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THE MET OFFICE GROWS UP:

IN WAR AND PEACE

by M E Crewe

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INTRODUCTION

This paper is based on notes made for talks given over some years past, hence specific references were sometimes not recorded, but much of the information can be found in the resources of the National Meteorological Library, Exeter. It is not intended to be a detailed comprehensive history but a personal collection of historical pointers to complement *Meteorology and Aerial Navigation* (Royal Meteorological Society Occasional Papers on Meteorological History, No.4; Crewe, 2002).

There was a time when people came of age when they became 21, so there may be some merit in the idea that meteorological services came of age in the 20s, that is the 1920s, although the period covered is really from the Edwardian era to what nearly became a second Edwardian age.

The First World War was a period of major changes, and a few notes may help put things into some context. Ramsey MacDonald of the Labour Party remarked ironically that the imperatives of war were achieving far more for social reform than had all the campaigns of the trade unions and progressive humanitarians in the previous half century. There were major advances in the emancipation of women, and the 1918 franchise reforms increased the electorate from 8 to 21 million. The death toll from the war was of the order of 8 or 9 million, and the losses in the influenza pandemic of 1918-19 could have been anything from 20 to 40 million. The changes in the practice of meteorology may have been on a rather different scale, but within our specialised world they were significant. Meteorology, as an interesting and possibly useful Edwardian pastime, became a scientific activity of increasing value to many human endeavours. The object of this paper is to record some of the ways that day-to-day meteorology changed and also to introduce notable meteorologists who either contributed to the improved meteorological services during the Great War or developed their interest in the subject. In the Annual Report of 1911-12 is a detailed summary of the services provided by the Meteorological Office, with the nearest approximation to a 'real-time' service being warnings of gales for shipping.

STAFFING

In 1914, some 30 of the 90 full-time staff of the Meteorological Office joined various branches of the forces. By the middle of 1915, the problems of the expanding work load and fewer staff led to a great increase in the number of women (clerks initially) being recruited. The staff also included the Meteorological Field Service (Forecast Division), known in France as 'Meteor', as well as Additional Temporary Staff for Special Duties. By July 1915, two officers, Captain Gold and Lieutenant Geddes, were at GHQ France and soon proved their usefulness. In November, Captain Gold was mentioned in a dispatch from C-in-C British Expeditionary Force (BEF), and in January 1916 Major Gold was awarded a DSO. By October 1915, the Meteorological Section of the Royal Engineers was formally established and the staff increased to 8 officers and 18 NCOs, plus various support staff and their own transport. During the remainder of the war, many men with qualifications in science joined the staff for voluntary duty or enlisted in the Meteorological Section of the Royal Engineers. Some of these possessed qualifications much above what was actually needed.

From 1919 to 1939, the Met Office pay-roll rose from 204 to 522, with more being recruited to the new Meteorological Branch of the RAF Volunteer Reserve, and by the end of the Second World War the Air Ministry staff numbered 6760. There were also many naval and army personnel involved with meteorology, though not necessarily full time.

Forecaster training was limited to graduate recruits who knew some basic mathematics and physics and then read up about meteorology in work published by the likes of Sir Napier Shaw or even Ralph Abercromby. Practical forecasting had to be picked up "sitting next to Nellie", i.e. by watching how seniors did it.

In March 1935, a draft reorganization introduced the idea of groups of stations to meet all aviation needs. The Met Office was also advised about plans for a trans-Atlantic flying-boat service. This had never been an area covered by routine forecasts, so an Investigation and Training Section of the Overseas Branch was formed. A team of graduates was set up at Croydon in February 1936 under S.P.Peters (formerly Cardington boss), learning from up-to-date texts such as David Brunt's book *Physical and Dynamical Meteorology* (Cambridge University Press, 1934). Staff developed expertise by crossing the Atlantic in cargo ships and by analysing series of old charts. Later in 1936, training of a more systematic nature started, first at Croydon and then over a Lyons Corner House in South Kensington (for more information, see Ogden 1992). Among the key players who contributed to the development of practical meteorological services one would note W.N.Shaw, W.H.Pick, M.A.Giblett, D.Brunt and E.Gold.

DRAMATIS PERSONÆ

An alphabetical roll call of some of the key players reveals many who made major contributions to meteorology during the 20th century but includes one or two who made their mark relatively briefly.

E.E.Austin, C.E.P.Brooks, D.Brunt, C.J.P.Cave, B.C.Clayton, H.Cotton, J.S.Dines, L.H.G.Dines, W.H.Dines, G.M.B.Dobson, C.K.M.Douglas, A.E.Gendle, M.A.Giblett. E.Gold, A.H.R.Goldie, G.Harris, H.Jeffreys, N.K.Johnson, R.G.K.Lempfert, H.G.Lyons, C.V.Ockenden, W.H.Pick, L.F.Richardson, W.N.Shaw, G.C.Simpson, M.T.Spence, G.I.Taylor, R.A.Watson-Watt

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ELEN ELAINE AUSTIN, MA

1895 – 17 July 1987 (Fig.1)

Miss Austin was an exceptional and early female scientific graduate recruit to the Met Office, joining in July 1918 with a Cambridge degree in Natural Sciences, gained after study at Mrs W.N.Shaw's college (Newnham). She was seconded to Imperial College as Napier Shaw's secretary when he was Professor of Meteorology there and served as his editorial assistant for his four-volume *Manual of Meteorology*. She returned to the Met Office in 1935 and thereafter specialised in climatology. She retired officially in 1955 as a Principal Scientific Officer but, in fact, stayed on until 1957 in a more junior grade. After Shaw died, she worked on significant climate papers for the Office, mostly upper winds and temperatures of various areas around the world. Most notably, she produced "A bibliography of the works of Sir Napier Shaw, FRS, 1854 -1945" (Austin, 1955).

Fig.1: Miss Austin

CHARLES ERNEST PELHAM BROOKS, ISO, DSc

10 November 1888 – 14 December 1957 (Fig.2)

Brooks joined the Meteorological Office as a Probationer in 1907 and by 1911 was a Clerk Assistant in the Statistics and Library Division under Ernest Gold. In 1912, he obtained a BSc degree with honours in geology, after studying in his own time, and in 1916 he gained an MSc in geology. In 1926, he was awarded a DSc in meteorology. He was a prolific author, pioneering climatologist and global key player in specialist library matters such as cataloguing. He was also an expert on meteorological statistics, writing the first specialist textbook on the subject (Brooks, 1953) with Nellie (Helen) Carruthers, who later married A.H.R.Goldie.

Fig.2: C.E.P.Brooks

PROFESSOR SIR DAVID BRUNT, KBE, MA, ScD, FRS

Fig.3: Sir David Brunt

17 June 1886 – 5 February 1965 (Fig.3)

After some years in academia, Brunt joined the Met Office in 1916, or, more specifically, the Meteorological Section of the Royal Engineers. In 1918, as Captain Brunt, he was at the Independent Air Force HQ, where he co-ordinated the flights of Lieutenants G.Marden and E.H.Sessions, and also Captain C.K.M.Douglas from May onwards. Their efforts impressed the Commanding Officer, General Hugh Trenchard, and the better upper winds and temperatures were used by Gold to brief General Rawlinson for the last series of attacks of the war.

When the Army Council asked the Meteorological Committee to take over meteorological work on artillery ranges near the end of the war, Captain Brunt became Superintendent of Army Services and held that post from 1919 to 1934. During this time, he established a research group at the Chemical Defence Establishment, Porton. He also became a visiting lecturer at Imperial College and in 1934 left the Met Office to become Professor of Meteorology at Imperial College, a post he held until 1952. His book *Physical and Dynamical Meteorology*, published in 1934, became the cornerstone for training forecasters in the middle of the 20th century, and may well have been the first to describe air masses and fronts in a practical way. For further information about Brunt, see Sutcliffe (1965) and Walker (1992).

CHARLES JOHN PHILIP CAVE, JP, MA, FRPS

1 May 1871 – 8 December 1950 (Fig.4)

Fig.4: C.J.P.Cave

Cave was a wealthy, well-educated gentleman who was greatly interested in meteorology. In 1901, he volunteered facilities for experiments carried out by W.H.Dines with meteorographs and kites, then helped to produce the results. Although not formally trained (but taught some meteorology by his friend Napier Shaw), he was mentioned regularly in the Annual Reports of the Met Office for his work, donations, writing, etc, but, like W.H.Dines, was never officially on the staff of the Met Office. Early in the war, he was commissioned in the reserve of officers in England and worked at the Royal Aircraft Factory, South Farnborough. When Meteor realized the need for observations in France, Cave was sent over to train meteorological observers, some with basic meteorological experience from other regiments and twelve from the Artists Rifles. But his stay in France was brief, only a month. By 1916, he was in charge at South Farnborough, having earlier been an honorary inspector of instruments, and he lectured to officers of the Royal Flying Corps. He also trained his Professional Assistant, R.A.Watson-Watt, with whom he wrote the first paper on radio direction finding. Unusually, Cave served twice as President of the Royal Meteorological Society (1913-14 and 1924-25); and his wife was at one time a vice-president (Ratcliffe, 1993). Clearly, Cave was a knowledgeable amateur who was respected enough by those in power to be given responsible jobs during the war.

FLIGHT COMMANDER BRIAN CHARLES CLAYTON, RN, AFC

Born 4 January 1890

Clayton was one of the fliers who realized the importance of gathering data about the state of the atmosphere and had the means and the motivation to do something about it. Flying off the Flemish coast during the winter of 1916-17, he produced "Records of temperature and altitude" which included comments by Sir Napier Shaw (Clayton, 1917). He served in the RNAS until 1918 and then transferred to the RAF, with the rank of Captain. He was awarded the AFC on 29 October 1918.

Another pilot, Major William Ringrose Gelston Atkins (1884-1959), presented his (Atkins') data in a report entitled "Variation of temperature and humidity with altitude: notes on the wind and other meteorological observations made at Aboukir" (Egypt) in 1917. This was published by the Cairo Physical Service in 1918 and in one of the Advisory Committee for Aeronautics Reports and Memoranda (No.436, 1918).

PROFESSOR HARRY COTTON, DSc, MSc

17 June 1889 – 27 July 1985

Corporal Cotton was a classic example of someone with an academic background deemed sufficient to qualify him to be a meteorological observer. He studied in Manchester under Professor Ernest Rutherford and lectured at Huddersfield Technical College before he joined up in 1916. Trained in engineering, mathematics and physics, he was sent to France, where he was interviewed by Ernest Gold, who thought him suitable to become a field meteorologist. He was posted to a double observer unit attached to a Scottish Division. Early in the war, balloons were used by aerial spotters, usually artillery men, but, as the need increased for upper winds and temperatures, they also included meteorologists. To put science and the military into context, he told the story of finding himself lodged *en route* with a unit looking after gas and discovered they were graduate chemistry teachers conscripted "just to turn on the bloody gas taps"!

Cotton recounted amusing incidents resulting from the fact that Meteor staff were attached to Army units for food and shelter but were answerable only to General Headquarters for their work. Sent to France with two stripes but no military training, no square-bashing or weapons training, but with GHQ authority to demand priority telephone calls, he had a lot of autonomy. The upper echelons realized the need for 'instant' reports if the wind changed to a direction potentially dangerous for the movement of poisoned gas, but the military men in the field took a long time to grasp the point that meteorological reports lose their value if not communicated as nearly instantly as possible. Military priority became mixed up with operational urgency, perhaps not for the first or last time. Cotton was promoted to Temporary Second Lieutenant in January 1918. His memoirs in the *Meteorological Magazine* are an interesting read (Cotton 1979, 1980). After the war, he became a lecturer in Electrical Engineering at what was then University College Nottingham. He published several important books and many articles and rose to become Professor of Electrical Engineering at Nottingham University. He retired in 1954 and then became an Emeritus Professor of Nottingham University.

