seating two (130 h.p.) and a Service three-four-seater (350 h.p.) for observation purposes, ambulance work and the like, are in an advanced stage of design. The latter can be modified for civil requirements, crop spraying and forest patrol particularly, and would also provide a suitable aerial taxi able to link airports with cities and similar work that no aeroplane can cope with. But the single-rotor helicopter is the aero-dynamic ideal. For similar gross weights it should prove more efficient for its power than any other aircraft, all of which represent a combination of two efficiencies, that of power transmission and that of lifting means, whether kite, gasbag or windmill. It may well prove more simple in construction than the gyroplane. Speeds of 200 m.p.h. and a very high rate of climb are reasonable expectations.

From a Service point of view there can be no doubt that, in one form or another, rotative wing aircraft will become a recognized type in general use. Where aerodromes are not necessary and even surface conditions do not greatly matter, naval and military co-operation takes on a new aspect and slow flying requires no special care. Deck landings will be possible on warships. Communication of many kinds, as with fast-moving tank battalions, scattered outposts in hilly country, provision of supplies by night to isolated picquets, control of operations by first-hand staff observation—there are numberless possibilities of great technical interest. Entire dependence on ground organization will be a thing of the past for such aircraft.

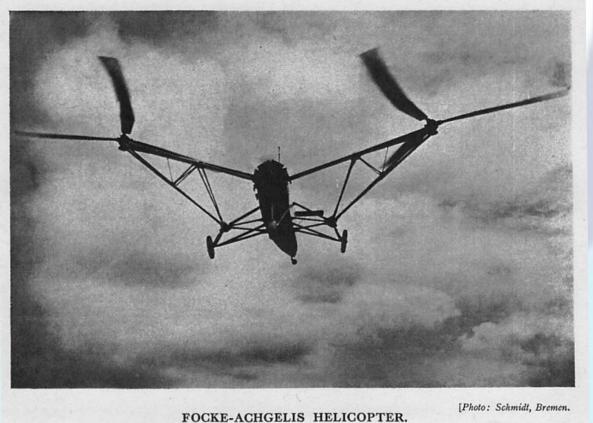
Many fixed-wing pilots confess to a feeling of insecurity with rotating wings, but every time a direct take-off gyroplane is given full over-revolutions on the ground it is being stressed more highly than in normal flight. In flight bumps and gusts only have the effect of increasing the lift of a blade, which flaps up until this lift is balanced by the centrifugal forces. This gives an increase of resultant stress in the spar only proportional to the size of the angle of increased flap—a condition far less severe than that occurring in a fixed wing, where the increase in stress is proportional to the actual acceleration, which may reach a value of several times G. The rotor damps out the effects of gusts within itself and the actual accelerations experienced by the fuselage and pilot are much less than those in fixed-wing machines. This effect, common to all rotors with flapping blades, is the more marked in the Hafner rotor because of the action of the control linkage in limiting the angles of flap. So much for the blades. As for the question of depending on a continuously running bearing, which appears to worry most critics-how many motorists worry over the possible unreliability of a front-wheel bearing? Yet these operate under much more severe conditions, and are more likely to suffer from neglect.

Remember again the original conception of the lifting screw and consider that the modern rotor has reached a definite stage of its development which provides stability and control under all conditions of flight. All present types of rotative wing aircraft are experimental. It only requires well co-ordinated effort to produce something sound and valuable in the very near future.

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[Photo: By courtesy of "Flight." HAFNER GYROPLANE, A.R. III. Mk. II.

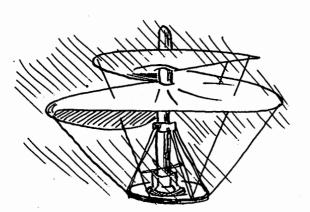


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WORLD THE IN UP GOING

Five decades ago people laughed at the "maniacs" who foresaw heavier-than-air flying machines. How loud the laughter must have been when Leonardo da Vinci suggested the helicopter — nearly five centuries ago! But nothing could have been more serious or carefully planned than Da Vinci's corkscrew helicopter. In his own words:—



"I say, that if this instrument made with a helix is well made, that is to say, of flaxen linen, of which one has closed the pores with starch, and is turned will great speed, the said helix is able to make a screw in the air, and to climb high

Unfortunately this machine was never constructed, let alone test flown. In fact, it was not until early in the 20th century that the Frenchman, Bregnet, managed to get off the ground in a helicopter he had designed himself. In Demnark Ellehammer produced the next successful 'screw-plane' as they were then called. Unhappily, both these gentlemen met so many difficulties, and so little encouragement, that they gave up their ideas for the time being.

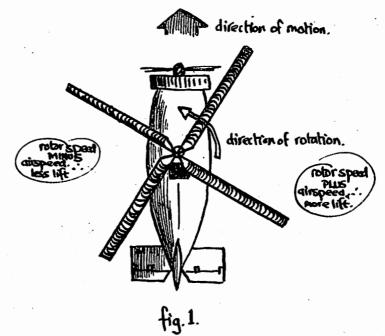
At about the same time Sikorsky — a Russian — was having moderate success. It was not until he fled the Russian Revolution and went to the U.S.A. that his ideas were fully developed. De Bothezat, one of Sikorsky's countrymen, also emigrated to the U.S.A. and continued his helicopter research. De Bothezat produced a monster machine, capable of lifting four men clear of the ground. Spain also offered her contribution in the form of Juan de la Cierva's autogiros which had considerable success and were built in conjunction with a British firm.

Of all these aspiring designers it was Sikorsky who finally designed and produced the first practical helicopter. For the first time he showed the world a machine that took off and landed straight up and down, hovered, and flew forwards and backwards. This was a great breakthrough and very deservedly, Sikorsky gained the first helicopter pilot's licence. The evolution of the helicopter followed quite naturally to give the high performance craft of today.

Basically there are two approaches to the problem of rotary wing aeroplanes. The first, and most usual, is to use an engine to turn the rotors. This provides lift, and by tilting this lift vector there is a component for propulsion. In this case the gyroscopic effect, (making the machine revolve), must be counteracted by either (a) using a counter rotating rotor or (b) using a tail rotor. The second approach is rather unorthodox, but nevertheless, equally valid. This

approach involves a free rotor to provide lift, with an engine to provide direct propulsion. The forward speed of the machine 'windmills' the rotor which creates the required lift force.

The first approach has been followed resulting in the conventional helicopter. And now, after a long period of stagnation, the autogyro principle is at last being applied to a practical craft. At first sight it might appear that an autogyro simply means making a rotor which will

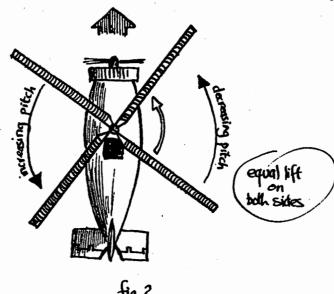


windmill freely, mounting it on some frame with means of forward propulsion and hey ho—off into the wild blue yonder. Not so!—

A fixed rotor would give more lift on one side than the other (Fig. 1), which would result in a wallowing flight path. The obvious answer to this problem is to decrease the lift produced on the forward going rotor blades, or to increase the lift on the rear going blades. To do this a change of the pitch of the blades is necessary as they rotate.

This variation of pitch could for example, be as much as 3° to 18°. It is possible to construct the rotor head in such a way that the rotor blades will automatically adopt the correct angle of

pitch to provide lift forces that are in equilibrium. In this case, where there would be no positive pitch control on the rotor blades, the craft would have to have small ailerons to provide lateral control. However, the problems do not end here and provision still has to be made for the stresses that the rotors must withstand. The effects of these stresses are illustrated in Fig. 3.

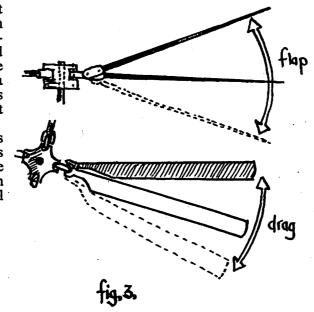


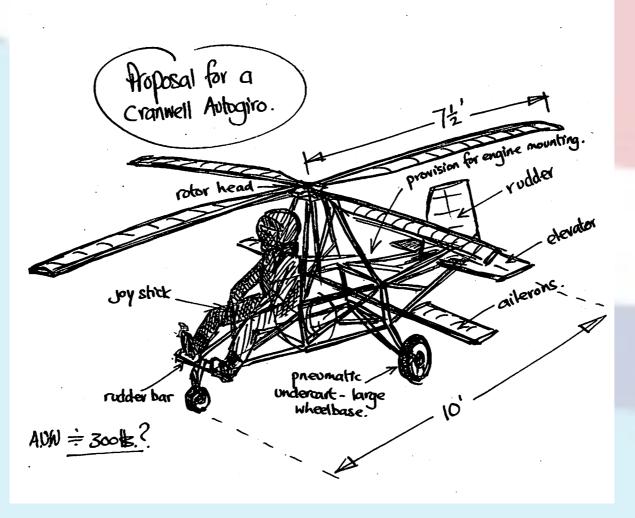
To understand fully this concept of aeroplane it must be remembered that the rotor replaces the normal fixed wing. Therefore, because the autogiro needs very little forward speed to maintain lift from the rotors, this machine can hover at virtually zero forward speed. A 'glider' version could quite easily be constructed. This craft would incorporate a free rotor and simple elevator, aileron and rudder controls. Tubular steel construction, canvas covered and wooden rotor blades would be adequate. By towing the 'glider' autogiro behind a car, sufficient speed could be reached to lift the machine high when

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it could cast off and manoeuvre until it sank back to earth. Once the rotor system had been proved, it would be comparatively simple to mount an engine behind the pilot with a pusher-prop to give the craft its own propulsive power. Whether a glider or powered version, the autogiro is controlled in the same way as an aircraft with fixed wings.

There are obvious refinements to this basic outline design—such things as collective pitch control to replace the ailerons—but there is plenty of scope in the crude craft for an aspiring aeronautical engineer.





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THE LAWS OF AIR WARFARE TO-DAY

By J. M. Spaight, C.B., C.B.E., LL.D.

The laws of war are assuagements imposed by custom or agreement upon warlike violence or the arbitrary acts of belligerents. They are not laws in the same strict sense as the laws of the realm. The latter are commands enjoined by a supreme authority, the State, which is in a position to enforce them by sanctions or punishments. The laws of war are not enjoined or enforced by any corresponding superior authority. Observance of them depends on the conscience, humanity and honour of the belligerents themselves, on their regard for their reputation in the eyes of neutral nations, and on the fear of retaliation by the enemy if they are infringed. They are in some degree more akin to the rules of a game than to laws in the usual sense. Nevertheless, they are in general recognized and observed, as history shows. The fact that they are sometimes broken does not disprove their existence. National laws are often broken too.

The laws of war, whether they relate to the sea, the land or the air, are derived from two different sources. They rest either on international convention or on the accepted practice of belligerents and neutrals. The laws of naval and land war are to be found mainly in The Hague Conventions of 1907, but they are to be sought also to some degree in usage and practice. For instance, it is a rule of naval warfare that a warship may sail under false colours, but must display her national flag before she fires the first shot in an action. This rule does not appear in any convention, but is one which is generally recognized. The laws of air warfare are made up almost altogether of usages of this kind. There is little as yet of rules deriving their authority from convention or agreement.

When The Hague Conference of 1907 met, human flight was in its infancy. The Wrights had succeeded in making some long hops in the air, but the aeroplane, a flimsy contraption then, was looked upon as a toy or, alternatively, as a dangerous freak. It was not taken very seriously. When, almost two years later, Louis Blériot made his famous Channel crossing, men began for the first time to think that there might be a future for the new invention. It is hardly surprising that the legislation of 1907, which is the main source of the laws of land and naval war, hardly dealt at all with the air.

One of the provisions betrays, indeed, in its title the undeveloped state of aviation at that time. This is the Declaration "prohibiting the discharge of projectiles and explosives from balloons or by other new means of a similar nature." The term "aircraft" had not yet been brought into use in 1907. The Declaration is wide enough in its terms to cover air bombardment of any kind. It was expressed to be operative until the close of the Third Peace Conference, which was to have assembled in 1915, but did not do so, the Great War then being in progress. It is still binding, therefore, upon the States which signed and ratified it, but these are only a

handful and include only two great Powers—Great Britain and the United States. It would be binding on these Powers, moreover, only if no non-contracting Power joined in the war. This proviso and the fact of still greater importance that a war between ourselves and the United States is the most improbable of all wars, deprive the Declaration of all real value to-day.

Another provision of The Hague legislation which concerns the air is that contained in Article 25 of the Rules for Land Warfare, signed on behalf of practically all civilized States in 1907. This Article prohibits "the attack or bombardment by any means whatever of undefended towns, villages, dwellings, or buildings." The words "by any means whatever" were inserted in order that attack or bombardment from the air should be included in the prohibition. A Convention on Naval Bombardment was signed also in 1907 and contains a provision practically identical with that in Article 25, but omits the words "by any means whatever." The reason was, no doubt, that the probability of balloons or other aircraft operating with fleets was considered remote at that time. The omission is, however, of not much practical importance. The naval rule prohibiting the bombardment of undefended towns, etc., must be held to apply to aircraft operating with a naval bombarding force. Otherwise the naval commander could send his aircraft to destroy an undefended place though he could not use his guns for this purpose; and this would clearly make the prohibition valueless.

The existing conventional law of air warfare is thus, it will be seen, distinctly scrappy. An attempt to give it more substance was made in 1922-23. A Commission of Jurists met at The Hague in that winter and drew up a code of rules for air war. The States which were represented were six in number—the United States, Great Britain, France, Italy, Japan and the Netherlands. The code which they drafted covered every branch of the law of the air in war, both as affecting belligerents inter se and belligerents vis-à-vis neutrals. There was, however, one lacuna: there is no article in the draft code relating to air operations against sea-borne commerce. The delegates were unable to agree upon an article for this purpose.

The code which they drew up has never been embodied in an international Convention, that is to say, it has not been given the stamp of official authority by the States which were represented at the meeting. It remains an unofficial set of rules but one, nevertheless, which is entitled to respect as representing the agreed views of a number of distinguished international jurists upon the laws which should govern air warfare. The importance attached to it is shown by a recent incident in the Far East.

On 24th August, 1938, a Chinese air liner was sighted by a Japanese naval squadron when the liner was on its way from Hong Kong to Wuchow. The air liner tried to hide in the clouds and the Japanese aircraft followed it, fired upon it and forced it to come down in the estuary of the Canton River. Of the seventeen occupants of the air liner, fourteen lost their lives. The pilot, who escaped, was an American named Woods, and

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the United States Government protested at Tokyo against the action of the Japanese air squadron. The Foreign Office at Tokyo tried to justify it by referring to the draft rules of 1923. These rules, it stated, had been observed by the Japanese forces since the beginning of hostilities. It is evident that Japan, at least, regards them as having the force of international law in the absence of any Convention.

It is true that Japan seems in some respects to have honoured the rules rather in the breach than in the observance. In the air bombardments of Chinese cities the prohibition laid down in 1923 cannot be said to have been scrupulously respected. That, however, has probably been due in some measure to the practical difficulty of applying the rules relating to bombardment. The rules allow bombardment only when it is directed at "a military objective," and then proceed to define a military objective as follows:—

"Military forces; military works; military establishments or depots; factories constituting important and well-known centres engaged in the manufacture of arms, munitions or distinctively military supplies; lines of communication or transportation used for military purposes."

Such objectives, it is laid down, may not be bombarded if they are situated in a city or town not in the immediate neighbourhood of the operations of land forces and if attack upon them would involve the indiscriminate bombardment of the civil population. The effect of this rule is clearly to place upon the officer in command of the bombing force a most unenviable burden of discretionary decision. He has to decide whether it is possible to bomb the objective without causing indiscriminate damage in the town, and this, from a height of perhaps 20,000 feet, will often be exceedingly difficult to judge. Naturally mistakes must occur now and then, and mistakes mean tragedies on the ground below.

Both in China and in Spain the rule of the military objective has at least nominally been observed. In the autumn of the year 1937 the British, French and American Governments addressed to Japan notes protesting against some of the air bombardments then being carried out. The Japanese Government's reply was that its airmen invariably aimed only at military objectives. A similar reply was given by the Nationalist authorities in Spain to British protests addressed to them. In both instances it is obvious that the rule, even if it is assumed to have been intended to be observed, has not availed to prevent terrible calamities to non-combatants and their property. In Spain, especially, there has been something approaching "frightfulness" in the air.

Some of the facts are disputed, it is true. When the little Basque town of Guernica was bombed by German aircraft on 26th April, 1937, and—post hoc or propter hoc—almost destroyed by fire, the Nationalists claimed that the destruction was due to incendiarism by the Basques and Asturians. Beyond question there was a very damaging bombardment, but the possibility cannot be excluded that there may have been some incendiarism as well. About Granollers, which was bombed on 31st May, 1938, there can



SQUADRON LEADER W. W. S.

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be no doubt; the town was visited by a British diplomatic official, Mr. J. H. Leche, a few days after the attack and his report made it clear that the incident was one of the deliberate bombardment of the civilian quarters.