DINES, DINES AND DINES – A DYNASTY OF METEOROLOGISTS

JOHN SOMERS DINES, MA

18 June 1885 – 15 May 1980

J.S.Dines graduated from Cambridge in 1906, in mathematics, and then worked for a year with his father (W.H.Dines) at Pyrton Hill, Oxfordshire, carrying out investigations of the upper air. He joined the Met Office in September 1907. Investigations of wind structure for the Advisory Committee for Aeronautics were transferred to the new branch of the Met Office at South Farnborough in 1912, with J.S.Dines in charge (Annual Report, 1912). In the autumn of 1913, accompanied by G.M.B.Dobson, he visited six stations in Germany to see how they dealt with forecasting and aviation work. By March 1916, he had transferred to the Forecast Division, where he remained for many years.

Fig.5: L.H.G.Dines

LEWEN HENRY GEORGE DINES, MA, AMICE

23 October 1883 – 6 October 1965 (Fig.5)

Like his brother Somers, L.H.G.Dines graduated from Cambridge in 1906, also in mathematics, but then practised as an engineer. Six years later, he joined the Met Office and was posted to Eskdalemuir. From there, he went to Valencia, where he served as Superintendent from 1920 to 1922. Then, after a year at Benson Observatory, with W.H.Dines, he remained at Kew for nearly a quarter of a century. He did a competent job dealing with instruments, especially those used for investigating the upper air, but scientifically he was not in the same league as his father W.H.Dines, or even his brother Somers.

WILLIAM HENRY DINES, BA, FRS

5 August 1855 – 24 December 1927 (Fig.6)

"One of the most noteworthy features of the Office during the war has been the issue of information about the average pressure, temperature and density at different levels in the upper air, prepared by Mr.W.H.Dines, FRS, from observations which he himself obtained" (Annual Report of the Meteorological Committee 1919). The information was originally requested by those interested in aircraft engines but proved "indispensable for questions of ballistics and for many purposes of aviation". Although he was never a Met Office employee or full-time academic, reference was made to the work and views of William Henry by nearly all of the meteorological writers of the day.

Fig.6: W.H.Dines

GORDON MILLER BOURNE DOBSON, CBE, DSc

25 February 1889 – 11 March 1976 (Fig.7)

Fig.7: G.M.B.Dobson

As a Research Student of Gonville and Caius College (Cambridge), Dobson worked from 1 October 1911 to 31 March 1913 as a Graduate Assistant at Kew Observatory, with a salary of £60 *per annum* from the Met Office plus a Studentship of £50 *per annum* from Gonville and Caius. Then, for six months in 1913, he was at Eskdalemuir Observatory to 'mind the shop' until L.F.Richardson took up the post of Superintendent. He also went to Crinan to help W.H.Dines fly kites and there met and became friends with George Simpson, who was also visiting. In 1912, he had a spell helping J.S.Dines with preparing charts and making pilot balloon ascents at Farnborough. Then, in the autumn of 1913, he accompanied J.S.Dines on a visit to six stations in Germany to see how they approached forecasting and aviation work. In 1913, the War Office offered him a lectureship in meteorology at the Central Flying School, Upavon. Whilst there, he launched balloons to measure the wind; and he presented the results of his work in a paper published in the *Quarterly Journal of the Royal Meteorological Society* (1914, Vol.40, pp.123-136). He also published a report entitled "Observations of wind structure made at Upavon in 1914" (Advisory Committee for Aeronautics Reports and Memoranda No.325, 1917). This report impressed G.I.Taylor and the two became friends with a mutual interest in turbulence. Although not himself a flyer, Dobson was very much involved with aviation and flying instruments. He became Director of the Experimental Department at the Royal Aircraft Factory (Royal Aircraft Establishment) at

Farnborough and, amongst other things, developed a meteorograph for making upper-air soundings with an aircraft (Middleton, 1969). Although he studied various aspects of the atmosphere, he returned to academic life in Oxford after the war and went on to become the world expert in the measurement and study of ozone.

CHARLES KENNETH MACKINNON DOUGLAS, OBE, AFC, MA

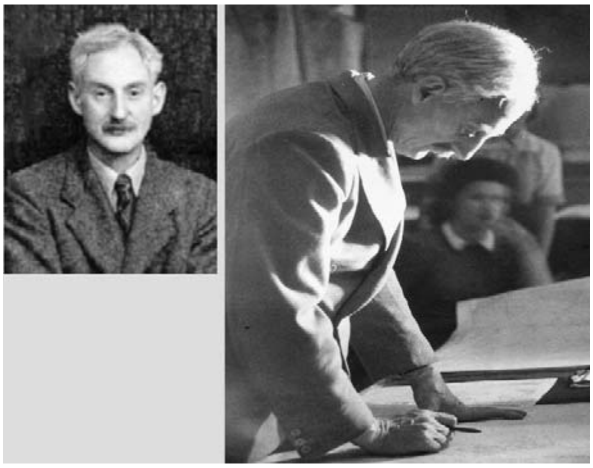


Fig.8: C K M Douglas in the 1920s and as senior forecaster in the 1940s

29 May 1893 -19 February 1982 (Fig.8)

Douglas was commissioned into the Royal Scots but then transferred to the Royal Flying Corps and followed his interest in meteorology, studying and photographing clouds and publishing papers on clouds and aeroplanes, even making a plea for the regular use of aircraft to make meteorological observations (Douglas, 1916). He was injured five times and rose to the rank of Captain. He caught the attention of Ernest Gold, who secured his services for a meteorological flight in 1918. After the war, he joined the Met Office to become one of the most respected synoptic meteorologists in the world and a key forecaster for Operation Neptune, the D-Day invasion of France (Field, 1999).

ALBERT EDGAR GENDLE, OBE

September 1886 – 7 December 1923

Gendle was a Boy at Kew Observatory and then, in 1908, became an Observer, later Clerk Assistant, at Eskdalemuir, when that observatory was opened. He worked at Eskdalemuir until 1913 and then joined the staff of the Met Office's South Kensington HQ. He trained with the County of London Yeomanry when war broke out but in March 1915 became a Lieutenant in the RNVR. When he left the Met Office, in 1919, he joined the RAF, as a Flight Lieutenant.

In 1918, he obtained a patent (GB127207, 30 December 1918) for improvements in connection with the weighing and filling of pilot balloons. To quote the Abstract of GB127207, he patented "Steelyard apparatus; computing-apparatus. An apparatus for use in connexion with small india-rubber pilot balloons employed for determining the velocity and direction of the wind, whereby the balloon is weighed and inflated sufficiently to give a certain rate of ascent … ".

Gendle wrote about meteorological conditions during Zeppelin raids in 1915 (copy of his report held in the National Meteorological Archive, Record Number 725590); and he produced the first internal report on services for transatlantic flights, which he passed to the Director on 2 January 1920 (Fig.9). A copy of this report (Gendle, 1920) is held in the National Meteorological Archive (Record Number 279951).

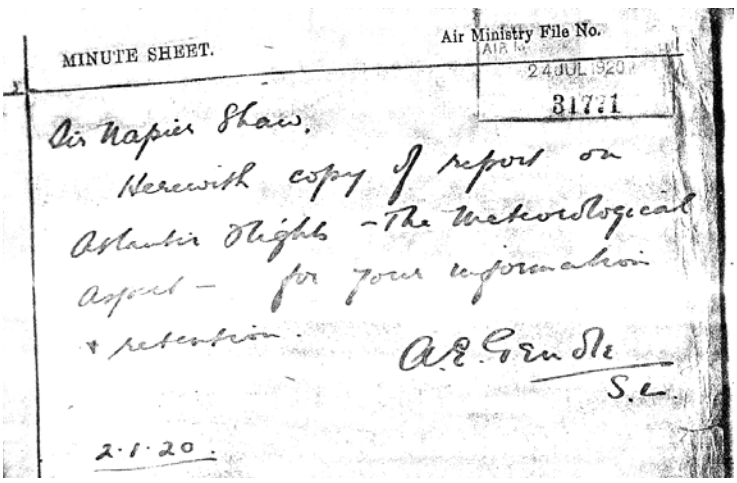

MINUTE SHEET.
Air Ministry File No.
24 JUL 1920
31771
Sir Napier Shaw.
Herewith copy of report on Atlantic Flights – The Meteorological aspect – for your information & retention.
A.E. Gendle
S.C.
2.1.20.

Fig.9: Gendle reported to the Director

On 7 December 1923, Gendle was killed when attacked by Arabs on the outskirts of Baghdad, Iraq. "Before the War", *Flight Magazine* reported, "Flight-Lieutenant Gendle was with the South Kensington Meteorological Department, and was selected to form the various observation stations of the RNAS throughout the British Isles. Later, he went to the Air Ministry, where he carried out the meteorological surveys and observations in connection with the transatlantic flights of the "R" type airships and of aeroplanes".

MAURICE ALFRED GIBLETT, MSc

15 July 1894 – 5 October 1930 (Fig.10)

Giblett was an exceptional mathematician who, after graduation from University College Reading in 1914, was a schoolmaster for most of the period 1915 to 1918 and thereafter served in the army for a short time. He re-joined the Met Office in November 1919, having been associated with it for a short while in late 1915, and quickly established himself as a very competent meteorologist, becoming Assistant Superintendent of the Forecast Division in 1922. He was co-author, with Jacob Bjerknes, of a paper about the life cycle of a depression over the United States (published in the *Monthly Weather Review*, 1924, Vol.52, pp.521-527). He also compiled the index for L.F.Richardson's classic book on *Weather prediction by numerical process*. Giblett was made Superintendent of the new Airship Division of the Met Office on 1 January 1925 and in this role initiated so much scientific work at Cardington that Rudolf Lempfert dedicated his 1931 Royal Meteorological Society Presidential Address to it (published in the *Quarterly Journal of the Royal Meteorological Society* in 1931, Vol.57, pp.119-131). Giblett and his colleagues learned how to forecast for large oceanic areas, becoming experts in air masses and fronts and then delivering forecasts in a new way using techniques like radio. Planning flights in new areas and at higher altitudes demanded major new climatological studies. Handling massive airships near the ground revealed the need to know more about low-level winds and temperatures. This led to Giblett starting a major investigation of the boundary layer, his legacy being an exceptional research tradition at Cardington and the blueprint for international aviation services. He was also an active member of the British Association for the Advancement of Science. Sadly, he perished in the R.101 disaster.

Fig.10: M.A.Giblett

ERNEST GOLD, CB, DSO, FRS

24 July 1881 – 30 January 1976 (Fig.11)

Gold was awarded First Class Honours in the Cambridge Natural Sciences Tripos in 1904 and became a Fellow of his College (St John's) in 1906. That same year, he was one of the first so-called 'qualified scientists' to join the Meteorological Office, but he returned to Cambridge the following year (1907) as Schuster Reader in Dynamical Meteorology and remained there until 1910, whereupon he returned to the Meteorological Office (Sutcliffe and Best, 1977). In 1912, he was awarded first prize of 2000 marks in an essay competition organized by the German Meteorological Institution.

Fig.11: Ernest Gold in 1935 and (right) near retirement

With great practical ability, Gold set up the first operational (military) meteorological service and demonstrated the vital role of meteorologists to the military hierarchy, to such good effect that he was mentioned in dispatches. He was awarded the DSO and OBE and rose to the rank of Lieutenant Colonel.

Gold oversaw not only the creation of an operational weather service but also the development of international aviation services, becoming President of the Commission for Synoptic Weather Information of the International Meteorological Organization (the body that in 1950 became the World Meteorological Organization). As an Assistant and, later, Deputy Director of the Meteorological Office, he dominated operational activities for a quarter of a century, including the dramatic expansion during World War II. He had a high reputation for his organizing skills and attention to detail.

Scientifically, he made at least two major contributions to practical weather forecasting. He produced a report for the Director of the Meteorological Office "On the calculation of wind velocity from pressure distribution and on the variation of meteorological elements with altitude", which must have been a revolutionary new technique for forecasters (Gold,1908). Later, he sent a letter to Sir Napier Shaw containing the original proposal for the term 'Thermal Wind'. The reply by Shaw included calculations by

J.S.Dines (Gold,1918). The thermal wind idea stemmed from 19 October 1917, when some Zeppelins had a serious navigation problem "through failure to allow for the effect of a warm air mass to the west in turning a weak southerly wind at low levels into a strong northerly wind at very great heights" (Gold, 1955). For convenience and as a brief résumé for others, the idea of ‘fitness for flying’ came into use as a function of the wind, weather, cloud and visibility and in some cases the type of aircraft.

Between the wars, Gold was an Assistant Director of the Meteorological Office, but more significant was his contribution to international meteorology. In 1920, the International Meteorological Organization (IMO) set up a Commission to deal with questions of synoptic meteorology and Gold was elected president, a post he held until 1947. He also served on three other commissions of the IMO and served as President of the Meteorological Sub-Committee of the International Commission for Aeronautical Navigation. He applied a scientific approach and presented a numerical index to the Third International Congress of Aerial Navigation. The concept of a ‘fitness figure’ was still widely used during the Second World War, and during the 1970s the concept was reinvented in the RAF as a ‘colour state’. He was a man of great ability who played a key role in the development of practical meteorological services in the 20th century and, perhaps even more importantly, international co-operation. He was a strong personality with an eagle eye for detail (Mason, 1976).

ARCHIBALD HAYMAN ROBERTSON GOLDIE, CBE, DSc, FRSE

7 July 1888 – 24 January 1964 (Fig.12)

Goldie was a Cambridge wrangler who joined the Meteorological Office in August 1913 and served first in the Forecast Division at Falmouth Observatory and then as Senior Assistant to L.F.Richardson at Eskdalemuir Observatory. He was commissioned in the Meteorological Section of the Royal Engineers in September 1915 and served the rest of the War overseas. He was Meteorological Officer to General Rawlinson at HQ 4th Army for some time and spent late 1917 and early 1918 setting up a meteorological organization for British Forces in Italy. He then returned to France and went on to become a Major and take command of the Meteorological Section of the British Army of the Rhine, with Headquarters in Cologne. He was mentioned twice in dispatches. In 1919, after demobilization, he rejoined the Met Office, where he worked until May 1953, rising to become a Deputy Chief Scientific Officer and the Deputy Director of Research. During World War II, he was much involved with the physics of contrails and developing the Mintra line on tephigrams. After his first wife died, he married Nellie (Helen) Carruthers – joint author of the *Handbook of Statistical Methods in Meteorology* with C.E.P.Brooks. He wrote many papers and was a well-liked, good research scientist as well as a competent administrator.

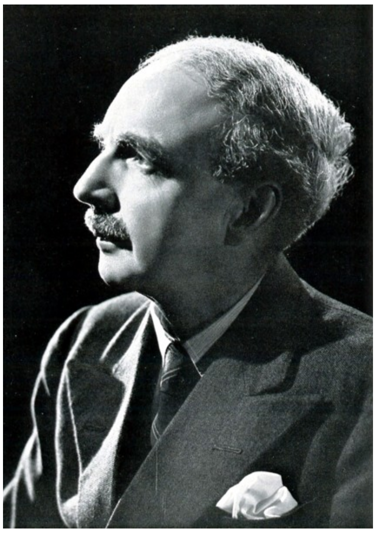


Fig.12: A.H.R.Goldie

GUY HARRIS, AFC (circled in the R.34 crew photograph: Fig.13)

It is difficult to be sure of Harris’s career. There was a Boy Clerk G.Harris at Kew in 1910-11 and a 'Clerk Computer' in 1913 but not named as 'Guy'. Lieutenant Guy Harris flew to the USA and back in the R.34 Airship in 1919 as the meteorologist in the crew, and was awarded the Air Force Cross (a medal awarded for gallantry or devotion to duty while flying during non-combative flight operations). Harris was at Howden (an airship base) in 1920, Andover in 1921, Pulham (another airship base) in 1923 and in the Met Office’s HQ Forecast Division in 1924. Thereafter, there is no mention of him resigning or being transferred. He must have been the first meteorologist to fly as an operational member of the crew of any aircraft. His practical experiences when preparing for and undertaking the flight must have helped Gendle with his unpublished report regarding trans-Atlantic trips (Gendle, 1920).

Fig.13: Some of the R.34 crew. Picture kindly supplied by Patrick Abbott (Abbott, 1994)

SIR HAROLD JEFFREYS, DSc

22 April 1891 – 18 March 1989 (Fig.14)

Jeffreys was a brilliant mathematician who was elected a Fellow of St John's College, Cambridge, in November 1914 and remained one for the rest of his life. He held the Isaac Newton Studentship from 1914 to 1917 and worked part-time at the Cavendish Laboratory on wartime problems from 1915 to 1917. He moved to the Meteorological Office in London in 1917, where he first applied his mathematical skills to "certain difficult questions in gunnery which came to us from the services" and then to "problems of the atmosphere". He was also in charge of the Library for some time. In 1922, he returned to Cambridge as College lecturer in mathematics and in 1926 was appointed to a university lectureship. He retired in 1958 and was one of the small international group of scientists who founded modern geophysics.

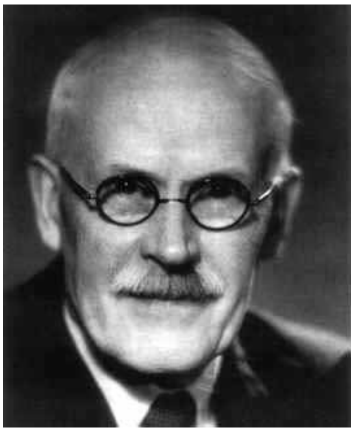


Fig.14: H.Jeffreys

SIR NELSON KING JOHNSON, KCB, DSc, ARCS

11 March 1892 – 23 March 1954 (Fig.15)

Johnson studied at the Royal College of Science, South Kensington, where he gained an honours degree in physics and carried out research in astrophysics. Then, in 1913, he went to the Hill Observatory at Sidmouth, as assistant to Sir Norman Lockyer and his son Dr W.J.S.Lockyer. He joined the RFC in 1915 and served as a pilot until 1919, soon coming to appreciate the importance of forecasting visibility and cloud correctly and supplying timely meteorological advice to pilots. He suffered a serious crash during a flight in bad visibility but survived to join the Met Office in 1919. His first posting was to Shoeburyness, to work on meteorology in relation to gunnery, and he was then, in 1921, seconded to the War Office to take charge of the meteorological section of the chemical warfare experimental station then being established at Porton in Wiltshire by the Royal Engineers. He left the Met Office in 1928 when he became Director of Experiments at Porton. He later became Chief Superintendent of the Chemical Defence Research Department at the War Office, only to return to the Met Office as Director in 1938. He overworked so much during and after the Second World War that his health was seriously undermined by the time he retired in 1953 (Gold, 1954a; Goldie, 1954).

Fig.15: N.K.Johnson

RUDOLF GUSTAV KARL LEMPFERT, CBE, MA, FInstP

Fig.16: R.G.K.Lempfert

7 October 1875 – 24 June 1957 (Fig.16)

Lempfert was the first scientist recruited by Napier Shaw into the Met Office (from Rugby School in 1902) and co-authored with him a seminal paper entitled "The life history of surface air currents: a study of the surface trajectories of moving air" (Shaw and Lempfert, 1906). This paper anticipated some of the work published after World War I by the meteorologists of the Bergen School who introduced the concept of fronts as boundaries between air masses.

Shaw wanted Lempfert, his Head of Forecasting, to lead the new Meteorological Section of the Royal Engineers during hostilities, but the second choice Ernest Gold got the job, reputedly because Lempfert's parents were born in Germany. Lempfert was, however, Superintendent of the Forecast Division in London throughout the war and worked as a forecaster on the bench – even doing night duties. With many changes of staff and greatly increased demands, including data, forecasts and training for Royal Engineers and Royal Navy units at home and abroad, especially in France, he kept the Forecast Division running and gained the CBE (Burton, 1996). The Met Office in London supported the staff in France with five telegrams daily, providing forecasts and coded reports in five-figure groups.* Many years later, Gold paid a glowing tribute to the work of the staff in London that supported the units in France (Gold, 1955).

** Reputedly, the telegraph company charged per word and deemed the average word was five letters, hence meteorological messages were established as five-figure groups – and stayed that way until computers allowed more flexibility.*

COLONEL SIR HENRY GEORGE LYONS, DSc, FRS

11 October 1864 – 10 August 1944 (Fig.17)

Fig.17: H.G.Lyons

Lyons was educated at Wellington College and Woolwich and became a Royal Engineers Officer who established his scientific reputation as director of the Geological Survey of Egypt. This later became the Egyptian Survey Department and included responsibility for a meteorological service.

The Royal Society nominated him on to the Meteorological Committee in February 1913. As a Major, he became officer in charge (Commandant) of meteorological services for the Army and, on behalf of the Director of the Meteorological Office, set up the Meteorological Section of the Royal Engineers in September 1915, under the technical control of Ernest Gold, with their functions defined as follows:-

- *To act as Meteorological Advisers to the General Staff, both at General Headquarters and at Army Headquarters.*
- *To supply all the meteorological information required by the Royal Flying Corps [later the Royal Air Force].*
- *To furnish the regular reports required for the correction of range in Artillery operations.*
- *To furnish meteorological reports and forecasts for offensive and defensive gas operations.*

Lyons was a formal traditionalist but an exceptional administrator and acted as Director of the Met Office from 23 May 1918 to 28 April 1919 to allow Shaw time to act as Scientific Advisor to the government and also to write a book needed to train forecasters. Colonel Sir Henry Lyons was a president of the Royal Meteorological Society (1915-17) and represented the Royal Society on the Meteorological Committee for 26 years. He was, perhaps, one of the most eminent army men to become active in the field of meteorology, although not basically a meteorologist. He retired from the army as a colonel in 1919 and became Director of the Science Museum in 1920 (Burton, 1998).