Many of the numerous bombardments of Barcelona, notably those of March, 1938, were clearly indiscriminate. Others were also open to condemnation in so far as, though directed, apparently, at military objectives, the bombing was so carelessly carried out that the sole sufferers were innocent civilians, including women and children. In the summer of 1938 the British Government sent two retired officers, Group Captain R. Smyth-Pigott and Lieutenant-Colonel F. B. Lejeune, to Toulouse, to hold themselves in readiness to proceed to Spain at the request of either belligerent party for the purpose of reporting upon any instance of illegitimate bombardment that might be alleged. This commission (of two) issued its first report on 1st September, 1938; it dealt with forty-six raids on Alicante and six on other towns in Republican Spain. Of the raids on Alicante the commission found that forty-one were directed at the port area or the railway station, which could be regarded as legitimate objectives; the remainder were either deliberately directed at civilian quarters or were tantamount in results to raids so directed. The commission also condemned raids on Sitjes and Torraviega as deliberate attacks on the civil populations, and that, too, was in effect their verdict upon the raid at Tarragona on 7th November. Their severest condemnation was reserved, however, for the attack on Barcelona on 24th December. They investigated the raid on the day after it took place and in their report, issued on 5th January, 1939, they stated that "all the evidence in their possession indicates a deliberate attack on human life with bombs designed for that purpose, at a moment when the streets might be expected to be more than usually crowded, in a part of the city where civilians, since March, 1938, deemed themselves to be immune." About sixty bombs, of small size and suitable for attack on personnel rather than buildings, were dropped, they stated, in the centre of the city.

It is clear from the reports in general that the Nationalist airmen, with their Italian and German auxiliaries, have allowed themselves a wide latitude in interpreting the rule of the military objective. The Nationalists on their side have charged the Republican airmen with bombing civilian areas also, but have made no request for investigation by the British commission.

Another of the rules contained in the draft code of 1923 has also been set aside not infrequently in the Spanish operations. This is the rule which prohibits attack upon an occupant of a disabled aircraft when he tries to

escape by parachute.

In an article on "The Rôle of Aircraft in the Spanish Civil War," in the Journal of the R.U.S.I. for August, 1938, Capitaine Didier Poulain, French Army Aviation Reserve, referring to air combats, writes: "The aeroplane itself may be brought down; but even so the pilot—as a rule untouched—can make use of his parachute. In Spain, however, that gives rise to rather horrible possibilities, since on many occasions aviators descending under their silken buoy have been pursued and machine-gunned down to the earth, so that finally only a corpse lands and is blown along by

the wind." Similar instances of attack upon escaping parachutists are recorded by Oloff de Wet in "Cardboard Crucifix."

In one respect the air fighting in Spain has shown an improvement upon the Abyssinian record. There has been no use of gas. In Abyssinia the Italian airmen sprayed mustard gas in great quantities in the rear of the Abyssinian armies; they did not use it in the actual engagements, where it might have endangered their own troops when contaminated ground was captured. The employment of gas was a contravention of the Gas Protocol which was signed at Geneva in 1925 and to which nearly all States, includ-

ing both Italy and Abyssinia, became parties.

It has already been mentioned that the Commission of Jurists were unable to agree upon a rule to govern aircraft operations against merchant shipping. They stated, however, in their report that there was no difference of opinion among them about the need for rules which would assure the observance of the dictates of humanity as regards the protection of the lives of neutrals and non-combatants at sea. The disagreement related only to the best means of achieving this end. There was a divergence of view as to whether aircraft should be empowered to divert a merchant vessel from her route by order signalled from the air, so that her cargo could be examined in the port to which she was directed to go, or whether the aircraft must first alight near the ship and carry out "visit and search" on the spot. Although no rule upon the subject was included in the draft code of 1923, it cannot be doubted that the commission would have condemned air attack without warning upon a merchant vessel, enemy or neutral, and instances of such unlawful attack have, unfortunately, occurred in the present Spanish war on numerous occasions. The need for a clear rule upon this point, agreed to by all maritime States, is evident from recent occurrences in the Mediterranean.

There have also been air attacks upon merchant vessels in port. Such attacks must be considered illegitimate when deliberately directed against the ships themselves, but the position is different when the damages which a ship suffers are not intentional but the incidental result of an attack upon the harbour or pier where she is lying. There is no Convention dealing with air bombardment in such circumstances, but there is one dealing with naval bombardment. Under this Convention-No. IX of The Hague, 1907 -it is permissible to destroy by gun fire certain specified objectives even in an undefended port if, after due notice, the inhabitants have not themselves destroyed the objectives. The objectives include "workshops or plant which could be utilized for the needs of the hostile army or fleet," and the actual harbour works-dock gates, piers, cranes, etc.-would come within these terms if they are used for the unloading of military supplies. By analogy, and in the absence of any specific rule governing air bombardment, the same rule could reasonably be held to apply to air attack upon a port. So, too, the naval rule which absolves the commander of the bombarding force from responsibility for damage inflicted without intention in the vicinity of the objective aimed at could be regarded as applicable also to air bombardment. This view has been accepted, it seems, by our Govern-

Spring 1939 - Laws of Air Warfare (4)

ment. Speaking in the House of Commons on 23rd June, 1938, Mr. Chamberlain said: "The British Government has always made a distinction between attacks on British ships which might be called accidental inasmuch as the ships were close to some objective, and that a hostile aeroplane aiming at that military objective might unwillingly involve a British ship in the attack. We have made a distinction between that kind of attack and an attack which was deliberately aimed at a British vessel." When the attack upon the ship was deliberate, said Mr. R. A. Butler, Under-Secretary for Foreign Affairs, in the House on 3rd June, we protested to the Burgos authorities, but not otherwise.

In one respect the present Spanish war has been a model of what ought not to be done in an international conflict. The law of neutrality has been set at defiance. One of the most unquestioned principles of that law has long been that neutral Governments must abstain from lending active support to either side. They are not obliged to prevent their citizens from trading with the belligerents, even in the supply of munitions, but they must not themselves furnish aid either in personnel or matériel to the States at war. This rule has been openly violated in Spain. Italian troops have been drafted in whole regiments to Insurgent Spain, German technicians have been sent there with official cognisance, and military equipment has been supplied by both these countries under arrangements which were obviously facilitated by the authorities. The Russian munitions which have reached the Republicans must equally have been dispatched with the Soviet Government's assistance. In regard to the supply of aircraft the disregard for accepted usage has been particularly flagrant. There has been the material for dozens of "Alabama claims" in what has been done in the past two and a half years.

The Alabama left Laird's shipyard at Birkenhead in July, 1862; she was wholly unarmed and without a fighting crew; she took her crew and armaments on board partly off the Welsh coast, partly in the Azores, and ran up the flag of the Confederate States. For two years she preyed upon Federal commerce until she was brought to action and sunk by the Federal frigate Kearsarge off Cherbourg on 19th June, 1864. For allowing her and two other ships to depart from British waters our Government was condemned at the Geneva Arbitration to pay the United States the sum of fifteen and a half million dollars. Bearing that incident in mind, the Commission of Jurists included in their draft code of 1923 a rule obliging a neutral Government to use the means at its disposal to prevent the departure of an aircraft in a condition to make a hostile attack against a belligerent Power, or carrying or accompanied by appliances or materials the mounting of which would enable it to make such an attack.

This (draft) rule has been infringed again and again in the Spanish war. Junker and Heinkel bombers have been sent under their own power from Germany, and Savoia and Caproni bombers from Italy, to the Insurgent forces; Potez and Bloch bombers have occasionally been sent similarly to the Republicans. The Italian bombers really operate in many instances from bases in Italy. They call at Majorca for fresh fuel and for bombs on

their way to raid Spanish coastal towns in the course of a round journey which starts and ends in Italy. Clearly the Republican Government would have ground for claiming heavy compensation from Italy if it were not itself to some extent open to the charge of having received similar assistance.

Some good at least may come out of the grim tragedy of the Spanish Civil War if it brings home to all nations the need for agreed rules upon a number of unsettled questions of international law. One lesson is the urgent necessity for the regulation of air bombardment. It was, no doubt, as the result of the experience gained in Spain that Captain Euan Wallace submitted some proposals upon the subject to a League of Nations committee at Geneva in September last. He proposed that the codification of aerial warfare should be undertaken along the following lines:—

Aerial bombardment of civilians should be declared illegal.
 The objects of air attack should be capable of being identified.

3. It should be laid down that any attack on definite objects must be carried out in such a manner as to avoid the accidental bombardment of the

civilian population in the neighbourhood.

Agreement would also be necessary, he suggested, in regard to the nature of military objectives. This, indeed, is essential if the rule is to be of any utility. It should be decided, *inter alia*, whether electricity plants, gasworks, water reservoirs and other public utility installations which serve the needs of cities and are only to a minor extent utilized in connection with armament work, are military objectives. Even then, it is a question whether Captain Wallace's proposals go far enough. Some more drastic settlement of the question may be found to be necessary if the air menace is not to remain as a sword of Damocles suspended over every capital and other great city of Western Europe.

If you are wise, you, too, will fly over here. Did you but know the blessings of Britain, you would clap wings to your feet, and run hither. To take one attraction out of many: there are nymphs here with divine features, so gentle and kind. Besides, there is a fashion which cannot be recommended enough. Wherever you go, you are received on all hands with kisses. . . . When a visit is paid, the first act of hospitality is a kiss, and when guests depart, the same entertainment is repeated. Whenever a meeting takes place there is kissing in abundance; in fact wherever you may turn, you are never without it. Oh, if you had once tasted how sweet and fragrant those kisses are, you would indeed wish to be a traveller, not for ten years but for your whole life in England.—Erasmus (from a letter written during his first visit to England in A.D. 1499).

-Arthur Stanley's "The Golden Road."

March 1951 - Flying in "The Good Old Days"

JOURNAL OF THE ROYAL AIR FORCE COLLEGE

JOURNAL OF THE ROYAL AIR FORCE COLLEGE

THE GOOD OLD DAYS



An interesting comparison with modern aviation is afforded by an old flying training manual published in 1918. The copy from which this article was composed belonged to a wireless telegraphist in the R.N.A.S. and is dated "Cranwell, June 4th, 1918." It contains much sound advice, and the basic principles of airmanship which it lays down have remained unchanged to the present day. Nevertheless, some things in the book appear strange, and even funny, when read today.

The author begins by outlining the qualities of a good pilot, stressing the need for fitness, enthusiasm and confidence, and suggesting some preliminary ground studies by which a pupil can prepare himself for training. He then makes the reassuring statement: "An aeroplane is a very simple type of machine compared to a car. For instance, there is practically no transmission to give trouble, no gearbox, clutch or differential to break or require daily attention. The tyre problem hardly exists on the aeroplane. A dozen control wires, generally duplicated, are the only vital parts of the machine where failure might mean an accident. Compare them with the hundreds of parts in a motor-car which may go wrong. Again, motor accidents are often due to the carelessness of the drivers themselves. In the air there is unlimited space for machines. They are not confined to certain narrow tracks and hence accidents are scarce." That was just as well, since they never used parachutes in those days.

The chapters on elementary flying and control are similar to those in any book on the subject, except that the principles of flight are a little vague. The aircraft in the diagrams are mostly Avro 504's, with long skids between the wheels. Mention is made, however, of the earlier Maurice Farman Longhorns, where the instructor leaned over the pupil's shoulder and shouted in his ear, making a grab at the controls when something went wrong. The front elevator on these machines was useful for gauging lateral level against the horizon, but apparently some pupils became so intrigued by its wagging up and down that they began to follow it, with catastrophic results. An interesting point of technique was that all landings were glide landings, with the engine switched off. Use of power was regarded as proof of misjudgment and poor flying. Instead of "taking off," the writer talks about "getting off," a subtle difference in wording which hints at the uncertainty of leaving the ground in those early machines.

The need for thorough knowledge of aeoplane engines is stressed, especially since pilots often had to land in a field and do their own running repairs on particularly unreliable types. Throughout the book, references to rotary engines appear; as they have now vanished completely from aviation a brief description of them may be of interest. All designs were highly ingenious pieces of machinery. The crankshaft was fixed to the air frame and the whole engine rotated with the propeller bolted to the crankcase. The idea was partly to improve the air cooling and partly to ensure smooth running, because they thought that the propeller alone would not have sufficient

momentum to keep turning if the engine misfired. In effect they used the engine itself as a flywheel. The 80-h.p. Gnome had no carburettor. Petrol was injected directly into the combustion chamber from the crankcase by means of a valve in the head of the piston. "The valve is caused to open by the suction in the cylinder on the intake stroke and a spring returns it to its seating when the piston ascends in the usual manner in the head of the cylinder."

Owing to their peculiar carburation, rotary engines could not be throttled back for slow running without cutting altogether. For taxi-ing and landing, the ignition was switched on and off in short bursts by means of a "blip" switch on the control column. The momentum of the engine kept it turning when it was not actually firing. Although rotary engines were generally lighter per pound per horse power than early radial and water-cooled types, they were very extravagant in oil. Centrifugal force drove it into the cylinder heads, where it burned and deposited soot on the plugs. It also leaked out of other points in the whirling mass and sprayed itself over the pilot. The piston-type oil pump caused oil to rise and fall in a little glass pulsator dome, and so the pilot could check that it was working properly. "If the gear ratio between the pump and the engine is known, it is possible to calculate the engine r.p.m. by timing the pulsations in the glass dome. In the Gnome engine the pump shaft turns at \frac{1}{4} engine speed." They could always check their calculations by looking at the tachometer.

The flight instruments described are much the same as those in a Tiger Moth. There were, of course, no gyroscopes; side-slipping and fore and aft level were shown by spirit-level devices. It may be useful to know that "the air speed indicator can be tested by blowing down the tube until the pointer shows 70 or 80 m.p.h.; the tube is then sealed by holding the tongue over it, and if there are no leaks the pointer will remain at the set mark."

The navigation chapters deal mostly with map reading, radius of action, compass swinging and so forth, without any mention of radio, which was carried only by artillery spotting machines. Full instructions are given on the preparation of a cross-country flight, including what to eat and wear, and what to take. "The pilot should see that a bag of tools, with a few spare parts, such as sparking plugs, valves, magnets contact breaker, some high-tension wire, a complete petrol pipe with unions, some insulating tape and copper wire, are securely packed away in the locker. If he is in the Service he must remember to take his Service cap with him. One last word before the pulpil takes the air. In view of possible forced landings, it is just as well to take plenty of money on the journey. This will not only make the period of waiting for relief more pleasant but will also facilitate repairs if made on the spot by local motor men or carpenters." But, above all, never forget your Service cap!

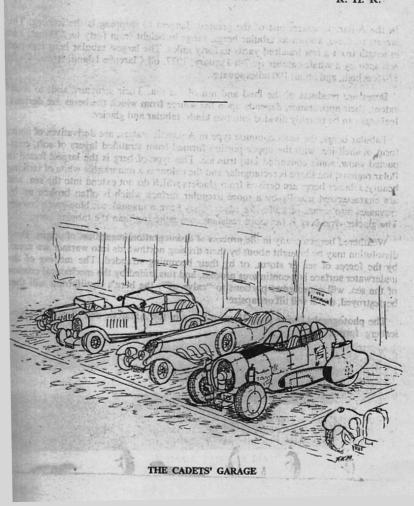
Perhaps the most interesting part of the book deals with aerobatics. "A pupil who wants to loop should select a machine that is known to loop easily, such as an Avro or B.E.2c. He should see that the machine is trued up perfectly and that all wires are correctly adjusted. It is dangerous to have anything loose in the front cockpit, and such things as cushions should be removed. He then ascends to 3,000 feet or 4,000 feet, gradually puts the nose of the machine down to a speed of 75 or 80 knots and pulls the control lever as far back as it will go, in one firm, strong pull, the effect of which is to cause the machine to rear vertically upwards and over." And round it goes. Tail-slides were apparently a recognized stunt, and spin recovery was achieved by centralizing everything. The small tail surfaces of the old biplanes are shown by the

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following extract: "A very quick method of turning is attained by switching off the engine momentarily and kicking on full rudder, and then centring it. The machine will drop most of its flying speed and turn through 90°." In all these manœuvres the gyroscopic effect of the rotary engine is most marked. To do a roll in the regulation manner "the pilot puts on speed and then pulls the stick back as in a spin, and kicks on full rudder in the same direction in which he wishes to roll."

Yes, those were the Good Old Days.

R. H. R.



March 1954 - Flying Forty Years Ago (1)

Flying Forty Years Ago

By CHRISTOPHER DRAPER, D.S.C.

We are much indebted to Mr Christopher Draper, the veteran pilot, for the reminiscences of the very earliest days of military flying which we publish below.

Mr Draper's most recent exploit will be fresh in the minds of readers. On 5th May last he flew an Auster under the 15 bridges between Waterloo and Kew, a distance of $11\frac{1}{2}$ miles.