CYRIL VICTOR OCKENDEN, BSc

12 July 1897 – 17 July 1988 (Fig.18)

Ockenden joined the Met Office as a probationer in 1914-15. As a Corporal during the war he was mentioned in dispatches. His potential was clearly recognised, for he was granted special leave after the war to study for a degree. He was a junior professional assistant at Calshot in 1924-5 and later a forecaster at several stations in the south of England. He wrote a number of articles for *Weather*, the *Meteorological Magazine*, the *Marine Observer* and the *Bulletin of the World Meteorological Organization*, one of them entitled “Use of Esperanto by meteorologists” (*Met.Mag.*, 1956, Vol.85, pp.56-57). He published only two papers in the *Quarterly Journal of the Royal Meteorological Society*: "A comparison between surface wind and ground day visibility at Andover and Winchester (Hants) over the four years 1924 to 1927" (1928, Vol.54, pp.337-340); and “High altitude pilot balloon ascents at Habbaniya, Iraq” (1939, Vol.65, pp.551-553). Some of us came to know him as a weather presenter on TVS from Southampton in the 1970s – perhaps the only ex-member of Meteor ever to work on television.

Fig.18: C.V.Ockenden

WILLIAM HENRY PICK, BSc, FInstP

14 January 1891 – 26 December 1947

Pick graduated in science from University College London in 1911 and then until 1914 taught science at Basingstoke. He served in the Meteorological Section of the Royal Engineers during the war and was commissioned as a Lieutenant in 1918. He served on the Western Front and in 1919 was in northern Russia in charge of meteorological detachments at Murmansk and Archangel. He joined the civilian staff of the Meteorological Office in 1920 and was posted to Cranwell, where by March 1921 he had written a textbook on meteorology for training RAF cadet pilots. Called *A Short Course in Elementary Meteorology* (M.O.247), it was a book that was for many years a cornerstone text for professional and lay students trying to understand meteorology. It was updated and reprinted many times. He remained at Cranwell until 1928 and then became a senior forecaster at Met Office Headquarters. Four years later, he was posted to Andover, where, as it was put in the obituary published in the *Quarterly Journal of the Royal Meteorological Society* (1948, Vol.74, pp.128-129), “he was back in immediate contact with aviation as Meteorological Officer with the Royal Air Force Unit engaged on research into cloud-flying with its attendant risks of ice accretion and collision". In 1939, he became Meteorological Officer at HQ Bomber Command; and later in World War II he was concerned with meteorological aspects of smoke screening.

LEWIS FRY RICHARDSON, DSc, FRS

11 October 1881 – 30 September 1953 (Fig.19)

Richardson gained a First in Part I of the Cambridge Natural Sciences Tripos in 1903 but did not take Part II of the examination. After that, he was employed for short periods of time at the National Physical Laboratory (twice), University College Aberystwyth, National Peat Industries Ltd in Newcastle upon Tyne, the Sunbeam Lamp Company in Gateshead and the Physics Department of the Manchester College of Technology. Then, in 1913, he joined the Meteorological Office, as Superintendent of the Observatory at Eskdalemuir.

As early as October 1914 he wanted to join a Red Cross unit of the Ambulance Corps, but permission was declined on more than one occasion. He persisted, without success, and eventually, in May 1916, resigned from the Met Office, after which he became a driver for a motor ambulance convoy lent to the 14th French Army. He made no direct contribution to the developing meteorological services during the war, but his ideas were known and probably influenced some of the decision making. A good summary of his situation comes in his own words from the preface of his 1922 book (Richardson, 1922):

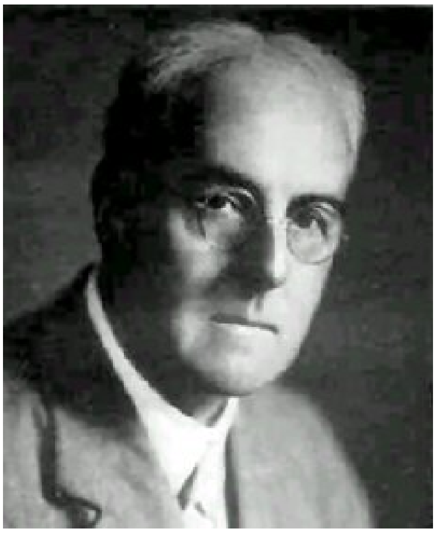


Fig.19: L.F.Richardson

The extensive researches of V.Bjerknes and his School are pervaded by the idea of using the differential equations for all that they are worth. I read his volumes on Statics and Kinematics soon after beginning the present study, and they have exercised a considerable influence throughout it; especially, for example, in the adoption of conventional strata, in the preference for momentum-per-volume rather than of velocity, in the statical treatment of the vertical column, and in the forced vertical motion at the ground. But whereas Prof.Bjerknes mostly employs graphs, I have thought it better to proceed by way of numerical tables. The reason for this is that a previous comparison of the two methods, in dealing with differential equations, had convinced me that the arithmetical procedure is the more exact and the more powerful in coping with otherwise awkward equations. Graphical methods are sometimes elegant when the problem involves irregularly curved boundaries. But the atmospheric boundary, at the earth, nearly coincides with one of the co-ordinate surfaces, so that graphs would have no advantage over arithmetic in that respect.

It has been customary to regard line squalls and other marked discontinuities as curious exceptions to the otherwise smoothly gradated distribution of the atmosphere. But in the last two years Prof.V.Bjerknes and his collaborators J.Bjerknes, H.Solberg and T.Bergeron at Bergen have enunciated the view, based on detailed observation, that discontinuities are the vital organs supplying the energy to cyclones. The question then arises: how are we to deal with discontinuities by finite differences? For such purposes graphs have a special facility which numerical tables lack. But it is not to be expected that a knowledge of the position and motion of surfaces of discontinuity will prove to be sufficient for forecasting, any more than 'vital' organs alone would suffice to keep an animal alive. So probably the most thorough treatment will be reached by tabulating quantities numerically, where they vary continuously, and by drawing a line on the table where there is a discontinuity. The line will be a notification to the computer that one may interpolate up to it from either side, but not across it.

This investigation grew out of a study of finite differences and first took shape in 1911 as the fantasy which is now relegated to Ch.11/2. Serious attention to the problem was begun in 1913 at Eskdalemuir Observatory with the permission and encouragement of Sir Napier Shaw, then Director of the Meteorological Office, to whom I am greatly indebted for facilities, information and ideas. I wish to thank Mr.W.H.Dines, FRS, for his interest in some early arithmetical experiments, and Dr.A.Crichton Mitchell, FRSE, for some criticisms of the first draft. The arithmetical reduction of the balloon, and other observations, was done with much help from my wife. In May 1916 the manuscript was communicated by Sir Napier Shaw to the Royal Society, which generously voted £100 towards the cost of its publication. The manuscript was revised and the detailed example of Ch.IX was worked out in France in the intervals of transporting wounded in 1916-1918. During the battle of Champagne in April 1917 the working copy was sent to the rear, where it became lost, to be re-discovered some months later under a heap of coal. In 1919, as printing was delayed by the legacy of the war, various excrescences were removed for separate publication, and an introductory example was added. This was done at Benson, where I had *again the good fortune to be able to discuss the hypotheses with Mr.W.H.Dines. The whole work has been thoroughly revised in 1920, 1921. As the cost of printing had by this time much increased, an application was made to Dr.G.C.Simpson, FRS, for a further grant in aid, and the sum of fifty pounds was provided by the Meteorological Office. For the construction of the index we are indebted to Mr.M.A.Giblett, MSc. The discernment and accuracy with which the Cambridge Press have set the type have been constant sources of satisfaction.*

The Annual Report of the Meteorological Office for 1917-18 stated that Mr.L.F.Richardson on leaving the Observatory at Eskdalemuir had presented an elaborate paper on *Weather Prediction by Finite Differences* which was forwarded to the Director for the consideration of the Royal Society. The Society offered a grant towards the cost of its publication, and the Cambridge University Press undertook the work with the title *Weather Prediction by Arithmetical Process* (Annual Report, 1918), but it was another four years before it actually appeared.

In 1926, Richardson gained a London University DSc in physics and then, in 1929, after losing interest in meteorology, a BSc degree in psychology from the same university! For details of Richardson's life and work, see Gold (1954b) and Ashford (1985).

SIR WILLIAM NAPIER SHAW, MA, ScD, LLD, FRS

6 March 1854 – 23 March 1945 (Fig.20)

Shaw graduated Sixteenth Wrangler at Cambridge in 1875 and gained a distinction in physics in the Natural Sciences Tripos the following year. He became a Fellow of Emmanuel College in 1877 and was employed soon afterwards in the newly-opened Cavendish Laboratory, where he worked first under James Clerk Maxwell and later Lord Rayleigh. His reputation as a scientist grew rapidly. He was elected a Fellow of the Royal Society in 1891 and became by 1898 Assistant Director of the Cavendish Laboratory. In 1900, he was appointed Secretary to the Meteorological Council, the body which controlled the Meteorological Office. As such, he was effectively Director of the Office, and from 1905 his official title was, in fact, Director. He pioneered the idea that the use of mathematics and physics might raise scientific standards in the Met Office and showed by a number of shrewd appointments the correctness of this vision.

Fig.20: W.N.Shaw

With R.G.K.Lempfert, he co-authored *The life history of surface air currents: a study of the surface trajectories of moving air* (Shaw and Lempfert, 1906), which anticipated some of the work subsequently published by the Bergen School, though they omitted to mention fronts as such. He was in the vanguard of meteorological scientists, as Fig.21 illustrates (see page 12).

When telegrams arrived for the Meteorological Committee in May 1915, Shaw negotiated with the War Office. By 10 June, Major Lyons (*q.v.*) had proceeded to General Headquarters in France as the Director's representative and to organize meteorological matters. Also, two members of the Meteorological Office staff had been released and granted commissions and sent to France. They were Captain E.Gold and Lieutenant A.E.M.Geddes. All this was set up in a little over one month.

A letter that Shaw wrote in 1913 is a good illustration of how far-sighted he was in the science of meteorology. Fig.21 is part photocopy and part transcript taken from the original when it passed through the National Meteorological Library and Archive some years ago. The added picture from Shaw's *Manual of Meteorology* Volume 1 has no caption but in the text refers to the meteorology of the future. In 1920, Shaw was invited to Bergen to discuss the ideas of the Scandinavian meteorologists and was accompanied by A.H.R.Goldie, C.K.M.Douglas and L.F.Richardson. The visit reflected the contact between Shaw and Vilhelm Bjerknes over some years; and Brunt even suggests that the Bergen work was a refinement of Shaw and Lempfert's publication on the history of air masses.

Appreciating the importance of upper-air data, Shaw introduced the tephigram in 1926, thus providing one of the main tools for future forecasters. Shaw was at the helm of the Meteorological Office until 1920 and was so successful in raising standards that the Government, in particular Winston Churchill, considered it so important for the Office to be under government, i.e. military, control that they put the Office into the newly formed Air Ministry. However, Shaw was convinced that meteorology was primarily a scientific pursuit and should be administered as such, even advocating such an approach in an annual report. Having the courage of his convictions, and being over retirement age anyway, he left his civil service desk job and pioneered the teaching of meteorology as a science by becoming Professor of Meteorology at Imperial College (Burton 1995).