He was born on 15th April, 1892. He secured his Royal Aero Club Certificate (No. 646) on 9th October, 1913. In January 1914 he found himself on the fifth course of the Central Flying School at Upavon, a mixed naval and military establishment of which Captain Godfrey Paine, R.N., was Commandant, Major Trenchard Assistant Commandant, and Captain J. M. Salmond one of the flying instructors. Between April 1914 and April 1918, Mr Draper was successively sub-lieutenant R.N.R., flight commander R.N.A.S., squadron commander R.N.A.S., and a major in the newly formed Royal Air Force. He is described in 'The History of British Aviation' (Vol. 2, p. 73) as 'one of the greatest pilots of Sopwith Camels in the world.' For his services he was awarded the French Croix de Guerre with Palm in 1917 and the D.S.C. in 1918. He was demobilized in April 1919.

Mr Draper saw service again in the Second World War as an officer in the R.N.V.R., reaching the rank of Lieutenant-Commander (A) in 1942. He was demobilized for the second time in September 1945.

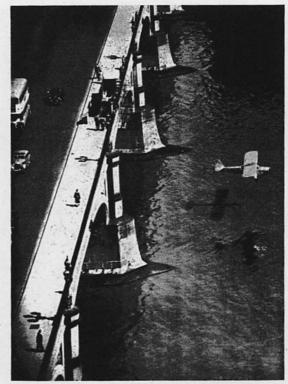
I T is just over forty years ago, in October 1913, that the Royal Aero Club granted me my certificate. In these days when the cost of everything has reached such astronomic heights, the £75 charged by all the flying schools in 1913 seems fantastic, as does the fact that it took six weeks to get in 3½ hours' flying. The reason for this latter fact was the weather. No instruction was given except in a flat calm, when little hops could be made from one corner of the aerodrome to another.

Dual control was achieved by the pupil sitting close up behind the instructor, like a pillion rider on a motor-bike, and putting his right hand on the instructor's right hand, the 'joy stick' being on the right. Dual control with the rudder was impossible. Instruction in this was given on the ground with the instructor behind keeping control of the engine to ensure that the plane did not take off.

The 50 h.p. 7-cylinder Gnôme engine was fed with petrol and pure castor oil through the hollow crankshaft into the crankcase, where centrifugal force carried it through a valve in the piston and out through an exhaust valve in the cylinder head. As there was no sump the

consumption of oil was almost greater than the consumption of petrol and it was flung out in all directions on to everyone and everything near. There was no throttle. The engine ran full speed or stop. The supply of petrol was controlled by a small tap on the left of the instructor, the flow being judged entirely by the sound of the engine. It was possible, however, to switch the engine on or off, 'blipping,' as we called it. This was the method used in landing or taxying. A pulsator glass showed that the oil pump was doing its job and was the only other engine 'instrument.'

There were only two flying instruments. One was a flat plate about three inches square connected to an arm which moved up and down a scale marked 0 to 50 m.p.h. This was fixed in the middle of the outer inter-plane strut and gave a very rough idea of the speed. The other instrument was a piece of string about 24 inches long, one end of which was secured to the trailing edge of the elevator. The elevator was mounted on two pairs of outriggers about six feet in front of the pilot's head, so that the string blew back directly in his line of sight. If it moved sideways, up or down, the pilot



The 'Fifteen Bridges' Flight: 5th May, 1953.

A view from Big Ben as Mr Draper's Auster emerges
from Westminster Bridge

knew he was not flying straight. This is the only 'instrument' I have ever met which was completely infallible.

All the instruction at the Flying School at Hendon, which I attended, was given in Boxkites, but there were only three of them. One was kept specifically for week-end flying, and one was invariably out of action for one reason or another. There was only one left then for the five or six pupils. It is not perhaps surprising that it took six weeks to accumulate 3½ hours.

The tests for the Royal Aero Club certificate consisted of five figures-of-eight within the boundaries of the aerodrome at a height of not less than 500 feet and two separate landings from the same height finishing within fifty yards of two Aero Club observers. As it was not possible to throttle down and landing had to be made by 'blipping,' it was not, in the true sense of the word, a glide without power. It was not many months after this that gliding down without using the engine was taught at all the schools and considered a true test of the abilities of a pilot.

Forty years later when I had occasion to requalify for a private pilot's licence, it was interesting to find 'power approach' now being taught, on the assumption, I suppose, that engine failure is the least worry, while in the early years it was a constant threat. While on this subject it is interesting to recall that from about 1916 until 1922 to stall a machine enough to stop the propeller dead, glide in and land by a given mark, became a useful practice. In the case of rotary engines it was possible to dive and restart the engine provided it was not left too late, but I never saw a stationary engine restarted. I need hardly add that there were no self-starters, so the manœuvre was quite thrilling, but it was not, repeat not, general practice.

A word or two about aerobatics. Looping had started before the 1914 war but was only carried out in aircraft which had been specially strengthened by extra bracing-wires. It was not until about the middle of 1915 that the machines I was flying in the Naval Air Service were considered strong enough without any modifications. These were mostly tractor biplanes of quite robust construction—anyhow looking adequately robust, for one's technical knowledge was pretty hopeless.

What we did not know and could not fathom at the time was the terrific gyroscopic effect of 80, 100 or 150 h.p. rotary engines, which required entirely different movements of the control for left and right hand rolls and spins. After the first loops carried out in fear and trembling at a completely deserted aerodrome at Montrose in 1915 (in a Bristol biplane with an 80 h.p. Gnôme rotary engine) the flying wires, as opposed to the landing wires, were so stretched that the wing tips could be moved up and down nearly six inches.



Pemberton-Billing single-seater pusher Scout with 50 h.p. Gnome engine

March 1954 - Flying Forty Years Ago (2)

About a year later rumours about spinning got around. I first saw one carried out by a Frenchman in a Nieuport biplane over an aerodrome near Paris. There was much speculation about how it was done. Everyone agreed that the first necessity was to stall. Once again trial and error was the only way to find out.

Two experiences stand out as rather unusual. The first was during the First World War and was actually the first time I flew over enemy territory, in a Sopwith $1\frac{1}{2}$ - strutter 2 - seater biplane, with a 110 h.p. Clerget rotary engine. Both landing wires were cut by bullets from an enemy aircraft after landing. And as soon as the air pressure under the wings ceased, the wings fell off.

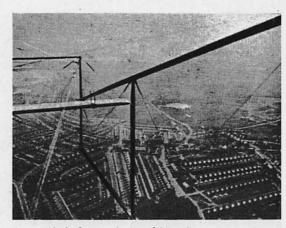
The second happened on the last day of a flying exhibition in Holland in 1919, in front of 90,000 spectators, in a tiny BAT Bantam biplane, 125 h.p. A.B.C. radial engine. Exactly at the top of a rather low loop the crankshaft broke immediately behind the propeller boss. Luckily I was in the right position to complete the loop and land in the middle of the aerodrome minus the prop. It is possible that the spectators did not realize what had happened or thought it was just part of the show. It was certainly some moments before the pilot realized what had happened: the engine nearly raced itself out of the machine. What I never understood was why the propeller came back, taking a chunk out of the top port wing.

In both these experiences youth and ignorance were a great asset, but of the two the after-effects of the first were worse.

A four-months' spell at a seaplane station on the Tay showed up some of the early struggles with underpowered seaplanes. By contrast with the days at Hendon when we could not fly if there was any wind, at Dundee we could not fly unless there was some wind. Neither the



A Caudron comes to a bad end. This batlike tractor biplane was powered by an 80 h.p.



A seemingly far from secure view of the earth from a Caudron biplane

Avro Seaplane, with a 150 h.p. Sunbeam engine, nor the Sopwith, with a 200 h.p. engine, would take off unless there was enough wind to help lift the machine on to the step of the floats. In my logbook there are many entries: 'Failed to get off.' Another headache was overheating. Tearing all over the Firth of Tay looking for 'catspaws' soon caused the watercooled engines to boil, but, once off, flying in these seaplanes over the wide open spaces of the Firth was quite the most pleasant form of flying imaginable. Also it was good fun to fly back and forth through one of the 29 arches of the Tay Bridge. (It may have been this that gave me a taste for 'bridges.')

Of the 'freaks' I came across, a quadroplane designed and built by Armstrong Whitworth at Newcastle - on - Tyne was interesting (though the designer would not like it called freak). At the time, 1916, the great cry from the pilots in the single-seater fighters in France was for visibility. Both the Germans and ourselves had introduced the triplane. This gave the same wing area but with a much reduced chord and consequently better visibility, but there was still that blind spot which caused so many casualties. Koolhoven, A.W.'s designer, thought he could go one better with the quadroplane. It had exactly the same performance as the Sopwith triplane, but being more complicated and costly to build was never adopted, though I carried out quite a number of tests with it for the Admiralty.

Another curious aircraft was a French Nieuport triplane in which the top plane had a backward stagger from the middle plane. This again was another attempt to give increased visibility. Even more curious was the fabric with which



Anxious Moment-a picture of Mr Draper taken at Broxbourne immediately before take-off on 5th May, 1953

the whole machine was covered. This was a kind of net of very fine mesh stretched tightly over wings and fuselage then doped with a transparent fluid. The idea of this was to make the machine as invisible as possible; theoretically sound, but in practice useless. The Navy had one of these machines at Dunkerque and when I was with No. 8 Naval Squadron in 1917-18 I carried out a number of tests at 1500 feet only to learn that it could be seen as easily as any other, if not more easily.

By the middle of 1917 every form of aerobatics had become commonplace, but a few of us tried hard to think up something new. One particularly naughty incident, ending up in a crash, nearly got me court-martialled. I was trying to see if it was possible to touch the water with the wheels. It was. On the second attempt, however, the water seemed to hold on to the wheels and pull the machine in. It should have turned over, but it sank right side up. My passenger and I had to wade ashore in only three or four feet of water. What was the wrong side up was my captain, who, unknown to me, had witnessed the whole affair. So I was on the mat and had to give my reasons in writing.

In conclusion, a story which emphasizes the need for cockpit drill might interest. It occurred during the last war and I was a material witness. A certain assistant flying control officer with thousands of hours' flying was persuaded to try his hand in a Hurricane, which he had never flown before. He enjoyed two or three local flights and a fortnight later he went up again. On this occasion he took a more recent machine and when it was time to lower the undercarriage he found he could not move the selector lever into the down position. The design of this lever was different, needing to be raised to pass it through the gate, whereas in the older model the lever had a fore-and-aft movement. He flew around for nearly three-quarters of an hour in a perfect sweat, realizing it meant a belly landing. It was only a practice machine for local flying and had no intercom. At the last moment, and entirely by chance, he got the lever over and the undercarriage down. Commander Flying told him later that if he had made a belly landing he would have court-martialled him. It occurred at a large and important naval air station where such an error by Commander F.'s assistant simply could not happen.

ABOUT THIS ISSUE

Readers will doubtless notice several changes in layout and typography in this issue of the 'Journal.' The Editorial Committee hopes that these changes, which have been made after exhaustive experiment and enquiry, will make the 'Journal' easier and pleasanter to read. It was the original intention of the Committee to complete the process of revision by this issue, the first of Volume XXVI, but this has not proved possible.

It will be appreciated that the Committee, in considering the problems of layout and typography, has been careful to take full account of the urgent need to make available more space for contributions of all sorts while at the same time improving production standards and reducing costs.

Supportions and constructive criticism from 'Journal' readers are welcomed by the Committee. These should be

Suggestions and constructive criticism from 'Journal' readers are welcomed by the Committee. These should be sent, in the case of officers and readers outside Cranwell, to the Managing Editor and, in the case of flight cadets and cadets, to entry representatives, a list of whose names appears at the foot of page 87 of this issue.

March 1955 - Flying Since the War

Flying Wing Since The War

It has been felt for some time that many readers of 'The Journal', particularly among Old Cranwellians, would like to learn something about the recent activities of Flying Wing. We, therefore, propose to publish annually a series of articles written by one of its officers. This first article, written by Flight Lieutenant A. B. Stinchcombe, our Old Cranwellian Editor, gives a brief account of Flying Wing's activities since 1946.

THE Flying Wing at Cranwell is responsible for the entire flying training of the flight cadets, but it is not a part of the College organization. It is, in fact, one of the three wings of Royal Air Force Cranwell. At the moment, this station exists solely because the College does, but it was not always so. In the past, numerous other units have lived at Cranwell and no doubt there will be other units in future, but always there has been, and will be, a closer liaison between the Flying Wing and the College than between the other occupants and the College.

The task of the Flying Wing is to make good pilots of the flight cadets and to continue their officer training during the time they spend at the flights. Just after the Second World War, the amount of flying done by each cadet during his stay at the College was in the region of 210 hours. As more advanced training aircraft have become available, this total has been increased first to approximately 250 hours and now to about 300 hours. It will remain much the same when the Provost/Vampire training programme becomes a reality.

When the College was reopened in 1946, the training aircraft used were the Tiger Moth and Harvard which were taken over from No. 19 Flying Training School. The Lincolnshire climate was not kind to those unfortunates flying in the open cockpit of a Tiger Moth and these were replaced by the Percival Prentice in 1948. This aircraft remained the basic training aircraft until 1952 when it was replaced by the De Havilland Chipmunk which enabled more instruction to be given during each flying detail. The latest change, to bring the College into line with the flying training schools, is to replace the Chipmunk by the Provost, a much more powerful basic trainer with a performance approximately the same as that of the Harvard. The Harvard continued to give outstanding service as an advanced trainer until 1953 when it was replaced by the Boulton Paul Balliol as an interim measure until the Vampire is introduced at Cranwell in the near future.

The new cadet, during his first two terms at Cranwell, continues to receive air experience and practical map reading instruction in the everfaithful Ansons of Headquarters flight. Until



The new and the old. The Chipmunk, basic trainer since 1952, has been replaced by



The construction of runways on the South Airfield proceeds steadily, though much remains to be done. Here, one of the machines involved in the work can be seen laying asphalt

recently a Meteor 7 was established at Cranwell to give the senior entry a little jet experience before leaving. This has been replaced by a Vampire T11.

The Wing Commander Flying is also the Chief Flying Instructor. The present holder of these offices is Wing Commander I. N. MacDougall, D.F.C., an ex-cadet. His immediate predecessor was Wing Commander, now Group Captain, D. Peveler, D.S.O., D.F.C., and before him was another ex-cadet, Wing Commander S. B. Grant, D.F.C. Until Wing Commander Grant arrived, the chair was very ably filled for several months by Squadron Leader R. B. Cole, D.F.C., A.F.C., the Deputy C.F.I., who was later invited to become an Associate Member of the Old Cranwellian Association. The previous Wing Commander Flying, Wing Commander A. R. D. MacDonnell, D.F.C., had departed to study Russian. The Chief Flying Instructor of No. 19 Flying Training School became the first C.F.I. when the College reopened after the Second World War. He was Wing Commander T. B. de la Poer Beresford, D.S.O., D.F.C., now the Air Adviser to the High Commissioner in Delhi. He, too, was an ex-cadet and his successor, Wing Commander R. J. P. Prichard, O.B.E., D.F.C., A.F.C., was invited to become an Associate Old Cranwellian.

The Flying Wing must have used more airfields since the war than any other single flying unit. When the College reopened, the South Airfield was used for training purposes and the North Airfield by the Radio School. The satellites were Wellingore and Barkston Heath. Unfortunately Wellingore returned to its rightful use as arable land, but other satellites were found. Digby was much in use until some time after the Equipment and Secretarial Wing had been incorporated in the College, but is, alas, available no longer. Spitalgate is still being used and others, such as Wigsley, Scampton and East Kirkby have been used by the kindness of their owners.

The summer of 1954 saw a change in the face of Cranwell. The advanced stage of training was transferred, lock, stock and barrel, to Barkston Heath, and the North Airfield at Cranwell reopened for use by the basic trainers. Then the contractors moved in and started building the runways. Already, the South Airfield presents an unfamiliar aspect to those who have not visited Cranwell for some time. When the runways are completed, it is intended that the Vampires of the advanced stage will operate from them and that the basic Provosts will take their turn to use Barkston Heath as their base. The lecturers at Cranwell will have to compete with the whine of the Goblin and a new phase in the life of the Flying Wing at Cranwell will have started.

June 1955 - Early Instrument Flying

Early Days of Instrument Flying

By J. H. P.

(An Old Cranwellian)

THERE has long been a saying among pilots: 'Visibility nil, even the birds walking,' to denote really bad weather conditions. Not so many years ago pilots were content to follow the birds' example and stay on terra firma, but now the development of instruments, radio aids to navigation, and automatic pilots, has enabled aircraft to operate, when necessary, under any conditions of visibility and cloudbase. A remarkable demonstration of this ability was given some years ago by the U.S.A.F. Flying Fortress which, with a safety crew on board, accomplished a flight from the U.S.A. to England without the controls being touched by the crew between lining up for the take-off and finishing the landing run at the end.

While it must be admitted that neither R.A.F. aircraft nor commercial airliners are yet able to emulate this feat, which of course can only be done with the aid of much costly and heavy equipment, the fact remains that the pilot of today is trained to view take-offs and landings in conditions of 500 yards visibility and 300 feet cloudbase with confidence, provided the necessary aids are available. Hence one of the reasons for the complexity of aircraft cockpits and pilot training today compared with 25 years ago.

In 1930 a pilot in an R.A.F. fighter squadron had a straightforward training programme. The aircraft, in some squadrons, had no radio, no oxygen, and their guns were only fitted in time for the fortnight's annual firing practice. The training he was required to do consisted largely

of formation flying and aerobatics, with some six hours of night flying in the summer. There was an early form of turn indicator in the cockpit, but this was ignored by many pilots because the only cloud flying instruction received at flying schools was with the use of the magnetic compass and 'bubble' (sideslip indicator). Flying in clouds by this method was not calculated to inspire confidence in instrument flying. The erratic behaviour of the magnetic compass during turns is well known.

However, official interest in tackling the problem of operating in bad visibility was not lacking. About this time the R.A.E., Farnborough, was working on a system for landing in thick fog. The procedure was to fly a captive balloon from the aerodrome so that it was just visible above the top of the fog layer. This alone called for unusually precise met. information. The balloon then was used as a guide for a pilot to start his descent on a pre-arranged compass heading, and at prearranged engine r.p.m. and airspeed readings. The aircraft used, an Avro 504N, made its approach at minimum speed-about 50 m.p.h. Below the aircraft hung a string with a weight at the end. When this weight hit the ground a light shone in the cockpit and the pilot had to pull hard back on the stick to flatten out and land. The system was not adopted for the R.A.F.

Also in this year, 1930, the Air Ministry started its instrument flying courses for squadron pilots, and, with others, I found myself reporting at the Central Flying School, Wittering.

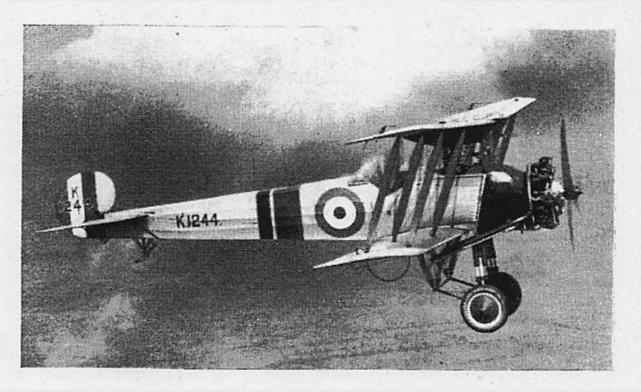
The C.O. of the Instrument Flying Flight was an officer who had recently returned from attending a course with the French Air Force. He told us that the French way of ensuring that the pupil did not cheat was to cover his head in the open cockpit with a sort of metal dish-cover, which was screwed down before take-off! For the final test—a navigational flight in a twin-engined transport aircraft—the pupil was accommodated in the passenger compartment where, just to confuse his normal sensitiveness to the attitude of the aircraft, the controls were arranged so that he sat facing the tail. He described his horror when, during the test, the safety pilot came back to watch him, leaving the cockpit unattended.

After hearing these tales we were much relieved to find that the French system was not being adopted in toto by the R.A.F. The C.F.S. was using the normal training aircraft of the time, the Avro 504N, and had fitted the pupil's cockpit with a folding canvas hood which could be operated either on the ground or in flight. Another local modification was to de-rig the aircraft so as to give them less dihedral angle, thus reducing their lateral stability. If a wing dropped in flight it remained down until the pilot corrected with aileron. This was considered desirable in case the normal stability of the Avro over-simplified the problem of instrument flying. The aids to instrument flying were simple enough-Reid and Sigrist turn and sideslip indicator (which has remained in use by the R.A.F. ever since), and a form of angle of climb and dive indicator consisting of coloured liquid in a vertical glass tube. The latter, however, was so affected by acceleration and deceleration errors as to be of doubtful use, except during steady flight. Lastly, a stop watch enabled one to change course accurately.

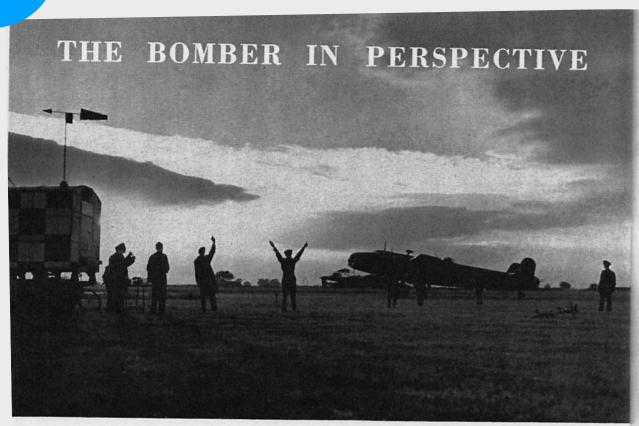
The syllabus of the course was remarkably similar to the modern equivalent, although much simpler, since at that time we had no radio (in training aircraft) and therefore no navigational aids and no assisted approach. All the same, the average pilot found his work cut out in learning to concentrate on his instruments and ignore his instinctive obedience to 'feel' and the message of the wind noise in the bracing wires of a biplane. We were taught climbing, gliding, gentle and steep turns, changing course, and recovery from spins. At that time we were made to skid all our turns, by holding off bank, thus making it easier to control the turning rate by use of rudder only. This is, of course, no longer taught. Then we finished up with cross-country flights, more a test of endurance than navigation since one was at the mercy of dead reckoning and a met, wind. With the hoods fitted to these Avros there was always a temptation to cheat by looking out through the slit between the hood frame and the side of the cockpit, and I remember on one cross-country peeping out at what appeared to be a convenient straight railway line, only to realize to my dismay that what I was following with such conspicuous success was one of the Avro's flying wires.

The course over, we went back to our respective squadrons, and although, in my experience anyhow, there was no sudden burst of enthusiasm for continued training in this new art—owing to lack of suitably equipped aircraft—the lesson had been well and truly learnt, that it was possible to fly an aeroplane in two ways, by the horizon and 'feel,' or by complete concentration on instruments. That lesson still has to be learnt by each new pilot today, though the modern trainee whose mind is filled from earliest days with instruments, cockpit drill, R/T procedure, and radio equipment. may unconsciously neglect the former method.

The Avro 504N, showing the blind-flying hood fitted over the pupil's cockpit. This folding canvas hood could be operated either on the ground or in flight



Autumn 1961 - The Bomber in Perspective (1)



"History of the Second World War: The Strategic Air Offensive against Germany 1939-1945" (4 Volumes) by Sir Charles Webster and Dr Noble Frankland (HMSO) 8 gns.

The strategic air offensive against Germany has been the subject of argument since the day it was launched. There was ceaseless debate in the War Cabinet, in the Air Ministry and in the Ministry of Economic Warfare. When the U.S.A. entered the war, yet another dissident voice was added.

After the war the controversy continued, and today there is still considerable interest in the story of the bomber offensive, particularly among students of war. The official history by the late Sir Charles Webster and Dr Noble Frankland will not completely satisfy the protagonists, but it will provide them with enough material to continue the debate — almost indefinitely.

The official history is four volumes long. Its length is, in part, due to the controversial nature of the subject. Every twist and turn of the great debate is fully documented; every contention is ably argued. Much of the evidence is familiar; but much of it is new.

In a short, but important, first section the authors, after defining the terms used in describing the concept of a strategic air

offensive, outline the doctrines which influenced that concept as it was built up during the inter-war years. This section contains the framework on which the whole of the study is based. The second world war was the first in which air power played a decisive part. The principles of war at sea and on land were already fully established and generally accepted. The task of the navy was to achieve and maintain supremacy over the seas to facilitate the movement of men and materials. The task of the army was to engage the enemy on the land, and, in so doing, defeat him. Thus the navy fought the enemy's navy and the army fought the enemy's army. But the task of the air force was less clear. This was not only because of its novelty but also because of its flexibility,

The maxim that 'the bomber will always get through,' which was first formulated in the 1930's, was really as old as the R.A.F. itself. Indeed, it and the R.A.F. had both grown out of the Zeppelin and the Gotha raids on London in 1917. If there were no defence against the bomber, the R.A.F. ought to include a large and powerful

bombing force in order to deter a possible enemy. That was clear enough. But what that force should bomb was another matter. Should it, like the other two services, attack its opposite number? Or should it attack the enemy's navy and army? Or would it be better employed in attacking the enemy's war industries and in this way weakening his armed forces? Or was it possible by bombing the enemy's homeland to weaken not only his power to resist but also his will to resist? There were those who believed that the war could be won solely by an air offensive against the enemy's homeland. This would be an offensive against the economy and morale of a nation, an offensive in which the navy and army played no part except to contain the enemy whilst the aerial onslaught was launched.

In 1939, there were those in high places who remembered the first world war with its Gothas and U-boats and who believed that Germany would be brought to her knees solely by an air offensive and a sea blockade. By 1945, they had been proved wrong on both counts. The air offensive and, to a lesser degree, the blockade were important and decisive factors but they were not the only factors. Germany had to be attacked and occupied by the army. The failure of Bomber Command was its failure to defeat Germany singlehanded; its success was to make Germany's defeat by the Allied armies possible and assured.

The authors trace this failure and success in detail. They divide the war years into four phases — the opening of the offensive and the transition to area bombing (Sep. 39 to Oct. 41), the mounting offensive (Nov. 41 to Dec. 42), the combined bomber offensive (Jan. 43 to Feb. 44), and the culmination of the offensive (Mar. 44 to May 45).

In such a complex story it is difficult to decide on the turning points. During the first phase, the most important turning point was the realisation that precision bombing by day was impossible without adequate fighter cover. The Spitfire and Hurricane, which had won the first great victory of the R.A.F., had insufficient range. There were two alternatives — to build fighters with a greater range or to bomb at night. When the Americans were faced with a similar dilemma in 1943 they chose to develop a long range fighter. In this way they were able to establish and keep the

day initiative which was so important during the last phase of the war. But in 1940 the British Air Staff chose to bomb at night, as did the Luftwaffe faced with the same problem in the same year. It was a choice of doubtful virtue. Air Commodore Coningham said in 1939 with remarkable foresight that there would be 'a never ending struggle to circumvent the law that one cannot see in the dark.'

Precision bombing at night was a failure. The crews could not navigate with any certainty in the dark and, if they reached the target, they could not bomb it accurately. It took some time for the Air Staff to realize how little damage was being done. This was the second turning point. Precision bombing was abandoned in favour of area bombing. This was a negative rather than a positive decision, but as Kitchener said, 'In war you must do what you can do, not what you would like.'

Navigational and bombing aids were essential; and so was a bomber with a greater range and bomb load. The new aids and the new bomber went into action in 1942, under Bomber Command's new C-in-C, Air Marshal Sir Arthur Harris. This was the third turning point. Under Harris the Command was to grow in authority and size. The bomber offensive was much criticised in 1942; Harris determined to assert the Command's authority by a demonstration of its growing power. This he did by the Thousand Bomber raid on Cologne. At that time the Command had 29 Lancasters; in 1945 it had 1087 sufficient for a Thousand Bomber raid by Lancasters alone!

Harris was persuaded by personal conviction and by the situation in which he found himself that area bombing was the only strategy open to him. In his battle for the aids and the resources he so desperately needed, he overstated his case. 'Victory, speedy and complete,' he said 'awaits the side which first employs air power as it should be employed.' It was true, as his critics have conceded, that strategic bombing was the best, and, in fact the only, contribution that could be made at that time towards winning the war. But the claim that bombing alone could win the war was never tested by events. Harris was never given a free hand or the resources which he deemed necessary.

Autumn 1961 - The Bomber in Perspective (2)

But the evidence contained in 'The Strategic Air Offensive against Germany points to the conclusion that he would have been proved wrong. There are three reasons for believing this. First, although the Battles of the Ruhr and Hamburg in 1943 went to Bomber Command, the Battle of Berlin undoubtedly went to the Luftwaffe. The absence of a long range fighter to protect the night bomber force was the determining factor. In March 1944, Harris conceded the Battle of Berlin to the Germans. Whether the growth of the German night fighter force from 665 aircraft in 1943 to 1047 aircraft in 1944 could have been prevented by precision bombing or more intensive area bombing is a difficult question — and the crux of the problem which faced the Air Staff and Harris. The Air Staff were moving more and more towards precision bombing whilst Harris stoutly defended area bombing.

Second, the German war economy, as can be seen from the figures above, was far from exhausted by the continuous onslaught during 1943 and 1944. The production of armaments continued to rise until the last quarter of 1944. This increase took place in spite of, and almost as a result of, the attacks on the Ruhr and Hamburg. The British Ministry of Economic Warfare failed to appreciate the resilience of the German economy. The truth was that it was never fully extended; there was a great deal of slack which could be taken up to offset the effects of bombing and even to increase production. The idea that the German economy was under such strain that it would fall apart by the slightest pressure at any point was incorrect.

Third, there was a grave misconception that German morale would be affected by bombing. The citizens of Solingen and Berlin were just as heroic as those of Sheffield and London. Morale was not seriously affected until the spring of 1945 when, with Germany

caught between the advancing Allied armies, defeat and occupation faced the German population.

The final turning point came when Harris was persuaded, one might say forced, to switch his attention to precision bombing, first in preparation for the invasion of Europe and then in support of the Allied armies. To his surprise, he found that precision bombing at night was now possible and effective. Oil and communications, which had always been on his list of targets but which had always been studiously ignored in favour of the area bombing of city centres, proved sensitive target systems. Whether an earlier attack on these systems would have shortened the war is open to debate. The earlier attacks on the ballbearing industry at Schweinfurt had proved difficult and ineffective; it was those failures which had encouraged Harris in his suspicion of 'panacea' targets.

Professor Medlicott has said in his book 'The Economic Blockade,' 'Thus in the last phase of the war the full range of economic weapons was at last being used with the deadly effect that the early economic planners had postulated; and the German fuel disaster had proved that there was after all an Achilles heel. But it had been struck by the bomber and not by the blockade.'

The authors conclude their history with a brilliant survey in which they say strategic bombing 'made a contribution to victory which was decisive. Those who claim that the Bomber Command contribution under different circumstances might have been yet more effective disagree with one another and often overlook basic facts.' In spite of this warning, the argument will doubtless continue. As Sir Charles Webster and Dr Noble Frankland say in their final paragraph, 'Hind-sight contributes powerfully to wisdom.'

THE JOURNAL

The Royal Air Force College Journal is published three times a year, at the end of the Spring, Summer and Autumn terms. Contributions are invited of articles, poems, photographs and drawings. These need not be confined to Royal Air Force and flying topics, but should be of general rather than technical interest. They should be addressed to 'The Managing Editor of The Journal, Royal Air Force College, Cranwell, Sleaford, Lincolnshire.' Unsuitable material will be returned. The Managing Editor, Editor and staff will be glad to advise intending contributors.

Spring 1962 - Cranwell Hovercraft (1a)

DESIGN FOR A HOVERCRAFT

SOMETHING that resembled a flying saucer moved down the runway. It looked as though it was flying — strictly low level-stuff — at a height of twelve inches, but it had no wings. The object slowed down from its cruising speed of sixty knots and halted. Surely now it would fall to the ground? No — it remained static, sitting on a layer of air and gently bobbing about like a table tennis ball on a fountain of water. This "thing" has been called a Hovercraft, a Cushioncraft, a Germ and so on, but, whatever the name, they all refer to Ground Effect Machines.

Any jet through which air is passing is acted on by a force in a direction opposite to that in which the air is moving. If the jet of air impinges on a solid surface soon after it emerges, then that force is augmented, and in the case of an annular jet the augmentation factor runs into hundreds. The simple annular jet is shown in Figure 1.

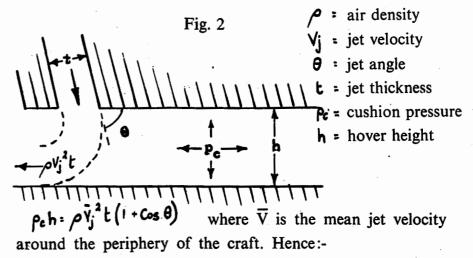
The annular jet of air contains a cushion of air and it is the pressure of this cushion that supports the craft. For a given hoverheight the cushion pressure depends upon

the velocity of the air curtain, the jet angle and the jet-thickness. (Figure 2), For small craft it is usual to take the jet thickness as about one quarter of the hoverheight.

For maximum cushion pressure the value of the jet angle is about 30°. However, to give the maximum lift: drag ratio, the optimum value of ⊖ lies between 45° and 50°. When the jet is inclined inwards there is a reduction of cushion area. By decreasing ⊖ from 45° to 30° there is a 10% decrease in cushion area. Although the air curtain method of containing the cushion makes for greater mobility and amphibious capability there is a tendency for the cushion to 'leak' out through the curtain. Sidewalls can be used to reduce this loss. The sidewalls themselves are not necessarily rigid. In fact, Britain's largest commercial Hovercraft employs flexible sidewalls. This use of flexible sidewalls reduces cushion losses whilst retaining the full amphibious capabilities of the craft.

At this point it is convenient to point out that in designing a Hovercraft there are spray and dust hazards to be considered. Obviously the spray and dust must be kept to a minimum and to do this a low cushion pressure is necessary. However, such a low cushion pressure would entail a very large in turn: the axial flow impeller needs extensive ducting to guide the air flow. This can be seen more clearly by studying Figure 3.