METEOROLOGICAL OFFICE,
SOUTH KENSINGTON,
LONDON, S.W.
September 6 1913

Dear Professor Bjerknes

The new superintendent of the Observatory at Eskdalemuir has ambitions about the solution of the meteorological future

The new superintendent, of the Observatory at Eskdalemuir has ambitions about the solution of the meteorological future by a finite difference solution of Laplace's Equation,' He presented me the other day with what he called a dream of a palace at the Hague in which 500 computers were taking down the observations for all parts of the world ??? out from a conductor's box in the middle of a great theatre, each computer dealing with the observations for one compartment, I explained to him that you had already set out upon the programme and recommended him to digest what you had already done, We have no copy of your two volumes at the observatory which is in Scotland 18 miles from any Railway Station and 60 miles from any library that is likely to have your books so I promised to see if I could get one for him. Have you any copies to give away? Or would the Carnegie Institution like to be asked to present one? Or shall I buy one? Please tell me frankly and I shall follow your advice,

I hope you are finding the work at Leipzig congenial & with kind regards to Madame Bjerknes and yourself

I am

Yours most truly

W. N. Shaw

Fig.21: Letter from Shaw to Bjerknes

SIR GEORGE CLARKE SIMPSON, KCB, FRS

2 September 1878 – 1 January 1965 (Fig.22)

Simpson was born in Derby and worked for his shopkeeper father until he was 19, when he proceeded to read physics at Owens College, Manchester, which was then (with the university colleges at Liverpool and Leeds) part of Victoria University. He carried out research on atmospheric electricity at the University of Göttingen from 1902 to 1905 and then, after a brief spell with the Meteorological Office, returned to Manchester (to what had by then become Manchester University) to become the first lecturer in meteorology in any British university. The following year, he joined the India Meteorological Department (IMD), but he remained in India only until 1909, when he accepted the invitation of Captain Scott to accompany him to the Antarctic as his expedition's meteorologist. In the Antarctic, he became known as 'sunny Jim' (after the trademark character on the 'Force' breakfast cereal packet).

Because of the illness of IMD's Director, Simpson was recalled to India in 1912 and remained there until 1920, apart from a spell with the British Expeditionary Force in Mesopotamia in 1916, secondment to the Indian Munitions Board from 1917 to 1919 and a short time in Egypt and the Sudan in early 1920 as a member of the Egyptian Government's Nile Projects Commission.

Fig.22: Sir George Simpson

He returned home in 1920 to become Director of the Meteorological Office, a post he held until retirement in 1938. Immediately after World War II broke out, however, he volunteered to return to the Met Office to serve as Superintendent of Kew Observatory to release James Stagg for important war work; and he remained in charge at Kew until April 1946. Whilst Director of the Met Office, Simpson generally did not encourage research by his staff but did publish much of his own work, most notably on atmospheric electricity, Antarctic observations and later, in life, palæoclimatology. At his invitation, Jacob Bjerknes and Tor Bergeron visited the Office in 1926 for the edification of the staff, but the Office was nevertheless slow to incorporate the frontal ideas of the Scandinavians into routine forecasting.

Sir George was perhaps best known as an exceptional administrator, a reputation established on the Antarctic expedition and in India and the Middle East but also shown fully by his work with the Meteorological Office after it had been taken over by the Air Ministry as an amalgamation of previously separate organizations. He set up a state meteorological service that coped well with steady expansion in the 1920s and 1930s and a more rapid expansion with the coming of World War II. Among the practical developments he oversaw whilst Director were the introduction of routine upper-air soundings, formal meteorological training and a nation-wide teleprinter network.

MAGNUS THORFINN SPENCE, OBE, BSc

9 January 1893 – 8 August 1985 (Fig.23)

Spence was the son of a life-long weather observer, also named Magnus, who was a schoolmaster at Deerness, Orkney. He joined the Meteorological Office as a Probationer in 1911, was commissioned in the RNVR during World War I, transferred to the RAF in 1918 and returned to the Office after the war as a graduate on the scientific staff with a BSc from the University of London. He became responsible for the Library in 1923 and subsequently became Assistant Superintendent in Climatology. He was in charge of the Observatory at Valentia in the early 1930s, later posted to the Edinburgh Office and then, before the outbreak of World War II, served as a forecaster at RAF Wyton, near Huntingdon. His most notable claim to fame was that he became the Chief Meteorological Officer at Bomber Command Headquarters during World War II. The award of his OBE was announced in the 1943 New Year Honours List.

Fig.23: M.T.Spence

SIR GEOFFREY INGRAM TAYLOR, OM, MA, FRS

7 March 1886 – 27 June 1975 (Fig.24)

Taylor was a brilliant physicist and applied mathematician who in 1908 took a First in Part II of the Cambridge Natural Sciences Tripos. He remained at Trinity College thereafter to carry out research in physics and then, in 1911, without any background in meteorology, became Schuster Reader in Dynamical Meteorology at Cambridge. Two years later, he served as meteorologist aboard *Scotia*, the ship which investigated icebergs on the North Atlantic after the *Titanic* disaster, and from it conducted experiments which led to new theories about the vertical transfer of heat and moisture by turbulent mixing of air close to the sea surface. Soon after the war broke out, he joined the staff of the Royal Aircraft Factory at Farnborough to carry out work in theoretical and experimental aeronautics; and he not only learned to fly, in order to investigate aircraft stability, but also to parachute. In February 1916, he became Professor of Meteorology to the Royal Flying Corps, a post which carried with it the rank of Major. He returned to Cambridge in October 1919 as a lecturer in mathematics, and further advancement of his career came in 1923, when he was appointed to a Royal Society research professorship which he held at Cambridge until his retirement in 1952. He had many research interests, notable among them turbulence, on which subject he became a world authority. He was awarded the Order of Merit in 1969. For further information about Taylor's long and illustrious career, see Batchelor (1976) and Sheppard (1976).

Fig.24: G.I.Taylor

SIR ROBERT ALEXANDER WATSON-WATT, CB, BSc, FRS, AMIEE

13 April 1892 – 5 December 1973 (Fig.25)

Watson-Watt studied engineering at the University College of Dundee (then part of St Andrew's University) and graduated in 1912. He joined the Meteorological Office in 1915 and was posted to the Royal Aircraft Factory at Farnborough to investigate the use of radio for providing warnings of thunderstorms for the pilots of aircraft, work he continued throughout and after the war. He took over as the officer in charge at Farnborough in 1917 when his mentor, Captain C.J.P.Cave, became ill, and he later co-authored a paper with Cave, also one with Shaw.

Watson-Watt showed his flair for scientific research and pioneered the use of wireless direction finders and cathode-ray oscilloscopes for locating lightning flashes and the directions of atmospherics. He was seconded to the Department of Scientific and Industrial Research in 1922 and never returned to the Meteorological Office. He suggested the name 'ionosphere' but is best remembered now for his pioneering work on radar. Though not a meteorologist as such, he remained an active member of the Royal Meteorological Society and indeed served as the Society's President from 1949 to 1951. For further information about Watson-Watt, see J.A.Ratcliffe (1975) and R.A.S.Ratcliffe (1992).

Fig.25: R.A.Watson-Watt

continued on page 15

WAR HONOURS

In addition to those already mentioned, there were many others who contributed to the successful development of what may be regarded as the beginning of real, operational meteorological services during the First World War.

The following are specifically mentioned in the Meteorological Office's Annual Report of March 1919.

Medals and honours were awarded as follows:
DSO to E.Gold, CBE to R.G.K.Lempfert, OBEs to R.Corless, A.E.M.Geddes, E.M.Wedderburn, E.Kidson and J.W.Bispham.

And the following were mentioned in dispatches:
Lieutenant-Colonel E.Gold, Captain J.W.Bispham, Captain D.Brunt, Captain E.H.Chapman, Captain F.Entwistle, Captain A.E.M.Geddes, Captain A.H.R.Goldie, Captain E.M.Wedderburn, Lieutenant J.G.Lamb, Sergeant-Major R.Pyser, Sergeant E.L.Clinch, Sergeant L.G.H.Lee (Observer at Raunds), Sergeant F.J.Parsons (Observer at Ross-on-Wye), Corporal J.Chaytow, Corporal C.V.Ockenden and Corporal R.M.Poulter.

ROLL OF HONOUR

Five members or former members of Met Office staff actually lost their lives, although none was actually serving as a meteorologist at the time, namely H.Billett, N.C.Bradnock, G.J.Barker, W.B.Greening. and E.T.Streets.

HAROLD BILLETT *was born in the 2nd quarter of 1890 in Keynsham, son of Edwin, a railway signal man and Fanny Billett. He had four brothers and a sister. In 1901, they lived at 42 Bright Sreet, Swindon. In 1911, he was awarded 2nd Class Honours in Physics, Royal College of Science London. He wrote Geophysical Memoir No 11 (refers to S Wales tornado on 27.10.13.) He worked at South Farnborough from 1 January 1914. He married Alice Louise Maylott at the beginning of 1915 before leaving on 24 February to take up an appointment in the Meteorological Service of the Government of South Africa. Granted leave to enlist in the South African Infantry, he joined 12.12.1915, returning to the UK 29 February 1916. Transferring to France to join BEF 6 August 1916, he was reported missing 18 October 1916; death presumed 14 June 1917.*

GEORGE JOSEPH BARKER *was born in the 2nd quarter of 1897 and was a private in the 1/13th Battalion of the London Regiment (TA) (5100) when he was killed on 10 October 1916 during the Sixth Phase of the Battle of the Somme aged 20. He was a Boy Clerk in the Statistical Division of the Met Office before joining up. He was probably born at West Ham, London. He has no known grave and is commemorated on the Thiepval Memorial Pier.*

NORMAN CHARLES BRADNOCK *was born in the 2nd quarter of 1895 in Fulham, London. He was the son of Richard and Ida Bradnock, of 20, Bank Buildings, Purley, Surrey. He volunteered for service with the 1/13th Battalion of the London Regiment and was probably killed in the Ypres Salient on 9 May 1915 aged 20. He was a Probationer in the Forecast Division of the Met Office before joining up. He has no known grave and is commemorated on the Ploegsteert Memorial Panel 10.*

WALTER BENJAMIN GREENING *was born at Fulham in the 4th quarter of 1896 and was a member of the Royal Naval Volunteer Reserve, Naval Division, Nelson Battalion, as an Able Seaman (London Z/288), when he was killed in an attack on the Chessboard position, above Anzac Cove, at Gallipoli on 3 May 1915 aged 21. He was a probationer in the Marine Division of the Met Office before he joined up. His Next Of Kin are not known. He has no known grave but is commemorated on the Helles Memorial, Panels 8-15.*

EDWARD THOMAS STREETS *was born in the 2nd quarter of 1897 at Hampstead, London, and was a Rifleman in the 1/5th Battalion of the London Regiment (TA) (302654) when he was killed on 12 April 1917 at Arras aged 20. He was the son of Mr Henry and Mrs Mary Anne Streets (née Snell), of 5 Normanby Rd, Willesden, London. He has no known grave and is commemorated on the Arras Memorial, Bay 9. Details of his meteorological career are not known but he may well have been a boy messenger (i.e. deemed to be below the rank of those named in the annual reports).*

CHRONOLOGY

PRE-1914

One activity worth noting is the existence of the Advisory Committee for Aeronautics, set up by Prime Minister Asquith in 1909, when he recognised that new technology was available. Over the next decade, a significant number of papers were published that laid some of the ground rules for understanding the four-dimensional atmosphere, turbulence, aerodynamics, flight navigation, etc. Napier Shaw was the leader of the meteorological part of the committee, with contributions from several of the meteorologists included in this paper, notably the two senior Dines (W.H. and J.S.), G.I.Taylor and C.J.P.Cave; and even Lord Rayleigh made a note about the formula for the gradient wind. G.M.B.Dobson wrote on low-level winds and aircraft instruments, though he was not himself a pilot. The point is that meteorology became accepted as a scientific pursuit which had a bearing on other activities, and even some politicians and military officers of high rank recognised the significance of the weather to the development of the newfangled aviation and 20th-century warfare technology.