The use of this ducting causes frictional



$$\rho_c = \frac{1}{h} \left[\rho \bar{V}_j^2 t \left(1 + \cos \theta \right) \right]$$

cushion area to carry a given pay load. This payload could be carried by a very much smaller craft if a higher cushion pressure is used.

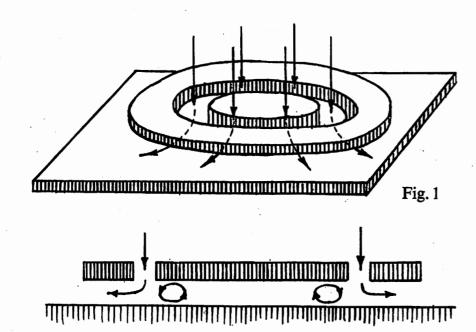
The jet being annular, it is not unreasonable to presume that the craft planform should be circular. In fact, the circular planform is most efficient for static hovering. But as the design forward speed of the craft is increased so the length: breadth ratio must increase also. A suggested optimum value for this ratio is between 2:1 and 4:1. This would indicate that an oval planform is the most suitable. Unfortunately, such a planform introduces complicated compound curves, so, to ease construction, a compromise is usually made.

The layout of the craft is now mainly determined by the type of impeller used to create the air curtain. There are two main types of impeller—the axial flow and the radial flow. With the axial flow type the air passes through the impeller blades parallel to the axis of rotation, whereas with the radial flow type the air flows into the impeller and comes out along the radii having been turned through 90°. Considering each

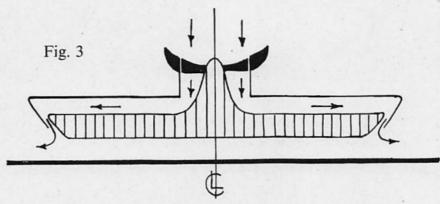
losses and the overall efficiency of the craft is impaired. Despite this the axial flow impeller is the popular choice, perhaps because it is smaller than its radial flow counterpart. The fact that the radial flow impeller turns the airflow through 90° has already been mentioned, so immediately it is obvious that there is no need for extensive ducting. A typical radial flow impeller layout is suggested in Figure 4.

Other factors that must be taken into account when deciding which type of impeller to use are the air intake area, the power required and the r.p.m. that must be maintained. The intake area should be a minimum so as to give the maximum area for carrying payload. Usually the maximum continuous power and r.p.m. are fixed by the type of powerplant used and so the impeller is designed to these specifications.

Forward propulsion of the craft can be by one of several means—jet engine, sail, propeller or simply by tilting the craft in the required direction. (This tilting causes air to spill from the cushion and by actionreaction the craft moves along). Drive for the propulsion can be taken from either the

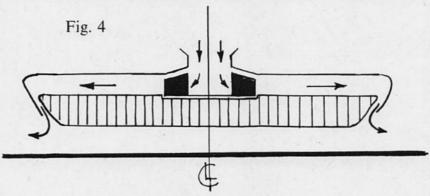


Spring 1962 - Cranwell Hovercraft (1b)



main lifting power plant, or from an auxiliary engine. Despite common belief that near-frictionless motion requires very little propulsive power, this is not true. (70% power is required for lifting and 30% for propulsion) At first sight the propulsive power might

Cranwell Hovercraft has been designed. Intended for amphibious operation at a height of approximately six inches this one-man craft will be capable of speeds around thirty knots. Both these quantities, i.e. hoverheight and forward speed, will



seem excessive but this is merely the power required to reach the hump speed; this being the speed at which the maximum drag occurs. Once the hump speed has been attained then only a fractional power increase is necessary to increase the speed.

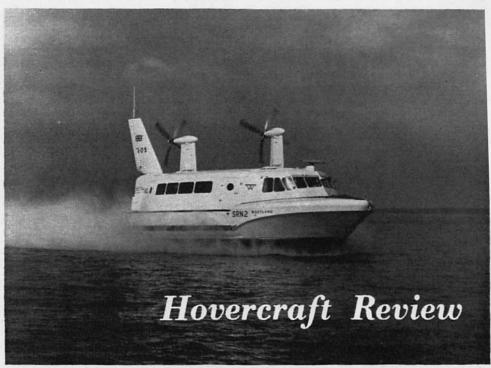
To control the craft, once again, there is not just one method but many. Even so, positive control is difficult to realise and Hovercraft will be liable to drift.

The study of Ground Effect Machines is only in the early stages so there is no definite theory that can be applied when designing a craft. However, a mixture of proven theory, empirical formulae and crude guess work is available for the designer. Bearing all the foregoing points in mind, and using perhaps more crude guesswork than is scientific, the

depend to a large degree upon the impeller and propulsive power used.

In conclusion, just a look into the future. The Hovercraft will not be developed to replace either ships or aircraft. It will be used as the "in-between" craft — to travel faster than ships and at lower speeds (and altitudes!) than airliners. A great advantage that the craft has over ships and aeroplanes is that it has a $33\frac{1}{3}\%$ — 50% payload as compared with about 20% for an ocean liner and 12.7% for such an airliner as the V.C.10. Despite this, the Hovercraft will probably only be employed as fast, comparatively small, short-haul ferry craft. The "air cushion" principle will also be applied to mono-rail trains. Above the Motorways will be a monorail with air-lubricated trains travelling from 200 to 500 m.p.h. There ought to be a great future for Hovercraft.

Summer 1962 - Cranwell Hovercraft (2a)



Saunders Roe S.R.N. 2

The British Hovercraft industry is the most advanced in the world today, and for one very good reason. In 1959 the Government foresaw the commercial and military potential of the Hovercraft and formed a company known as Hovercraft Development Limited, the primary purpose of H.D.L. being to co-ordinate the development of British Hovercraft. There is certain basic information that is made available to all aspiring Hovercraft manufacturers, and, if necessary, there is also limited financial backing for projects.

Christopher Cockerell's dream of an air-riding vehicle materialised in the form of S.R.N.1., built under contract by the Saunders-Roe Division of Westland Aircraft, Ltd. This was the first of the British Hovercraft and since the day S.R.N.1. made her maiden hover Saunders-Roe have been busily occupied with the problem of how best to employ this fascinating and novel concept in transport. Elaborate testing facilities and detailed experiments are the basis of the Saunders-Roe design philosophy—from which S.R.N.2. has now emerged: the world's largest Hovercraft. The following table of data shows the relative merits of the three main air-riding vehicles in Britain today:—

Туре	Saunders-Roe	Vickers-Armstrong	Britten-Norman
	S.R.N.2	V.A.3	C.C.2
Length Beam A.U.W. Payload/No. Passengers Power Hoverheight Speed Range Cushion Pressure	64ft. 6ins. 29ft. 6ins. 21 tons 6.14 tons/66 4×815 b.h.p. 1—2.5ft. 70—80 knots 200 miles 30 p.s.i.	52ft. 6ins. 25ft. 0ins. 8 tons 2 tons/25 4×425 s.h.p. 8 ins. 60 knots 87 miles 20 p.s.i.	27ft. 0ins. 17ft. 1in. 1½ tons 1½ tons/10 1 × 220 b.h.p. 1—2 ft. 48 knots 500 miles 12 p.s.i.

These three versions of air cushion machines share the same advantages, due entirely to their fully amphibious capabilities. They are not limited by tidal waters, or shallow water; nor are they useless on rivers that run dry for part of the year, and, being air lubricated, these craft enjoy smooth operation, even at their high cruising speeds. Immediately there spring to mind a number of possible uses for these Hovercraft—sheltered water ferries, transport along equatorial rivers, operation on tidal rivers where ships are limited to "high water" operation, and so the list goes on. In fact, these are not wild dreams but considered possibilities. Southdown—the south coast bus company—are debating the use of S.R.N.2. as a fast south coast ferry service.

At the moment the Southdown buses running along the Sussex coast roads average 15 m.p.h. Holiday makers would probably be quite prepared to pay the extra fare to travel shorter routes at 80 knots, for this is what S.R.N.2. could achieve. By travelling a few hundred yards offshore the routes between seaside resorts would be more direct and a great deal faster. This is the immediate plan for S.R.N.2. From Southend to Bournemouth by Hovercraft is 200 miles, and at 80 knots the trip will take around the $2\frac{1}{2}$ hour mark. The same journey, but along the most direct road route, is nearly 300 miles and at 15 m.p.h. it would be a 20 hour marathon on the part of the driver! Obviously this is a route chosen to suit the S.R.N.2. with its range of 200 n.m. But it does show very clearly that for certain services the Hovercraft is better than existing transport. The main problem arising from this particular proposal is whether the various seaside town councils will allow the Hovercraft beaching facilities. But such towns depend upon visiting holiday-makers for their livelihood, and it is possible that the better and easier transport by Hovercraft will encourage tourists. There can surely be no serious objections.

Thinking back to the publicity-hunting Channel crossing by S.R.N.1 there is food for thought in the fact that S.R.N.2 could cross from Dover to Calais in less than thirty minutes. Perhaps future developments — e.g. S.R.N.3, a 40 ton, 120 passenger version of S.R.N.2 — will be used in the cross-channel rôle. Before leaving the Saunders-Roe side of the story, it is interesting to note that S.R.N.2 makes the fullest possible use of flexible rubber side curtains to contain the air cushion. Also, S.R.N.2 — unlike S.R.N.1 — uses a centrifugal (radial flow) impeller.

Raging torrents of flood water and dried up river courses — equatorial rivers are both within the twelve month span of each year. Consider for a moment the problems that must face banana growers, for example. For part of the year they have river transport for their crops, but when the river dries up and slows to a trickle so does their river transport slow to a standstill. A list

Britten-Norman C.C.2



Summer 1962 - Cranwell Hovercraft (2b)

the only company to have sold a Hovercraft. The Ministry of Aviation paid £25,000 for the first model of C.C.2 and this craft is now being used for commercial research at R.A.E. Bedford. It is also Britten-Norman's proud boast that they have at least one thousand enquiries about C.C.2. In fact, once the production line for C.C.2 starts rolling there will be a very ready market for these craft.

Getting back to the more conventional use of Hovercraft — Vickers-Armstrong (South Marston) Limited, have recently completed the V.A.3. This craft carries 25 passengers and is intended for commercial evaluation over a west coast route. The V.A.3 goes into commercial operation this summer, but by mid-April (the time this article went to press) it had not hovered. However, Vickers-Armstrong had at least three months to test their craft. Even so, it is worth-while pointing out that Saunders-Roe have already been testing S.R.N.2 for more than three months and are still not prepared to put their craft into commercial use. Perhaps Saunders-Roe are too cautious, or maybe Vickers-Armstrong intend using the early commercial trips in V.A.3 to finish the testing programme. Bearing in mind that the Vickers-Armstrong craft has an operational hoverheight of only 8 ins. and a range of less than 90 miles, the V.A.3 will be very restricted in the routes it can travel. However these are merely design features and it is quite likely that in designing V.A.3, the Vickers-Armstrong team aimed at low operating costs, thereby sacrificing the performance slightly.

A review of the British Hovercraft Industry would not be complete without some mention of the engines for Hovercraft. It is impossible to make a sweeping statement about Hovercraft powerplants. What it is possible to do is to look at existing craft and consider their engines. The Britten-Norman C.C.2 uses a Rolls Royce L.V.8 engine — a perfectly standard motorcar engine — in a somewhat "hotted up" condition. On the other hand, both Saunders-Roe and Vickers-Armstrong have turned to Bristol-Siddeley for their powerplants. Gas turbines, (Nimbus for S.R.N.2 and Turmo for V.A.3), seem to be the order of the day. Despite their undeveloped state, these engines have such performances that when, during S.R.N.2's initial trials, one of the four Nimbus engines failed, the craft continued to operate entirely satisfactorily. In fact, S.R.N.2 went on to complete the test programme on three engines only. It is obvious that no matter what demands are made by Hovercraft designers, Bristol-Siddeley are capable of producing the engines for the job.

Hovercraft are a commercial proposition and have a military potential. Future developments will see even larger craft, of the 100 ton class, taking their place in the transport picture. With the armed forces already actively engaged on Hovercraft testing at Lee-on-Solent (H.M.S. Ariel, Inter-Services Hovercraft Trial Unit) it is safe to assume that the military potential of Hovercraft will soon be explored to the full. Perhaps there will be Air-Sea Rescue Hovercraft for the Royal Air Force.

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Summer 1963 - Cranwell Hovercraft (3a)

The Cranwell Hovercraft



At about the same time as the Saunders-Roe Hovercraft, S.R.N.1. first hovered, work began at Cranwell on the design-study for a single-seat hovercraft. The studies progressed slowly until early in May 1961 when Saunders-Roe fostered the interest. With such a ready source of information and encouragement the design-study was well advanced by July 1961, and a model hovercraft was constructed. The model hovered well and proved very useful to test design features.

By this time the commercial battle was on — Vickers-Armstrong and Britten-Norman both making all out efforts to catch up the Saunders-Roe lead. As the commercial field widened, so the scope for visits and information increased to such an extent that by April 1962 two cadets spent a week touring the companies of the Hovercraft Industry. With each visit, ideas and plans began to form and an outline design of the Cranwell Hovercraft — designated C.H.1. — was drawn in the Summer of 1962. The design specification was quite simple :—a single-seat craft that would hover in a stable condition at about six inches, and, with modifications, be capable of low/medium forward speeds with adequate control.

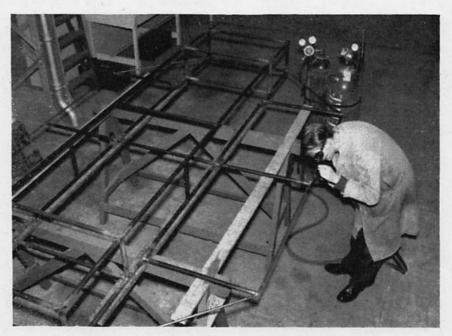
The hovercraft principle is basically the formation of a peripheral air curtain to contain an air cushion, at sufficient pressure underneath the craft, to support it.

The estimated loaded weight of 800 lbs., and the use of the relatively low air cushion pressure of 10 lbs./sq. ft. entailed a cushion area of 80 sq. ft. This requirement, combined with the use of an aspect ratio of 2:1 necessary for low/medium forward speeds, resulted in the overall dimensions of: length — 12ft. 6ins. and beam — 7ft. 6ins. Other design features — chosen from purely theoretical considerations — were the jet angle of 45°, the jet thickness of 1½ins. and an engine power of 30 b.h.p.

From early on it was obvious that such an ambitious and experimental project could hope for very little official backing. Fortunately a number of companies responded generously to the request for help — (B.S.A. — engine; Accles and Pollock — steel tube; Dowty-Rotol —

impeller; Shell, and Flamingo Foam — expanded polystyrene; Atlas Preservatives — protective paints; Renolds — chains and sprockets; Smiths — instruments) — and the components stockpiled in the Cadets' Instructional Workshops, where the craft was to be constructed. When it came to the construction the only limitations were those imposed by the cadets' engineering abilities.

It took a long time, but eventually, after many hours of gas welding, the tubular steel skeleton took the shape of the basic space frame. Into, and on to, this frame had to go the impeller, the ducting, the buoyancy chamber, the engine and the pilot's seat



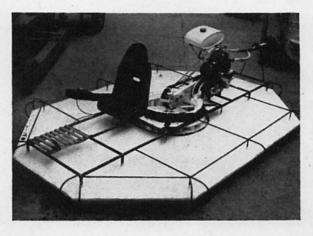
The tubular steel skeleton took the shape of the basic space frame

At first the craft was intended to employ an axial-flow impeller, but it soon became obvious to the designer that the radial-flow type would be far better. So it was that the Dowty-Rotol "bicycle wheel" impeller was mounted on its special shaft in the centre of the frame. There were many problems to take into consideration when the transmission system was designed. The final system entailed off-setting the engine, which in turn meant that the pilot would have to sit to one side to counter balance the engine. B.S.A.'s engine — a 500 c.c. "twin" — was mounted in its own frame, which was mounted on the main frame. Chain drive from the engine leads to a bevel gear transmission box located on the upper end of the impeller shaft — the gearing arranged so that with the engine at maximum continuous revs the impeller would run at its optimum r.p.m. Under such conditions the main problem seemed to be that of overheating, so an oil temperature gauge was fitted and displayed on the pilot's instrument panel. A tachometer was also displayed on the panel, which incorporated the twist grip throttle and an engine cut-out button. A clutch pedal completed the pilot's engine controls.

C.H.1., with impeller installed, engine mounted and transmission connected, was ready for engine trials early in the New Year of 1963. These initial tests showed that the engine, its mounting, the transmission system and the impeller installation were all satisfactory.

The craft was designed for amphibious operation so provision had to be made for it to float. Consequently a large buoyancy chamber was built into the lower half of the space frame. Expanded polystyrene, covered with special protective paints and glass cloth, was used to form

Summer 1963 - Cranwell Hovercraft (3b)



this chamber, — which also acts as the lower ducting to guide the airflow. Sheet polystyrene was used as the upper ducting, forming the outer skin of the craft. It was this ducting that would guide the airflow radially from the impeller, through the diffusion region and into the convergent nozzle around the periphery of the craft. This produces the air curtain which is directed inwards at a given angle, (the jet angle), — for C.H.1. this was 45°. A small air intake lip completed the ducting.

Although the main aim was to construct a craft that would hover statically, there was always the question of propulsion and control. A very refined—

and far too ambitious — system was evolved along the lines of the Britten-Norman ideas. Two longitudinal ducts contained controllable vanes that would deflect the air forwards or backwards. The ducts were never satisfactorily completed.

At this stage of the story it is interesting to note the man-hours required by this project. The design-study was done by one person, but once the construction work began a group of cadets formed. The tubular frame was made by four cadets. Then, as problems cropped up and the going became tedious, the group diminished to two. There was a sudden influx and the numbers rocketed to twelve, but over half of these cadets were "part-timers." The "full timers" num-

bered four, and these cadets went on to finish the project alone. The project would have been impossible without the co-operation of the staff of C.I.W. The idea of C.H.1. had taken two years to materialise, and from "drawing board" to "maiden hover" took just one year.

4th May, 1963, and the time had come to test the theory and the construction. The first hover was satisfactory — the hoverheight varying between $\frac{1}{2}$ in. and 2ins. The tilted altitude was due to the incorrect positioning of the pilot's seat. Other problems that were immediately obvious were the vibration and overheating of the engine.

No one could have expected an experimental project to "get off the ground" without some snags and this first trial was very satisfactory.

The group now had some results, and problems, to work on — and modifications were necessary. The impeller had to be tightened more securely on the shaft; the oil pipes had to be made more flexible to withstand the vibration; but perhaps the most significant modification was to decrease the jet thickness to 1 lb.



Quite easy, really

With all these "mods" embodied C.H.1. hovered again, and this time the results were remarkable. Hovering at 4ins. the craft was static and stable — conditions very difficult to achieve.

Four days after the maiden hover, the Commandant took the controls of C.H.1. and hovered.

The first public hover is scheduled for 14th June, at the Air Ministry. To this end the craft has been stripped and overhauled. Further modifications have been introduced and once again the question of propulsion and control arises. One idea was to use auxilliary engines driving propellers, but on the advice of the Royal Aircraft Establishments this was discarded and instead it was decided to use the pressure of the air cushion for propulsion and control.

At the time of going to press the propulsion and control system has not been tested, but there is every indication that it will prove very satis-

factory.

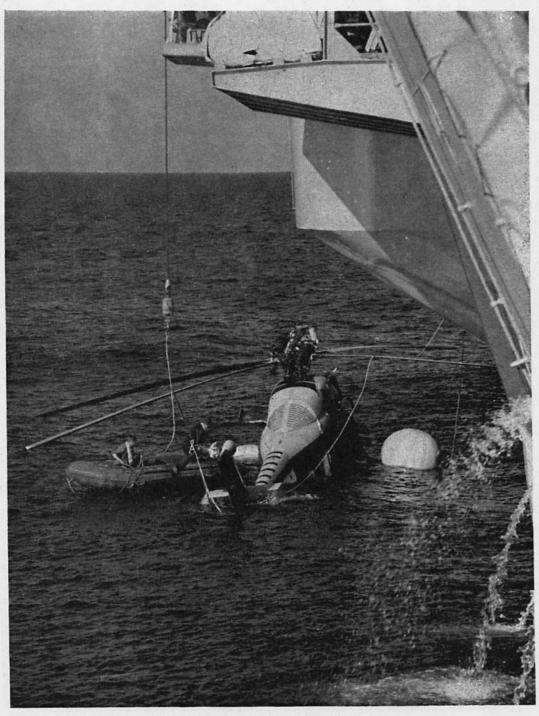
The successful completion of C.H.1. has surprised many people — Cadets who, for two years, have said "it'll never fly!" and scientists who were convinced that the project was too ambitious — but it is only the beginning of a new interest at Cranwell. Already ideas for C.H.2. are forming — carrying two people at a hoverheight of two feet, and travelling at 60 knots....

A cash prize is available for the best contribution to each issue of The Journal.

For the Spring 1963 issue the prize was awarded to Senior Flight Cadet C. C. Hayson for his illustrated article "And Jazz Music was Born "

The prize for this issue goes to Under Officer D. R. Green for his article "The Cranwell Hovercraft."

January 1969 - The Goldfish Club (1)



HMS Eagle comes alongside



JOINING THE GOLDFISH CLUB

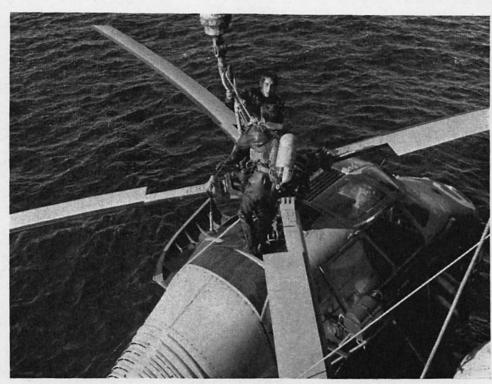
If you read Tuesday 1st October's Daily Express you would have seen on the second page a picture of a helicopter that had ditched in the North Sea. I was in that helicopter.

The machine had come from HMS Eagle, to which five flight cadets and myself were on a week's detachment, and was taking part in a combined anti-submarine exercise with two other helicopters and a destroyer. HMS Odin, an 'O' class submarine, was to

attempt to get in a position to torpedo Eagle. The helicopters, controlled and aided by HMS Cavalier, were to ensure a safe passage for the carrier.

Before embarking on the exercise Lieutenant Peter West, the pilot, gave me an extensive briefing on the ditching drill — not that we were likely to go in! In fact the other two crew members, a Master Rating and the observer, Lieutenant Jan Greener, were dis-

January 1969 - The Goldfish Club (2)



The crew is winched off

cussing the number of flights they had made without incident. After take off each helicopter was given an area to search by Cavalier, ours being on the right flank. Ten minutes after take off two pieces of equipment failed—My throat mike and the automatic pitch stabilizers. This meant I could not ask stupid questions and that Lieutenant West had a very difficult task in keeping the helicopter steady in the hover.

About an hour later another helicopter reported a suspected contact and Cavalier ordered us to a new position. There was a smell of fuel in our aircraft so once the required area was reached the Master Rating was lowered out to see if there were any leaks. His report was negative so, much to his relief, he was winched back in again. The sonar set was then lowered into the water and almost instantaneously two things happened. Firstly the lead helicopter made a positive contact with the submarine and the air became jammed with messages, secondly our engine decided it had done enough for one day.

Events started happening fast. Lieutenal West pulled on the collective hitch control ar sent out a mayday call. But it does not tal long to fall twenty-five feet. The result we nobody heard the mayday and due to the pilot's quick action we made a gentle 'plop into the sea.

When I heard the mayday call I wondere what was going on. This doubt was soo cleared up on hearing, and feeling, the red drop and seeing the sea approaching.

On impact with the water the inflatio bags on each wheel inflated so that from the cockpit four feet above the water all seeme relatively safe. However the floor of the cabin was five feet below the cockpit and at the time of ditching the cabin door was oper. Thus when the helicopter hit the water cloud of spray shot into the cabin and twent members of the Royal Navy shot out.

Once the rotors had stopped and Lieutenan West had told me it was safe to leave I though the best thing to do was to jump away from the helicopter and then inflate my dinghy. But as Lieutenant Greener rightly pointed out, there was plenty of time to inflate the dinghy first and then step into it without getting wet. This I proceeded to do. The observer who after shooting out of the escape hatch had stayed on the side of the helicopter to avoid the rotors, now inflated his dinghy and stepped into it. Unfortunately for him he did not appreciate the difference between the stability of a rubber dinghy and an aircraft carrier and was soon in the water. He pulled himself back onto the dinghy only to have it sink from underneath him. Having nowhere better to go he returned to the helicopter. By this time my dinghy was inflated so I sat down gently and then paddled away.

After approximately ten minutes the rescue helo appeared and very nobly decided to get the 'crab' out first. When the strop came down I had no idea what to do with it so I sat in it causing the pilot acute problems in keeping the helicopter steady. The Master Rating put the strop under his armpits and was raised with relative ease.

A large crowd of goofers had gathered for our return to ship, all wanting to know the fate of the helicopter and crew. After answering a few questions the Master Rating and I went below to change into dry clothing before reporting to sick quarters for a few medicinal tots of whisky. Whilst with the medical staff we learned of the fate of the sea boat sent out to rescue us.

On reception of the SARBE pulses the tannoy announcements went something like this: 'Emergency, emergency, emergency, helicopter ditched, launch sea boat and send out standby helicopter sea boat launched sea boat taking on water sea boat sinking crew taking to water ' Throughout the sinking the midshipman had kept his position in the boat and his hat on.

Thus the rescuers had to be rescued. The crew later stressed the fact that they had remembered to put the bung in and that the keel had cracked on launching.

The helicopter and sea boat were later recovered by the aircraft carrier and throughout the whole episode nobody was injured although the new members of the Goldfish Club did get badly 'smashed' in the Wardroom that night.

J. M. Womphrey

A second boat arrives



January 1969 - Battle of Britain Film (1)



Dual Spitfire 8 being flown by the author

THE MAKING OF THE FILM

BATTLE OF BRITAIN

by

SQUADRON LEADER D. H. MILLS

The film of the Battle of Britain, including the events which led up to it, is due for release in London in September 1969. It was originally intended that it would be released in September 1968, in time for the 50th Anniversary of the Royal Air Force. Unfortunately, however, the proposed backers of the project lost interest, and it took a year for new backers to be found.

The producer is Harry Saltzman, well known for his series of James Bond films, the co-producer is Benjimin Fisz, who flew with the Royal Air Force in the war as a member of a Polish Squadron, and the film is backed and distributed by United Artists, an American film company. The director is Guy Hamilton, who directed at least one of the James Bond pictures, as well as a number of other well-known films and he was assisted as aerial director for most of the flying sequences by David Bracknell.

The film is based broadly on the book 'Narrow Margin,' and the official histories of the battle. It purports to be completely unbiased, and to show each side of the story without frills or embellishment.

The line-up of stars taking part in the film is most impressive, and most of them take fairly small parts as mythical Station Commanders and Squadron Commanders. For instance, Kenneth More, plays the part of a Station Commander, and Michael Caine, Robert Shaw and Christopher Plummer are Squadron Commanders. Among the main characters in the story are Sir Lawrence Olivier as Lord Dowding and Trevor Howard as Sir Keith Park. There are also well known continental actors playing the parts of the various German Staff Officers and Squadron Commanders, from Goering downwards. Apart from the obvious characters mentioned the film deals with factual history, built around fictional characters, and all squadrons and people manning them are fictional.

The film will last for two and a half hours, and there will be forty minutes of flying sequences.

Apart from the studio work done at Pinewood Studios, airfield locations and sets were built in Spain, where the German airfield scenes were shot, Duxford, which had four different sets built on it, North Weald, Hawkinge and Bovingdon. Flying also took place from Debden, Panshanger, Sywell, Lydd and Montpellier in Southern France.

Model shots were made on the South Coast, and when I left, a model unit was scheduled to spend a fortnight or so in Malta, in search of good weather. We operated for the most part from Duxford, with some time spent at Debden and Bovingdon.

The primary camera aircraft was a converted B25 Mitchell, with camera positions in nose and tail, and also two waist positions. It is very well equipped, including closed circuit television, with a play-back facility for use by the director. Also used extensively for camera work was an Allouette helicopter, which had a camera mounted in the port passenger position. These two aircraft were used for most of the air to air shots: the B25 for large formation work, and the helicopter for smaller formations and for filming particular manoeuvres.

The Heinkel III bombers, 2-seat Spitfires, 2-seat ME 109, and one Mk 9 Spitfire were also used to carry cameras at various times.

A total of twelve Spitfires took part in the film; this number included two dual Spitfires and three belonging to the Royal Air Force Memorial Flight at Coltishall.

One Spitfire (Mark 2) had in fact taken part in the Battle of Britain, and until the last fortnight or so still had the original engine. This engine gave up eventually, luckily with no more than a slightly apprehensive pilot to show for it, and the aircraft has now been re-engined with a Merlin 35, and will be added to the Royal Air Force Memorial Flight fleet in the near future.

There were three Hurricanes comprising one belonging to Hawker Siddeley, one belonging to the Royal Air Force Memorial Flight, and one which had been rebuilt privately in Canada, and which now belongs to a Mr Samuelson.

Sixteen Messerschmitt 109s were used, including one dual aircraft. They are all Spanish built, and have Merlin engines. Thus, their nose shape is not quite the same as the

January 1969 - Battle of Britain Film (2)

aircraft used during the actual battle. They were the newest aircraft in the film, the Spanish Air Force having used them operationally until about five years ago.

Two Heinkel IIIs were brought to this country, but up to twenty were used for the shots taken in Spain. The Spanish Air Force still use them operationally.

It had been hoped that the Stuka in the Henlow museum would be made airworthy, and in fact the engine was started. But in spite of only fairly minor work being required on it, the money was not forthcoming, and the project was dropped. However, there is a Stuka shaped ex Proctor, which looks the part from most angles, and this will no doubt appear in the film.

It is worth noting that all the ME 109's, the two HE III's, one Spitfire 9 and the Stuka/Proctor were bought by the film company for the film. The other aircraft were either hired to the company by private owners, and the Royal Air Force, or, as in the case of the Hawker Siddeley Hurricane, and Rolls Royce Spitfire 14, loaned to the company.

Other aircraft involved were two static Hurricanes, several static, and several taxiable Spitfires, and a large number of full size static fibre glass models of Hurricanes, Spitfires, ME 109's and Stuka's for shots of dispersal scenes.

They also used half scale free fall models for shots of crashes, and quarter scale radio controlled models of various types for other flying sequences. In addition to these aircraft models were a large number of models of Chain Radar masts, a French chateau, the London skyline and other topical items.

Originally there were ten pilots seconded from the Royal Air Force: the Commanding Officer, Wing Commander George Elliott, four Squadron Leaders, and five Flight Lieutenants, all from Flying Training Command. However, one member left early on in the detachment, so for the most part we were nine pilots strong.

The Royal Air Force Memorial Flight aircraft were always flown by Coltishall pilots, and in addition there was one civilian pilot employed by the film company, Vivian Bellamy. He was extremely useful to have, having been a test pilot at one time, and knowing the Spitfire very well. He also knew all the 'ins and outs' of civilian flying, and the Board of Trade rules and how to interpret them.

The ME 109's and HE III's were flown, in the main, by Spanish Air Force pilots, with some help in Spain from four members of the Texan organisation known as the 'Confederate Air Force.' One American, Connie Edwards, remained and flew the ME 109 throughout the filming in England. We got on well with the Spaniards, and found them to be generally very able pilots. They were led by the Chief Test Pilot of the Espana Aircraft works at Seville, Commandante Santa Cruz, an excellent man in all respects.

Four of the Spanish pilots, and the American, checked out in Spitfires, and six of us in the ME 109.

The Spitfires and Hurricanes were all initially serviced and refurbished where necessary, by a firm called Simpson Aviation Services, of Elstree. They continued to do second line servicing of the British aircraft throughout the film, and in fact, are still involved with servicing the aircraft before they are returned to their various owners.

First line servicing of the British aircraft was done by Royal Air Force personnel, all of whom had volunteered for the job. This not only included the flying aircraft, but also the static and taxiing ones. As might have been expected, there was a very large percentage of senior NCOs in their number. They all worked very hard, and produced excellent results from old and in some cases, very tired aircraft.

The Spaniards had their own servicing team, led by an engineer officer of the Spanish Air Force. They initially carried out both first and second line servicing, but as time got more and more protracted so they gradually left, and eventually much of the Spanish first and second line servicing was done by the Royal Air Force and Simpson Aviation ground crews.



ME 109

The fact that, once in good flying condition, the aircraft continued to fly with relatively little unserviceability, is a great tribute to all the ground crews involved, especially those loaned by the Royal Air Force.

I reported to Royal Air Force Debden on 28th April, and met five other pilots, who had already been there a week, and the other four who were reporting at the same time as myself. We went to Pinewood Studios the next day, and learned something of the background to the film, what we were expected to do, the aircraft we were to fly, and so on. Flying started on 30th April at Debden.

At this stage we had one dual Mk 8 Spitfire and two Mk 9 Spitfires. Conversion consisted of 40 minutes in front of the dual aircraft with a pilot who had converted the day before in the back, and consisted of general handling and three or four circuits. Then a couple of solo details in Mk 9's, then formation, attacks and tail chasing. We continued to make the odd trip in dual when the Mk 9's were not available or full. The weather was very dull during this period, and I did not seem to fly much above 700 feet for the first half dozen sorties.

Two pilots only were cleared to fly the Hawker Siddeley Hurricane, one of whom I volunteered to be. I collected it from Henlow in early May, having had a briefing at Dunsfold on how it worked. So then we had three Spitfires and one Hurricane.