The Meteorological Office at that time had little to do with original research. The most significant activity was work on the investigation of wind structure, which originated in Surrey under the control of a private individual – W.H.Dines. But Dines was concerned that his kite wires might inconvenience or even endanger the general public, so he moved to the more sparsely-populated Pyrton Hill and then to Benson in Oxfordshire. By March 1911, it was agreed with the Army Council that there should be a meteorological branch office “at the Aircraft Factory, South Farnborough, in the charge of a trained meteorologist” (Annual Report, 1911). Some of the experimental work by W.H.Dines in the investigation of wind structure for the Advisory Committee for Aeronautics was transferred to the new Branch Met Office at South Farnborough, with his son J.S.Dines in charge. The boundary between private and public work was sometimes very blurred!

Also before the war started, Shaw reported, in 1912-13, that "at the request of the War Office arrangements have been made for a course of instruction in meteorology at the Royal Flying School at Upavon, and for the supply of forecasts to the Naval Flying Schools at Eastchurch and Montrose” (Annual Report, 1913). The electric telegraph was being used for near-real-time operational purposes, even transmitting the data for the construction of the day's weather map to Upavon, at least during the Central Flying School’s term-time. The newfangled aviation was dragging meteorology into the 20th century. Shaw was also in contact with Vilhelm Bjerknes and the ideas which he and his team were developing in Norway.

The first meeting of the International Commission for Scientific Aeronautics was held in Vienna in May 1912, but it appeared to concentrate on soundings of the upper air, with little or no reference to aeroplanes. It was in 1913 that the centibar or millibar replaced the inch for barometric measurements; in fact, the Commission talked about going fully metric.

1915

Aviation and gas warfare heightened the profile of meteorology and led to the realization by military authorities that the weather affected military activities. The acceptance of that reality may not have been entirely new, but what was new was the realization that meteorological science had developed to a level that might offer some help with military problems.

On 5 May 1915, the General Officer Commanding the Royal Flying Corps sent to the Met Office a telegram in which he asked for help in connection with aircraft operations

The first use of gas occurred in April 1915, when chlorine was discharged over a fairly nondescript piece of land near Ypres (Fig.26). The officer responsible for dealing with the expected gas warfare, Major C.Foulkes at General Headquarters (GHQ), promptly wrote seeking help with problems such as wind direction and speed (Annual Report, 1917). Napier Shaw had the foresight to realize that meteorology could help and the belief that he had staff who could do the job. He acted immediately.

Fig.26: The Ypres salient (courtesy M.J.Wood)

In a little over a month, he had negotiated with the War Office and arranged for his representative, Major Henry Lyons, to proceed to GHQ in France as Officer-in-Charge of the Royal Engineers' Meteorology Unit ('Meteor'). In addition, two Meteorological Office staff had been released, granted commissions and sent to France. They were Captain Ernest Gold and Lieutenant A.E.M.Geddes. Soon, a reserve of officers was commissioned at 'Home', ready to replace or supplement those on 'field service'.

At about this time, there were some 2,400 qualified pilots worldwide, about 1,200 of them French, but there were only fifty in the United States, where military aviation barely existed. Not until 1917 was the American isolationist policy changed, and when was the change was great. The budget for aircraft went up a hundred-fold, an American Expeditionary Force was organized and an Army meteorological and aerological service was planned and implemented. Dr William R.Blair went to France as a Major to lay the groundwork for 300-plus meteorological troops expected to arrive in England and France in early 1918. After visiting the British and French military weather services, he found them smoothly-running operations that held the respect and support of their clients. It was not long before the telegraphic interchange of data was organized and agreed (Bates and Fuller, 1986).

1916-17

As the whole concept of operational meteorology was so new, it took a few months to establish a routine operational practice, but it is notable throughout the war that there were many practical advances made. In 1914, for example, a few dozen pilot balloon ascents were made at three stations, plus an insignificant number elsewhere. By 1918, over 13,000 balloons a month were being issued. In November 1916, Chinese lanterns had been adopted to allow successful ascents at night. After an ascent lasting half an hour, the computation of upper winds used to take the best part of an hour. Gold reports (Gold, 1955) that "with the assistance of Lt. Entwistle and Corp. Durward, the procedure was simplified". Then, with appropriate instruction and experience, observers were able to do the computations during the ascent using the recently introduced slide rule (Fig.27) with the final results available two minutes after the end of the flight. This was a transformation in the efficiency of providing data to pilots and the artillery.

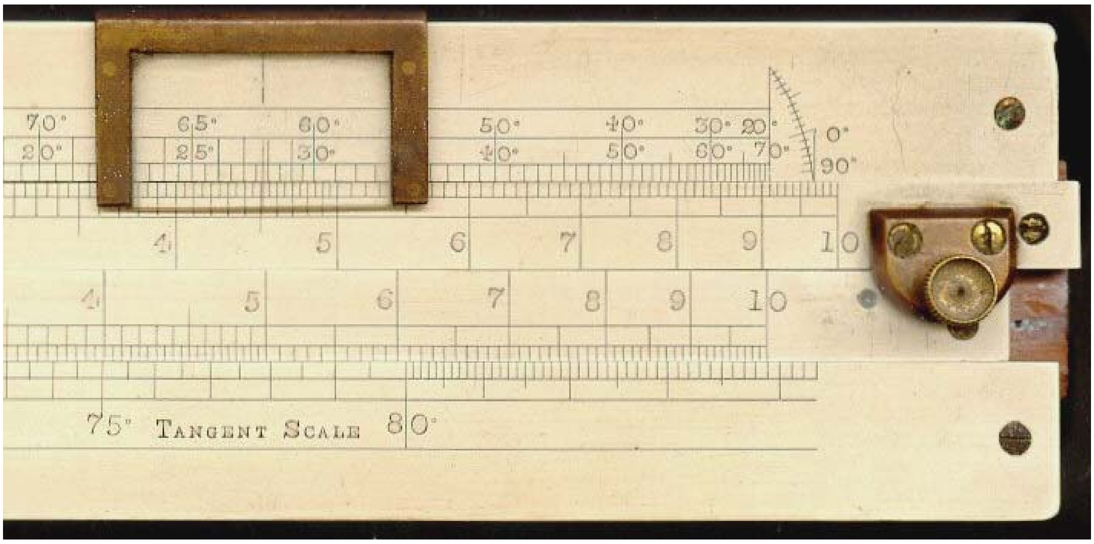
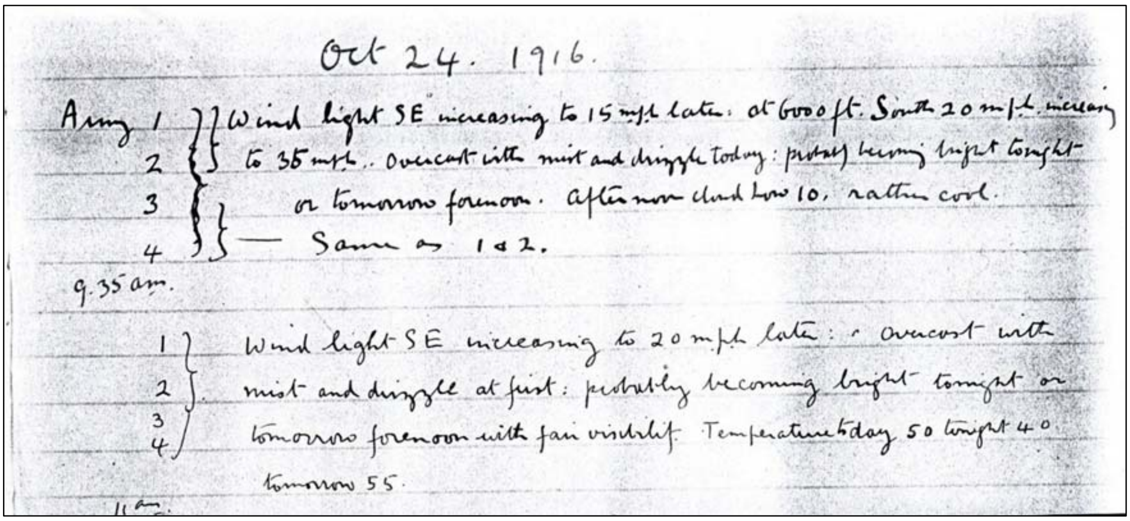


Fig.27: Mark I pilot balloon slide rule, introduced in 1915

The style of presenting reports and forecasts changed dramatically with experience gained. In London, the daily press commented on the supposed influence upon the weather of the heavy bombardment in France. In the journal *Notes and Queries*, it was explained that the level of energy was insufficient to affect the weather, and experiments elsewhere had also failed to show a connection. There had recently been a spell of brilliantly fine weather in spite of the continued bombardment (Meteorological Office, 1916a). Another subject attracting attention in the Circulars was the introduction of the Summer Time Act in 1916 when, for the first time, voluntary and climatological observers had to become used to Greenwich Mean Time and Summer Time. Some even used GMT for the observation time but 'Local Time' in the remarks column for times of thunderstorms, start of rain, etc. It took a while to establish general standards that were acceptable internationally.

It was in 1916 that Gold started keeping a logbook of forecasts issued; and they were very brief, as can be seen in Fig.28.


Oct 24. 1916.

Army 1 } Wind light SE increasing to 15 mph later. at 6000 ft. South 20 mph increasing
2 } to 35 mph. Overcast with mist and drizzle today: probably becoming bright tonight
3 } or tomorrow forenoon. Afternoon cloud low 10, rather cool.
4 } — Same as 1 & 2.

9.35 am.

1 } Wind light SE increasing to 20 mph later: overcast with
2 } mist and drizzle at first: probably becoming bright tonight or
3 4 } tomorrow forenoon with fair visibility. Temperature today 50 tonight 40
tomorrow 55.

11 am.

Fig.28: The earliest recorded operational forecast

By late 1917, a much more comprehensive presentation had been developed, adding a little more detail about visibility, upper winds, etc. From the outset, copies of synoptic charts were prepared by hand in very limited numbers for GHQ and AHQ. Later, at the instigation of Captain Goldie, 'clay copiers' were introduced, which permitted the copying of local Daily Weather Reports for wide distribution, as shown in Fig.29.

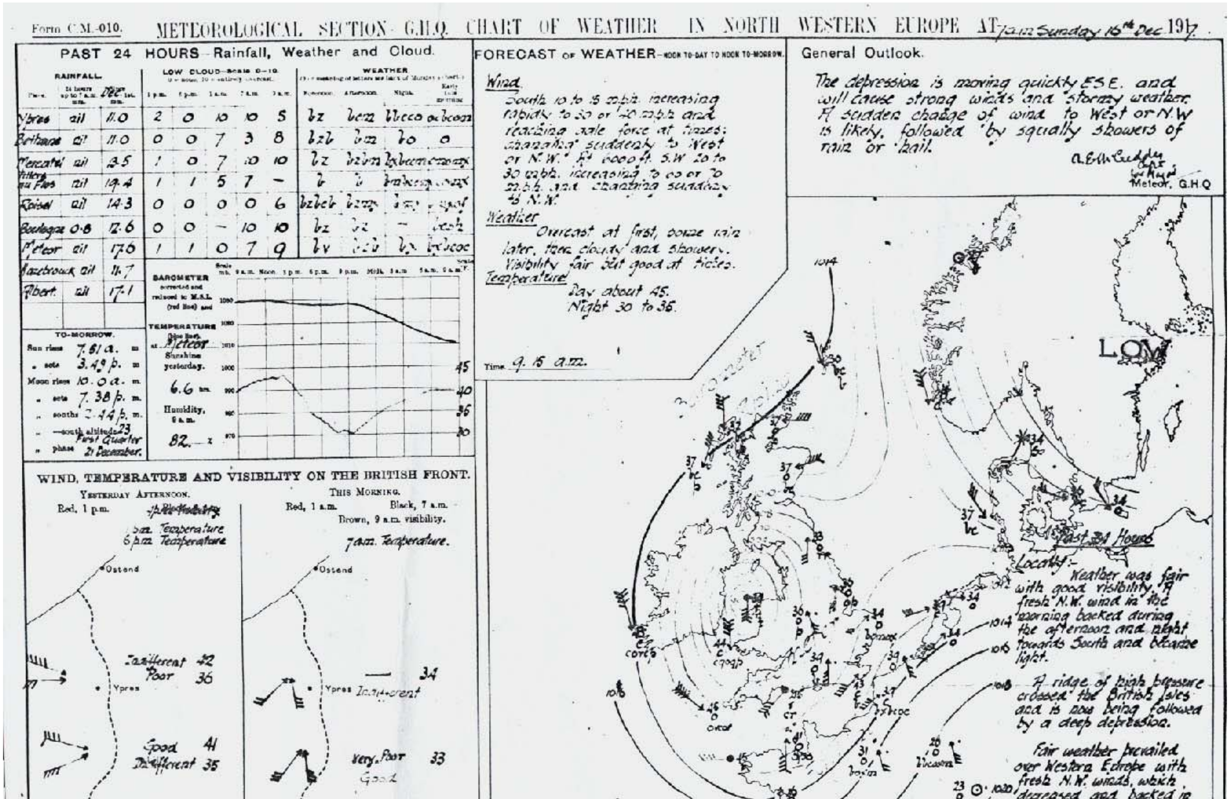


Fig.29: Daily Weather Report and forecast, December 1917

1918 – GREAT WAR LEGACY

As is historically quite common, war encouraged rapid advances in technology and science, and meteorology was not left behind. With some oversight from the Advisory Committee for Aeronautics, the understanding of the aviator's environment improved dramatically, as did the services provided to the airmen. At the beginning of the war, pilots would look out of the window to see if the weather was fit for flying, then trust to luck, but by 1916 attempts to improve efficiency and safety had begun, as illustrated by the first recorded 'operational' forecast shown in Fig.28 (Gold, 1916-1919).

Towards the end of the war, the number of Meteor staff had risen to 28 officers and 187 other ranks. Shaw clearly foresaw the future of meteorological services when he wrote in the 1918 Annual Report: "Now that the weather is recognised to be of primary importance in so many of the affairs of life, and the requirements of so many departments of the Navy, the Army and the Air Force include a knowledge of weather conditions, not only at the surface in the various parts of the globe but at elevations which have up to now been of interest to the meteorologist alone, some more comprehensive organization is necessary. And it is felt that the steps towards this organization cannot be postponed until after the war." Shaw was disappointed that the Government valued the meteorological service so highly that the Office was transferred to the new Air Ministry.

1919

The real pioneer in meteorological reconnaissance was C.K.M.Douglas, who found time while an operational pilot to study clouds and take photographs. He then publicized his work by publishing an article entitled "Weather Observation from an Aeroplane" (Douglas, 1916). Gold presumably saw the paper and initiated a research flight in 1918. This proved to be scientifically and operationally so successful that a formal Meteor Flight was operating for part of 1919. It was formed in February at Berck-sur-Mer in France for weather research flights but disbanded in August, probably at Cologne. Two of the aircraft that were flown are illustrated in Figures 30 and 31. The use of aeroplanes to study the atmosphere has gone on more or less continuously ever since.

Fig.30: Bristol F2B in the Shuttleworth Collection

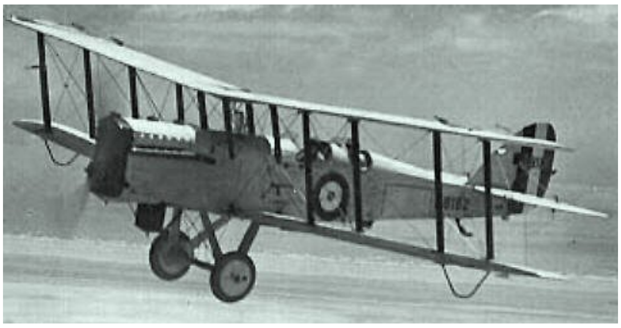
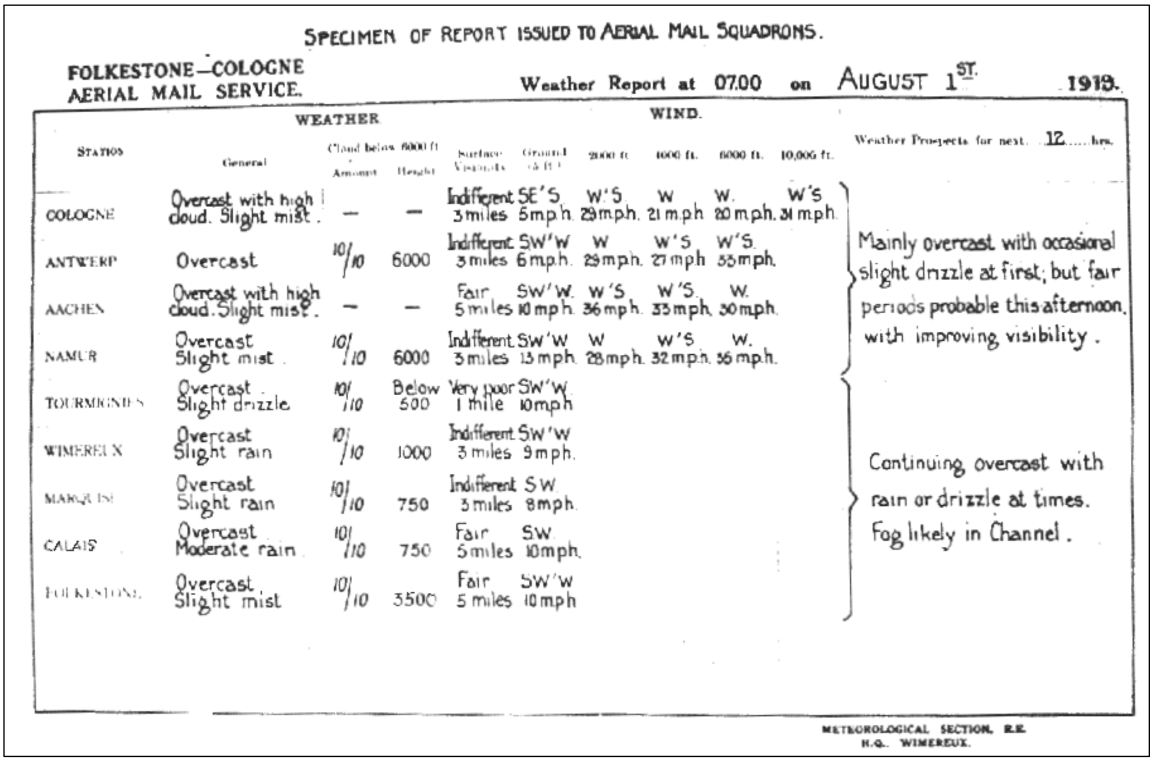


Fig.31: De Haviland DH9

At the end of 1918, RAF Communications Squadrons had started regular services between London and the Peace Conference in Paris and soon afterwards began a regular airmail service to Cologne, with more formal flight information provided (see Fig.32, on page 20).

By autumn 1919, virtually all suitably trained officers and NCOs were demobilized and Army activities suspended, except for the work at some permanent Army bases. These bases were placed under the control of the Superintendent, former Captain David Brunt, and comprised Shoeburyness, where range and accuracy trials took place, West Lavington (Larkhill after October 1920), where artillery training took place, and Porton Down, where gas-warfare and related investigations such as smoke screens were investigated. In addition, meteorological support was provided at annual Artillery practice camps, and training was also organized for Anti-Aircraft units.



SPECIMEN OF REPORT ISSUED TO AERIAL MAIL SQUADRONS.

FOLKESTONE–COLOGNE AERIAL MAIL SERVICE. Weather Report at 07.00 on AUGUST 1ST. 1919.

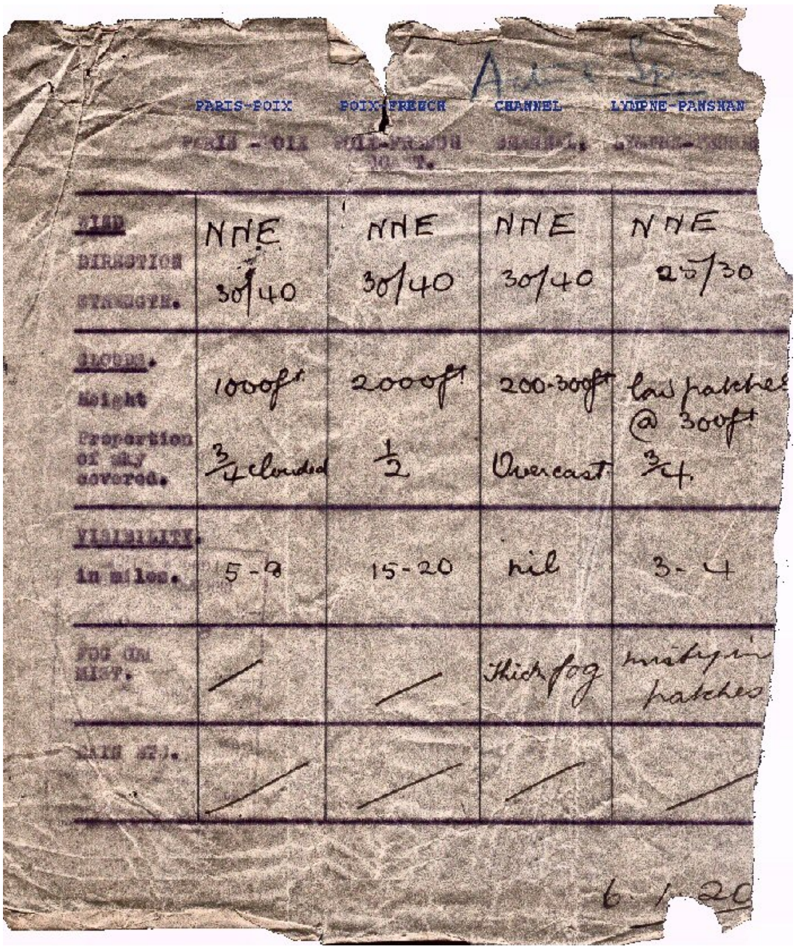
Station	WEATHER: General	Cloud below 6000 ft: Amount	Cloud below 6000 ft: Height	Surface Visibility	WIND: Ground	WIND: 2000 ft.	WIND: 4000 ft.	WIND: 6000 ft.	WIND: 10,000 ft.	Weather Prospects for next 12 hrs.
COLOGNE	Overcast with high cloud. Slight mist.	—	—	Indifferent 3 miles	SE'S 5 m.p.h.	W'S 29 m.p.h.	W 21 m.p.h.	W. 20 m.p.h.	W'S 31 m.p.h.	Mainly overcast with occasional slight drizzle at first; but fair periods probable this afternoon, with improving visibility.
ANTWERP	Overcast	10/10	6000	Indifferent 3 miles	SW'W 6 m.p.h.	W 29 m.p.h.	W'S 27 m.p.h.	W'S. 33 m.p.h.		
AACHEN	Overcast with high cloud. Slight mist.	—	—	Fair 5 miles	SW'W. 10 m.p.h.	W'S 36 m.p.h.	W'S. 33 m.p.h.	W. 30 m.p.h.		
NAMUR	Overcast Slight mist.	10/10	6000	Indifferent 3 miles	SW'W 13 m.p.h.	W 28 m.p.h.	W'S 32 m.p.h.	W. 36 m.p.h.		
TOURNIGNIES	Overcast. Slight drizzle.	10/10	Below 500	Very poor 1 mile	SW'W 10 m.p.h.					Continuing overcast with rain or drizzle at times. Fog likely in Channel.
WIMEREUX	Overcast Slight rain	10/10	1000	Indifferent 3 miles	SW'W 9 m.p.h.					
MARQUISE	Overcast Slight rain	10/10	750	Indifferent 3 miles	SW 8 m.p.h.					
CALAIS	Overcast Moderate rain.	10/10	750	Fair 5 miles	SW. 10 m.p.h.					
FOLKESTONE	Overcast. Slight mist	10/10	3500	Fair 5 miles	SW'W 10 m.p.h.					