We left Debden and operated from North Weald for about a week in May, until the Spaniards arrived at Duxford. At North Weald a lot of ground shots were done, with us taxiing past as background action with real actors doing the running to and climbing into the static aircraft in the foreground. A little flying in support of this was involved, but not much.

Finally we got to Duxford at the end of May, and started doing upper air work. However,

we had to move back to Debden in early June while they did a large amount of ground shooting on various sites built at Duxford. and some Hurricane flying took place at Duxford, from a grass strip, at this time. However, the main flying, large formation shots, was done from Debden during this period.

Back to Duxford in late June, and six Spitfires went off to Hawkinge for the week. The Hurricanes, and myself stayed at Duxford.

During this build-up period, further refurbished Spitfires appeared from Henlow, most of which initially had overheating troubles. However, once sorted out, they kept remarkably serviceable. Also at this time the Coltishall aircraft came on to the scene, and so did the Canadian Hurricane.

Generally speaking from then on we were at Duxford until the aircraft went to Sywell for filming of grass take offs and landings in late September, and got bogged down for a week. We all moved to Bovingdon at the end of September.

January 1969 - Battle of Britain Film (3)

In the meantime, after a fortnight of extremely bad weather at Duxford in early August, the Spitfires, three ME 109's and the camera B25 went for ten days to Montpellier in the South of France, to film formation shots in good weather. They did a large amount of flying there, most pilots getting 25-30 hours during the period, in transit and filming. Those, like the Hurricane pilots, who stayed at home hoping to achieve something with the Hurricanes, ended up doing endless taxiing at Duxford on non-airworthy Spitfires, amid exploding holes in the ground. Exciting in a way, but not exactly like the South of France by Spitfire.

Once at Bovingdon, everything got slower and slower, and more and more half-hearted, and the dread day came on Friday 11th October, when all but one of us were told we were not required back on Monday. Typically it was a wet, miserable day, so we could not even make an excuse to have a last ride in a Spitfire.

The flying was very varied, and in some instances very exacting. It ranged from special take off and landing shots, which had to be positioned in a certain way, formation take offs and landings in similar conditions, individual and formation manoeuvres with the helicopter camera aircraft, to large formation mix-ups to simulate dog fights behind the B25 camera aircraft.

All flying exercises were preceded by a briefing in some detail, of what the airborne director and cameramen wanted, and this did not always match up with what was physically possible. Even when this was pointed out, the filmers who after all, controlled the money, tended initially to ride rough shod over our suggestions, and we would have to go ahead and try what they wanted. After several wasted sorties, with perhaps 28 aircraft airborne for an hour and a half, they did start to see reason, and our suggestions were sought more readily. This, the very bad weather, the language difficulty with the Spanish pilots, and some rather poor communication equipment, all added up to a large number of wasted sorties, and frustrations all round.

The method of trying to stage a dog fight provides an excellent case in point. The idea was to lead the formation in the B25, using

the tail camera position. Follow that maybe, by the two HE III's in loose formation, and on perch positions on either side to have a mixed bag of Spitfires, Hurricanes and ME 109's, say a dozen on each side. Over and above this was usually a Spitfire and a ME 109 on a separate perch, whose job it was to provide foreground action close to the B25 using the various smoke devices with which they were fitted. Several aircraft in the main formation, both the HE III's, and even the B25, were also fitted with smoke. On the command 'Action !' the two large formations would converge behind the HE III's, within camera view of the B25, fan out into individual aircraft, weaving and tailchasing, smoking where they could, and the two individualists would make a close pass on the B25, one on the other's tail. In amongst all this, one Heinkel would normally smoke and fall out of the formation. As can be imagined it now and again got quite exciting in the middle of this lot, and it was very frustrating when one saw the rushes to see how unexciting it often looked on the screen.

Add to all this, a film director in the B25, who was impatient for every one to reform formation as quickly as possible for it all to happen again, the B25 pilot knowing that he was going outside his designated area and wanting to turn round, a camera man interested in which way the sun was, HE III's which could only go at 160 kts or less, having to re-form formation, Spanish pilots who initially were not too happy with speaking English, or with navigating over a foreign country, and who did not like their ME 109's for manoeuvring at much below 170 kts, and pretty poor communications, and it is not surprising that people tended to get a little despondent now and again.

However, one or two shots they did take of such formations were spectacular, and can obviously be used with different cuts, and different emphasis, time and time again in the film.

In addition to the large formation filming, individual formations of Spitfires, Hurricanes and ME's were filmed making attacks on their opposite numbers, from both the B25 and the helicopter and some of these look very good indeed.

The two seat Spitfires were used in large formations in the background where they will not be noticed, as were the Mk 14 and Mk 19 Spitfires with their rather different nose and tail shapes. The two seaters also used to carry camera men who took film of formations from within, and one of them was converted to be flown from the back cockpit, with a camera/mirror combination which provided film taken through the gunsight. Some good film was obtained in this way, and I was lucky enough to do some of this flying, chasing a smoking ME and attacking HE III's; so can claim to be director and cameraman of two or three sequences; whether they use them in the film remains to

Another interesting camera mount was built into the wing of a Mk 9 Spitfire, in which the camera watches the pilot as he flies the aircraft, and searches the sky. ME 109's appear in the background and flash past, the aircraft smokes, and the pilot opens the hood and starts to undo the straps. Not unnaturally, it is not carried to the logical conclusion, the final part being from a mock-up at the studio.

The poor weather was the biggest bugbear of the whole film. We were not permitted to fly in IMC by the Board of Trade, and not many of us particularly wanted to, with some of the older and more unreliable instruments. For historical accuracy all filming had to be done in sunlight, if possible, with white fluffy cumulus cloud about. There was very little of either this summer and we waited endlessly at all the places we operated from, in varying degrees of comfort, for a miracle to happen, and seldom did it. Even on perfectly flyable days by any other standard we often could not fly, because the weather, or light was not just right. This, and the fact that continuation training was practically non-existent because of the cost to the Company, were among the biggest morale drainers of the detachment.

To say that I am delighted and thankful for having been given the opportunity to fly Spitfires and Hurricanes, is a thorough understatement. I cannot remember, in 3,000 hours of flying, enjoying any type of aircraft as much as the Spitfire, very closely followed by the Hurricane.

I was thankful that there was a dual Spitfire available for the familiarisation sortie, because it was rather a surprise to have all that noise, rather rough sounding noise after a Jet Provost or a Chipmunk, not to be able to see well for landing, and to find such sensitive elevators. However, after forty minutes I was very happy to go off, in poorish weather, in the Mk 9, which I enjoyed very much. But the aircraft I liked best of all is a Mk 5 now belonging to the Shuttleworth Trust, which is a delight to fly, being lighter than the Mk 9 and better harmonised on the controls. I cannot imagine a nicer pure flying aeroplane.

The Hurricane I flew from scratch, and found very comfortable, but not as cleancut on the controls as the Spitfire. However, it has several good points, being very nice for general handling, more easily flown ade-

Spitfire 9 - G-ASSD



January 1969 - Battle of Britain Film (4)



A typical 'Battle of Britain' film summer scene at Duxford

quately by inexperienced pilots, and, of course, having a wide under-carriage, is easier to control on the runway after landing. A bit lacking in performance compared with the Mk 9 Spitfire, but nearly as good as a Mk 5. Another delightful aircraft to fly.

I was also lucky enough to fly the ME 109 for one sortie. I would have liked a couple more, to enable me to assess it better, but it again seemed a very pleasant aircraft once one got used to the unusual sports-car type seating position, non-adjustable rudder pedals, seat which had to be adjusted before flight and the coffin-lid type canopy, which once shut can hardly be opened from inside. It does tend to swing about rather, particularly on take off, because of the narrow track undercarriage, which is a long way in front of the centre of gravity. I am told that this led to a large number of accidents during the war, and it certainly led to one at Duxford, in which the aircraft swung on landing and was written off. The pilot, a Spaniard, was unhurt. In the air, it handled very well in the rolling plane, not as well as a Spitfire in the pitching plane, and tended to slip and skid without the pilot noticing it. This largely because there is no adjustable rudder trim on the aircraft. Those with a little more experience in the type liked it very much.

Although the part of the film we were

mainly concerned with was the pure flying of the aircraft, we did have some opportunity of seeing something of the filming on the ground, particularly during shots at the various airfield locations at North Weald and Duxford. Here, as spectators, one got the idea of the tremendous amount of organising which falls on the location manager, who has to organise all the props, extras, actors, directors, cameras, camera men, make-up men, hair-dressers, carpenters and labourers into the right places at the right time, also house and feed them, and attend to complaints from local farmers about people on their land, and local school teachers about aircraft endlessly low-flying over the school. Also,

the mixture of organisation and artistic ability required of the assistant director, who, with his various assistants, sets the whole scene up for the director proper. This really becomes harassing when aircraft are to be taxied as background to actors playing some scene, with mock bombs blowing up not far away, and the one off shot of the Duxford hangar blowing up and burning down, also not far away. Add to this vagaries of wind direction, blowing smoke over the cameras, and the sun only shining fitfully, and life for everyone becomes rather hectic, and at times a certain tartness between directors and others tends to creep in.

However, once we realised their problems, and once they realised we were not prepared to attempt the impossible, or even imprudent, at their whim and fancy, we did get along very well, and found it was a pleasure to work under conditions so different from the normal Service ones, and with people with such a different outlook.

I must finally mention the meticulous attention to detail in camouflage and markings of all the aircraft, and the enormous expense incurred in obtaining or making up authentic period MT and other vehicles, the provision of authentic uniforms, including flying helmets and flying kit generally, and the creation of airfield dispersals with fibre

glass buildings, turf covered plywood dispersal pens, and the full sized fibreglass models, and, in one case, facade of a French chateau, I mentioned earlier. All this only on the airfield dispersals. Far more was done in the studios and in Spain before we joined the film, and one can see that all this, with the immense cost of buying and operating the large numbers of aircraft involved, adds up to an extremely expensive film.

I flew 49 hours on Spitfires, 32 on Hurricanes, and half an hour on the ME 109, over a period of nearly six months. Those lucky enough to go to France achieved about 28 hours more than I did. This flying in itself

was great fun, and ample recompense for long hours of sitting around waiting for things to happen. But add to it the chance to see a film of this size being made, to meet the people making it, including the Spanish pilots, with whom we got on very well, and to serve as a member of a 13 UE Spitfire Hurricane Squadron of tremendous spirit, in 1968, and one can appreciate what a marvellous, rewarding and unforgettable experience it was.

I am assured by those few who have seen the first rough cutting of the film put together, that the whole thing is a tremendous success, and I, for one, am very much looking forward to seeing it.

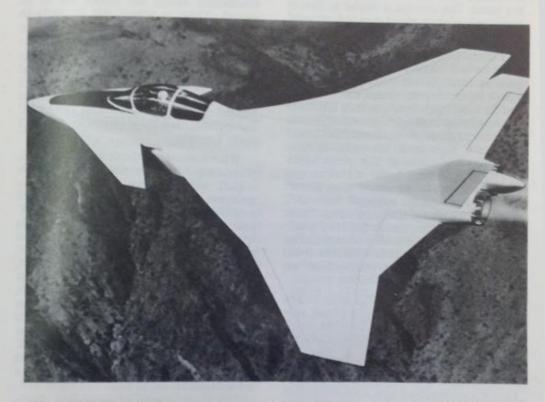




1982 - Composites

Advanced Composites In Aircraft Construction

This article has been prepared by Flight Lieutenant J E Morton, Department of Specialist Ground Training.



Artist's impression of a future combat aircraft using carbon fibre composites. (Reproduced by kind permission of British Aerospace PLC).

There has been much research and development work over the past 2 decades devoted to producing better materials for aircraft structures. Better, in this case, means exhibiting more strength and stiffness for a given weight, together with improved

resistance to corrosion and fatigue. The most promising material that has emerged to date and which is incorporated in aircraft being designed today is carbon fibre composite or CFC. The carbon fibres themselves are finer than a human hair and are made by heating

nylon-like threads to a very high temperature. This gives them a strength to weight ratio greater than almost all other known materials. CFC is made by incorporating layers of the carbon fibres, packed densely either side by side or woven into mats, with a plastic matrix. The matrix is usually epoxy resin similar to the Araldite that we use for repair jobs around the home. The concept is similar to that of reinforced concrete where steel rods are used to reinforce a matrix of concrete.

Because CFC can be moulded into almost any shape and thickness when it is made, it has great potential for use in aircraft structures where excess material means excess weight and therefore inferior performance. The fibres can be oriented to give strength and stiffness in the required directions and rivetted and bolted joints are kept to a minimum because structures are made in one piece where possible. It has been found in practice that about one-tenth of the weight of an aircraft part can be saved by making it from CFC instead of the normal aluminium alloy. This is demonstrated in the Harrier GR Mk 5 which will enter RAF service in a few years time. The wing, front fuselage and tail of this aircraft will be made of CFC, which has produced an estimated weight saving of 400 lbs.

Even greater weight savings of up to 30% can be made by designing completely new aircraft to be made using CFC from the outset. At this stage a design can evolve which makes the whole aircraft smaller to take full advantage of CFC construction. Because costs are generally in proportion to overall aircraft size for a given aircraft type, a smaller aircraft which can fulfil a given mission will be cheaper to buy and run. In addition it is estimated that in the long term CFC structures will be no more expensive, or even cheaper, to make than the directly equivalent metal structures. One further advantage of CFC is that it seems to suffer much less than metal from fatigue damage caused by alternating loads. This, together with the natural resistance of CFC to corrosion, should reduce the 2 factors which cause a great deal of the RAF's airframe repairs and modifications.

CFC does have some potential drawbacks. such as a greater susceptibility to impact damage than metals, and exhaustive tests and trials are currently being carried out by aircraft manufacturers to establish adequate design procedures to ensure that the strength advantages of CFC structures will be maintained during the service life of an aircraft. There is always this necessity to examine all possible implications before an innovation in the aviation world is fully accepted and the RAF is also currently studying the long-term maintainability and cost aspects of CFC construction. This is not only for aircraft like the new Harrier and others which may follow but also for CFC replacement parts for in-service aircraft such as the Tornado.

It is estimated that the aircraft of the 1990s. particularly high performance military aircraft, will have well over half of their airframes made from CFC. There are still areas where metals cannot be replaced by CFC such as high temperature zones and places where there are high concentrated loads in restricted spaces. These aircraft of the future might look like the Agile Combat Aircraft, recently shown in mock-up form by British Aerospace, or like the Grumman X-29A experimental aircraft with forward-swept wings. It has been possible to design practical high performance forward-swept wings like these only since the advent of CFC construction with its superior stiffness which can be tailored to make the wing twist advantageously under load.

To sum up, the use of CFC in aircraft construction has its disadvantages, which are currently being rigorously analysed by experimentation and monitoring, but the advantages are expected to outweigh these. Coupled with the other advances in aircraft technology, particularly in flight control systems, the use of CFC should lead to smaller and lighter but more capable combat aircraft which will slow down the ever-increasing cost

1983-1984 - Optical Fibre (1)

OPTICAL FIBRE COMMUNICATIONS

This article has been prepared by Flt Lt K Henderson, Department of Specialist Ground

Over the last 10 years the concept of using light signals transmitted through glass fibres for communications has grown from a theoretical suggestion to a practical and efficient system, It is now certain that the next generation of communications networks will use optical fibres in preference to metallic conductors. This article is intended to explain the technical basis of optical communication systems and to outline the military applications, both present and future, of

A communication link has 3 essential composuch systems. nents: a transmitter, a channel and a receiver. In a normal telphone circuit the transmitter is the microphone which converts sound waves into an electrical signal, the channel is the metal cable down which this signal travels and the receiver is the earpiece which converts the electrical signal into an approximation of the original sound plus noise and cross-talk by courtesy of British

Telecom.

such as a laser or light emitting diode (LED) which converts the electrical signal from a mic rophone or other source into a light signal, the channel is the glass fibre which guides the light and the receiver is a photo-diode which works on the same principle as a light meter and convens the light signal back to an electrical one. It will be noticed that the optical system uses electrical signals as intermediaries; attempts are being made to produce devices which allow some signal processing, such as filtering, to be carried out directly on the optical signal, but there is no prospect of eliminating electrical power from the system in the forseeable future.

Since the heart of an optical communication system is the fibre, it is necessary to consider the basic theory and types of available fibres before discussing the systems in general. A longitudinal section through the simplest type of optical fibre is shown in Fig 1.

t normal cladding Fig 1

The core consists of glass of high refractive index while the cladding is of low refractive index, so that when a ray of light A passes from core to cladding it is refracted away from the normal as shown, a part of the light also being reflected from the interface. A ray such as B, however, strikes the interface at such an oblique angle that refraction is impossible and total internal reflection takes place, thus confining the ray to the core of the fibre along which it travels by means of multiple reflections. If, as is normally the case, the diameter of the core of the fibre is only a few times larger than the wavelength of the light used it is found that only a limited number of angles of incidence on the interface can lead to propagation down the fibre. In fact the fibre behaves very much like a waveguide used to confine radio waves, although the theory is more difficult because some of the electromagnetic energy, even of confined rays, leaks into the cladding which must thus be made of equally pure material as the core to avoid losses. The permitted ray angles are referred to as modes of propagation and, since they travel different distances as shown in Fig 2, they move along the fibre at different speeds.

present systems is 0.85 μ m (1 μ m = 1/10,000 cm), the manufacture of such fibres is very

A number of factors determine the distance which optical fibre links can cover. The most obvious problem is loss of energy due to absorption and scattering of light within the fibre; anyone who has tried to look through the edge of a pane of window glass will appreciate that in normal glass such losses are quite high. The purity of the glasses used in optical fibres, however, is now such that light can be transmitted with aceptable losses for distances in excess of 100 km, and this is the technical breakthrough which makes optical communication feasible. Such long ranges give optical systems a great advantage over metallic cable links which require repeaters (amplifiers) every 2 or 3 kilometres; all optical repeaters can be positioned inside buildings such as telephone exchanges or communication centres thus simplifying repair and maintenance

Another problem to be overcome is pulse spreading due to the varying speeds of propagation in multi-mode (large diameter) fibres. Most optical communications systems use digital

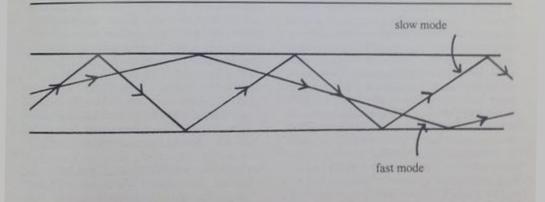


Fig 2

By making the core of the fibre of very small diameter, approximately equal to the light wavelength, it is possible to eliminate all but one mode so that the light travels with a single speed; since the wavelength of the infra-red light used in signals, ie messages or data are coded into trains

Since the different modes will arrive at different times at the receiver a square pulse will become degraded as shown in Fig 3.

1983-1984 - Optical Fibre (2)

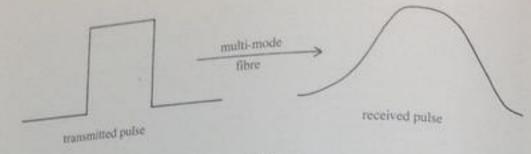


Fig 3

If the pulses are closely spaced they will overlap causing incorrect decoding and message corruption. This effect becomes worse as the fibre gets longer and so the long distance links use small diameter mono-mode fibres. A similar difficulty is encountered due to the variation in speed of light of different wavelengths—dispersion. Although the light sources used are essentially of one wavelength, the pulsed signals cause a spread in bandwidth so that dispersion must be taken into account and represents a serious limit on the lengths of links and the rate at which pulses can be transmitted.

Fortunately, it is found that if the wavelength of light used is raised to 1.3 µm both energy losses and dispersion effects are minimised and data rates of 140 million pulses per second over ranges of 120 km can be obtained. It is therefore certain that the next generation of optical communications will use this higher wavelength, although this requires the sources and detectors to be made of special material using complex microelectronic construction techniques. It must not be forgotten, however, that many communications links are quite short and these can be implemented using relatively cheap multimode systems—in fact many short range applications use very cheap plastic fibres.

The military applications of optical fibre technology are potentially almost limitless. The advantages over copper cables include:

Reduction in weight and volume leading to easy handling.

Low cost, allowing redundancy (duplication) to be built into the system.

Security. Optical fibres are almost impossible to 'tap', and any such attempt can be detected easily. They are also immune to electro-magnetic jamming and resistant to the electric-magnetic pulse (EMP) produced by nuclear weapons.

These advantages are offset by a single major disadvantage; optical fibres, because of their tiny dimensions, are difficult to join and repair. This problem is quickly being solved, however, and is unlikely to impede the introduction of the systems.

The obvious first area for the introduction of optical fibres is in ground-based communication systems. Project Uniter, the new RAF Integrated Communications System uses the technology widely. Similarly, aircraft information and data systems, which are becoming ever more complex, will, in the future, tend to be based on optical fibres which will allow large amounts of data to be handled and also allow sufficient duplication to avoid system break down resulting from battle damage.

Slightly more futuristic developments include:

Missile guidance. An optical fibre could carry a TV video signal from a missile to the fire unit and relay control signals back to the missile. Similar systems could be used on torpedoes.

Tactical communications. It has been suggested that optical fibres (of sufficient strength) could be laid from the air to provide rapidly deployed battlefield communications.

There is no doubt that the use of optical fibre technology can, and probably will, increase the speed and efficiency of military communications and data handling dramatically. As longas care is exercised in implementing reliable and well-planned systems, a new era in military itelligence and communications is about to begin.

1985-1986 - Space

SPACE IN THE DEPARTMENT OF AIR WARFARE

This article has been prepared by Wg Cdr D de Garis RAF. Directing Staff Weapons and Astronautics

Launching of the first Sputnik into Earth orbit in October 1957 surprised the world and triggered another technological competition between the two Superpowers. In the next four years the United States achieved 29 successful space launches against six by the Soviet Union. Indeed, by the end of 1961 four men had been into space: two Soviet cosmonauts had orbitted the Earth whilst their two American counterparts had experienced sub-orbital rides. It was 14 years before Britain first launched its own satellite but long before that the importance of the military use of Space was apparent. Accordingly, in 1962 the Chief of the Air Staff directed the formation of a Royal Air Force Aerospace Briefing Team (ABT). The team has remained in existence and has the task of monitoring activities in Space and promoting within our Service an awareness of the military applications of Space developments.

Initially, the ABT was established within the College of Air Warfare located at RAF Manby in Lincolnshire. It survived the change of location to the RAF College Cranwell and now thrives within the Department of Air Warfare (DAW), Currently, the briefings are undertaken by two of the Weapons and Astronautics Section specialists and an electronics and communications expert from the Aerosystems and Electronics Warfare Section. The principle medium for spreading the Space message is the Senior Officers' Aerospace Study Period held three times each year at Cranwell. In the three days of each period a wide range of Space-related topics is covered by the three DAW staff augmented by highly qualified visiting lecturers. For instance, the United Kingdom's first astronaut-elect, Squadron Leader Nigel Wood, gave the mid-'85 course a fascinating insight into his task of launching the communications satellite Skynet 4 from Shuttle.

Virtually all courses passing through DAW are treated to Space briefings at various depths (heights?) during their sojourns. Thus Air Warfare Courses, GD Aerosystems Courses, Senior Officers' Weapons Study Periods and Electronic Warfare Courses all get a taste of Space. However, the ABT does not limit its activities to Cranwell; it has regular engagements at the Royal College of Defence Studies, The Joint Defence College and the Service Staff Colleges. Additionally, there are specialist presentations to bodies such as RMCS Shrivenham and the Central Tactics and Trials Organization. Of course the appeal of Space extends beyond the Services and so individual team members often address Usiversity Air Squadrons, University Physical Societies and even the likes of the Holland and Kesteven Branch of the Dental Association!

Undeniably the many invitations to the Team derive from its enviable reputation developed through years of exhaustive research into Space topics. Other significant contributions to that reputation have come from the builders of the ingenious demonstration modes and the talented artists who have produced so many of the striking visual effects used in the presentations. These factors, coupled with the high level of topical interest in President Reagan's Strategic Defence Initiative, bring an increasing number of invitations for the Team's services both at home and abroad. This year alone the ABT has addressed defence colleges and military staffs in Bangladesh, New Delhi, Rome, Bonn, SHAPE, Portugal, The Hague, the Western European Union in Paris and our own MOD.

Before you are tempted to immediately volunteer for duty with the ABT it may be worth outlining a little of the distaff side. For a start, the tools of the trade when travelling constitute a bulky 100 kilograms of excess baggage. If the physical burden is not enough there is always the added frustration of having every Customs Officer worldwide sheet on inspecting the mesterious washing geocentric orrery from deep within the boxes. Then there is the sustematic buttoncrunching and staining that certain 5-star hotels apply to tailor-made KD; although it does seem that the corresponding unitorns from RAF Stores are immune from such abuse, and the ability to hold desired creases. Added to all this is the risk of physical danger. In this year, potentially the most sinister event was that which left a would-be magger in Paris perpleted - be could not make himself understood to one of out intrepid travellers! More importantly, despite the physical dangers and in the face of all the frustrations, there is no him that any of the Team members would like to leave their posts and thus there will be no space in 'space' for quite some time.

May 2012 - RPV Warfare

Complex World, Complex Challenges: The Operation Of Remotely Piloted Aircraft Systems In Afghanistan

Dr Peter Lee, King's College London Lecturer in Air Power Studies, RAF College Cranwell

Base in Nevada, USA, was responsible for the deaths of four Afghan civilians and injuries to 2 others. This was the first Ministry of Defenceacknowledged killing of civilians involving the Reaper since the UK began remotely operating the equipment in Afghanistan in 2007¹. On a larger scale, American Reaper operations in Afghanistan, as well as in Pakistan, regularly result in civilian deaths. Available statistics are highly disputed, with a clear disparity between NATO-sourced reports and Afghanistan/ Pakistan-sourced reports. However, it is likely that USAF-operated Reapers in Afghanistan and CIA-operated Reapers in Pakistan have resulted in many dozens, perhaps many hundreds, of civilian deaths.

RPAS operations represent only a small, though increasingly important, proportion of the overall military effect in Afghanistan: a military effort that supports the strategic aims

long-term regional stability. RPAS operations that result in the deaths of civilians make up only a small proportion of the sorties flown but attract a high media profile, both domestically and internationally. However, civilian deaths in this highly complex asymmetric war attract not only unfavourable headlines, but also prompt a number of questions. These include, but are not limited to: Why has the UK government deployed RPASs in Afghanistan? What are the strategic and personal implications of civilian deaths, so called 'collateral damage'? What psychological impact does remote killing have on the Reaper crews, as well as on civilians in areas of operation? To what extent do NATO allies, especially the UK and US, share culpability for each other's actions?

A brief exploration of these questions will highlight the difficulty of conducting complex air operations in a hostile and uncertain enemy environment in the twenty-first century. It will also indicate the degree of sophistication required in current and future RAF training if air force personnel, of all ranks, are to develop the critical analytical skills and global political awareness necessary to successfully support the UK government's strategic aims through the application of airpower.

War is as old as humanity itself and the essence of war through the ages has remained largely unchanged: the desire of one state, tribe or group to impose its political will on another. Technological advances enable killing in war to be conducted on an industrial scale, using weaponry

n 25 March 2011 an attack from a Royal Air Force Reaper, a Remotely Piloted Aircraft System (RPAS) operated from Creech Air Force strategists even a century ago. The RPAS typifies the advances that have been made and present political and military leaders with the ability to kill enemies where covert infiltration on the ground would be impossible, at almost no risk to one's own airmen. However, before specific issues concerning the use of RPASs are identified, let us consider the basis on which they are currently being deployed

> On 12 September 2001, twenty four hours after the Al Qaeda attacks on New York and the Pentagon, President George W. Bush declared a wideranging and open ended 'War on Terror'. That same day, in response to a request from the US, NATO invoked Article 5 of its charter, thereby formally involving the UK in any military response:

The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defence recognised by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area².

The US and NATO sought no United Nations Security Council resolution authorising military action, adjudging that the principle of self-defence set out in Article 51 of the UN Charter legitimised their response to the attacks. In the weeks that followed, it emerged that the group responsible, Al Qaeda, and its leader Osama bin Laden had conducted their planning and training in Taliban-led Afghanistan. On 7 October 2001, after the Taliban government in Kabul refused to hand over bin Laden and other Al Qaeda personnel, US and UK forces launched an aerial bombardment and the fighting in Afghanistan began.

The extent to which the right to self defence justified the invasion of Afghanistan, when it was not the state itself but a group operating from within its borders that attacked America, continues to be a source of debate. The moral argument appears to be the most permissive and the right to self defence has sat at the heart of the just war tradition for millennia. International law, in the form of the UN Charter, was set out in the context of inter-state activities and does not easily lend itself to actions between states and sub-state actors such as Al Qaeda. Despite this on 20 December 2001, the UN Security Council authorised the establishment of an 'International Security Assistance Force' to assist the Afghan Interim Authority in the maintenance of security in Kabul and its surrounding areas³, authority that has been extended multiple times until the present.

Setting aside the intricacies of international law and military operations in Afghanistan, at no point has the UN provided any legal basis for the CIA's RPAS operations in Pakistan. Though mandated by the US government, American use of the Reaper across the Afghanistan/Pakistan border is in clear violation of Pakistan's sovereignty under Article 2 of the UN Charter which states:

All members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the UN4.

While the UK currently uses the Reaper within the terms of the UN authority granted to ISAF, its close military alliance with the US over the past decade means that in many quarters, both at home and abroad, the UK shares at least some degree of moral culpability for their partner's

At the level of tactical operations all military personnel operate under Rules of Engagement (RoE) that are authorised by their own governments, thereby locating armed forces personnel within their respective domestic legal frameworks. In addition, the UK is a signatory to the Rome Statute and all British Military personnel also fall under the jurisdiction of the International Criminal Court (ICC). Contrarily, the US, amongst others. does not submit to the authority of the ICC and would actively seek to prevent their soldiers, sailors, marines or airmen from facing trial at the

Further complicating matters is the nature of the insurgency in Afghanistan, fought as it is within civilian communities, with violence aimed at Afghans and ISAF personnel by other Afghans and foreign fighters. The 1977 Protocols Additional to the Geneva Conventions were compiled with the intention of protecting civilians in times of international armed conflict. Article 48 sets out the responsibility held by an attacker, a responsibility that complicates all allied actions, especially

In order to ensure respect for and protection of the civilian population and civilian objects, the Parties to the conflict shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives and accordingly shall direct their operations only against military

In the murky world of insurgency warfare such as we find in Afghanistan today, even if the Taliban or Al Qaeda choose to fight from amongst concentrations of civilians, the UK, as signatories to the 1977 Additional Protocols, is not released from its legal obligation to apply lethal force in a discriminating manner. Interestingly, the US has not ratified the 1977 Additional Protocols, which raises an ethical dilemma when British military personnel are operating RPASs alongside Americans. For example, a British crew⁶ seconded to the USAF would still operate the Reaper according to UK RoE. However, if presented with a target that fell outside those rules there is nothing to prevent that British crew from temporarily being replaced by an American crew whose more permissive RoE might allow the use of lethal force. In such a circumstance no laws

would appear to have been broken, yet the moral underpinnings of the UK's legal position appears to be somewhat precarious.

There is also a potential moral hazard in the use of unmanned aerial systems. One of the preferred uses of the RPAS is for the 'targeted killing' of key individuals. The lack of physical risk to the crew of the systems can result in the political willingness to undertake operations that would otherwise be avoided because of a high risk of allied casualties and the accompanying opprobrium of the general public. Such thinking necessarily escalates the risk to 'enemy' civilians where operations by conventional forces would otherwise be avoided because of the potential loss of military lives. This moral hazard can only increase as technologically advanced governments and militaries strive for greater and greater autonomy of remotely operated weapons systems

One final concern to be raised is for those who operate lethal weapons platforms from great distances. Unlike previous generations of aircrew who have faced the dangers of battle (as well as current crews of manned combat aircraft) from within a war zone. RPAS crews at Creech Air Force Base work in a relatively comfortable physical environment and at the end of each day continue a normal domestic existence with family and friends. Studies are already underway to assess the psychological consequences of living with an ever-present dichotomy of peace and war over an extended period. In addition, the RPAS crew can spend much greater time familiarising themselves with a target before killing him of her than is the case with the crew of a fast jet, who might only have a few seconds to acquire and strike a target before departing the scene equally quickly. Subsequently, the RPAS can spend much longer loitering overhead, its crew watching in great detail the physical consequences of the missile or bomb that they have just dropped.

From this brief consideration of events in Afghanistan over the past decade it quickly becomes apparent that complexities and tensions exist from the political justification of the use of force to the military application of lethal violence: exemplified here by the Reaper. There are no easy answers. Conventional warfare of the type seen thirty years ago in the Falkland Islands appears with hindsight to be almost straightforward when compared to the dilemmas posed on the ground and in the air in Afghanistan. Outright military victory against the Taliban appears as distant as Goose Green and Mount Tumbledown; the very notion of 'winning' is being redefined. The challenge that faces the Royal Air Force both now and in the future is to prepare its personnel to operate decisively and effectively in diverse and ambiguous situations, delivering effective airpower while maintaining the legal and ethical standards that the British people demand. RAF College Cranwell will continue to play a vital role at the heart of that endeavour and the Air Power Studies team is proud to make its small contribution.



^{1. 1.} http://www.defencemanagement.com, 6 July 2011, 'RAF Reaper strike killed

^{2.} Article 5, The North Atlantic Treaty, 4 April 1949.

^{3. 3.} UN Security Council Resolution 1386, 20 December 2001.

^{4. 4.} Article 2. Charter of the UN. 26 June 1945.

^{5.} Article 48. Protocol Additional to the Geneva Conventions of 12 August 1949.

^{6.} A Reaper crew consists of a pilot and a sensor operator. The former flies the aircraft while the latter controls surveillance equipment and the deployment of