METEOROLOGICAL SECTION, R.E. H.Q. WIMEREUX.

Fig.32: Information for cross-channel flights in 1919

1920s

Much of the development of meteorological services in the 1920s and 30s was a continuous refinement of the methods and principles created and established to meet the demands of the First World War. Few records remain, so it was interesting to find the fragment of a real forecast shown in Fig.33.



	PARIS-POIX	POIX-FRENCH COAST.	CHANNEL.	LYMPNE-PANSHAN
WIND DIRECTION STRENGTH.	NNE 30/40	NNE 30/40	NNE 30/40	NNE 25/30
CLOUDS. Height	1000 ft	2000 ft	200-300 ft	low patches @ 300 ft
Proportion of sky covered.	3/4 clouded	1/2	Overcast	3/4.
VISIBILITY. in miles.	5-9	15-20	nil	3-4
FOG OR MIST.	—	—	thick fog	misty in patches
RAIN &c.	—	—	—	—

6 / 20

Fig.33: A surviving fragment of a forecast from 1920

PUBLICATIONS

In spite of the courses of tuition that had been introduced for the services, Shaw also saw the need for reference material and training manuals in the form of *The Weather Map* and the *Meteorological Glossary*, which were both first published in 1916 (Meteorological Office, 1916b,c). These were, perhaps, the first 'textbooks' intended to define and explain technical meteorology for customers (the military) who needed to know about the weather to assist with their activities. These proved so successful that there were four issues within two years. Although these were attributed to Shaw, he acknowledges in the introduction to the fourth issue of the *Meteorological Glossary* (which appeared in 1918) that various articles were written by W.H.Dines and E.V.Newnham at Benson, C.J.P.Cave and R.A.Watson-Watt at South Farnborough, and Major G.I.Taylor and several other staff at the Met Office headquarters.

L.F.Richardson published *Weather prediction by numerical process* in 1922. However, his book remained little more than an academic novelty for more than 20 years, and only since the coming of the electronic computer has it been appreciated and recognized as a ‘classic’.

If one considers the popularity and use of a publication, then Pick’s *A Short Course in Elementary Meteorology*, first published in 1921, must rate as one of the most influential of all books on meteorology.

Shaw’s *magnum opus* in four parts, *Manual of Meteorology*, was a comprehensive work on the subject but a little indigestible and not easy to assimilate by ordinary folk, while *The life history of surface air currents: a study of the surface trajectories of moving air*, written with R.G.K.Lempfert in 1906, was a pioneering work that perhaps never achieved the recognition it deserved.

So far as textbooks are concerned, Brunt’s *Physical and Dynamical Meteorology*, published in 1934, must be deemed very influential, since it became the cornerstone for training forecasters in the middle of the 20th century and, as noted earlier, may well have been the first book to describe air masses and fronts in a practical way.

Mention should also be made of the scores of technical publications that contributed to the development of meteorological services during this period. Gold, in particular, wrote or supervised many items on essential matters such as forecasting techniques and meteorological codes.

LOCATIONS

In 1910, the Meteorological Office moved from Victoria Street to new premises in South Kensington: the first Headquarters built especially for the Meteorological Office, on the corner of Exhibition Road and Imperial College Road (Fig.34). It still existed in the 21st century and looks much the same as it did when first built. Many people would recognize it only as a Post Office (which it no longer is), but this is no coincidence because, in 1910, Met Office communications relied on the electric telegraph and telegrams, so co-location was the original plan. Much of the building is now used by the Science Museum, which is next door. In the Met Office building, now called the Smith Centre of the Science Museum, all the data were collected, collated, distributed and analysed and forecasts produced.

Fig.34: Met Office HQ and former Post Office

In addition, there were three observatories, at Kew, Eskdalemuir and Valencia, plus a station used for investigation of the upper air, working for the Met Office but run by a private individual, W.H.Dines. By 1912, South Farnborough had been added as the first Branch Meteorological Office, what was eventually called an outstation. Routinely, observations were sent in by telegram from 29 stations in the British Isles.

During the Great War, South Kensington was the primary support centre for all the armed services at home and abroad. It could be claimed that this is the place where operational meteorology really started, because it supported the network that developed on the continent.

By 1918, a network of stations was providing a full range of services to military units, as illustrated by the sketch map below (Fig.35), which was found in the National Meteorological Archive but has never before been published so far as is known. Details of Fig.35 have been used to produce the legible version shown in Fig.36.

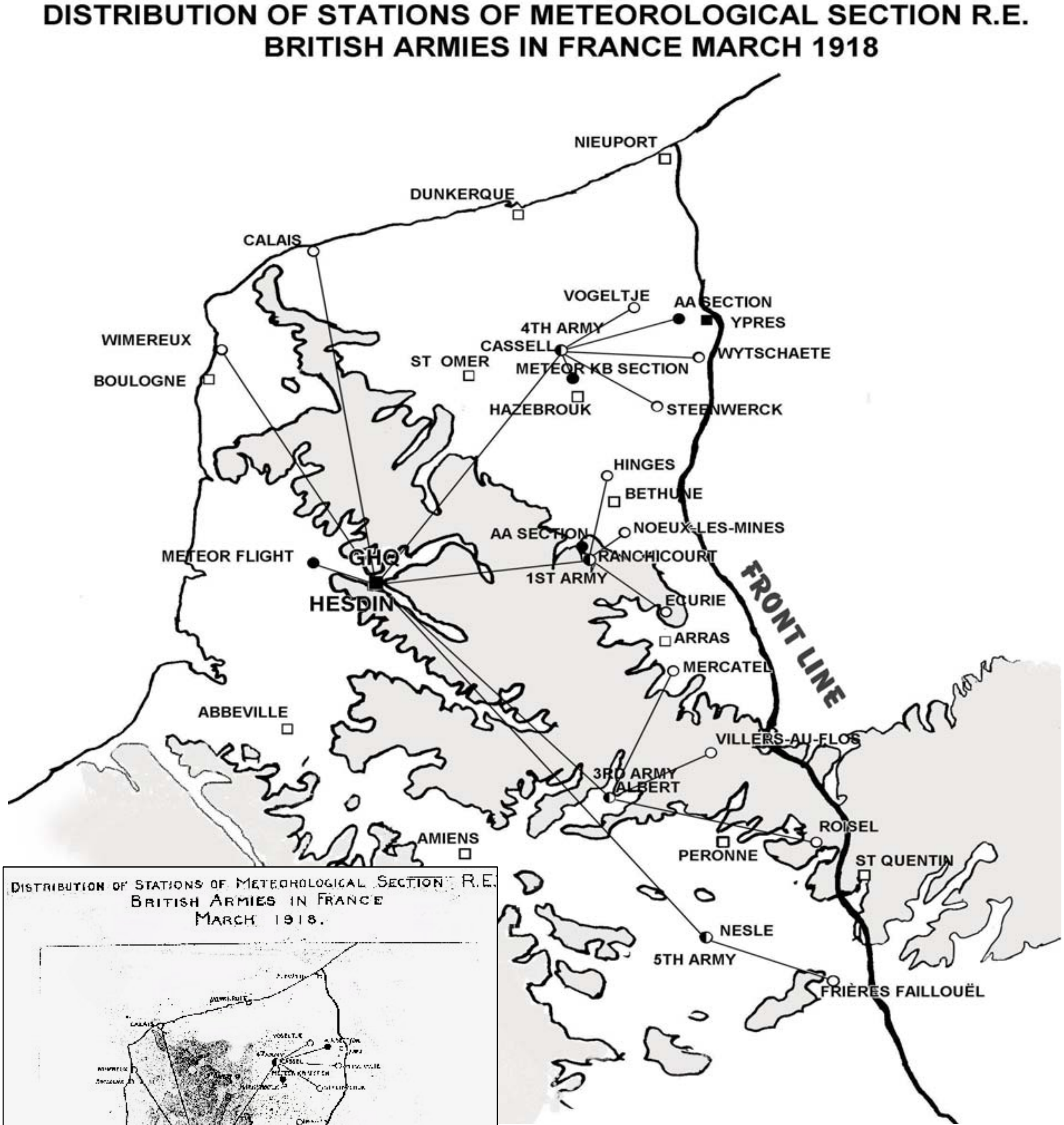


Fig.36 (based on Fig.35): Meteorological outstations established to provide services for the artillery, flying, gas warfare and meteorological research.

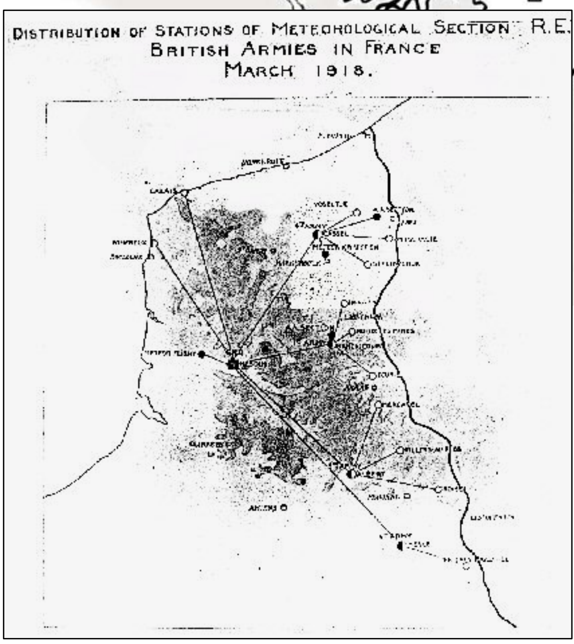


Fig.35: This photocopy of the original is barely legible so has been redrawn to create Fig.36.

OUTSTATIONS

By 1920, Gold was back in charge of the Forecast Service and had introduced the idea of outstations or, as they were called at the time, Distributive Stations – eight of them, plus Farnborough and two army stations, Shoeburyness and West Lavington. Civil aviation had started in 1919 and arrangements were soon introduced to support routine flights to the continent, as shown in Fig.37.

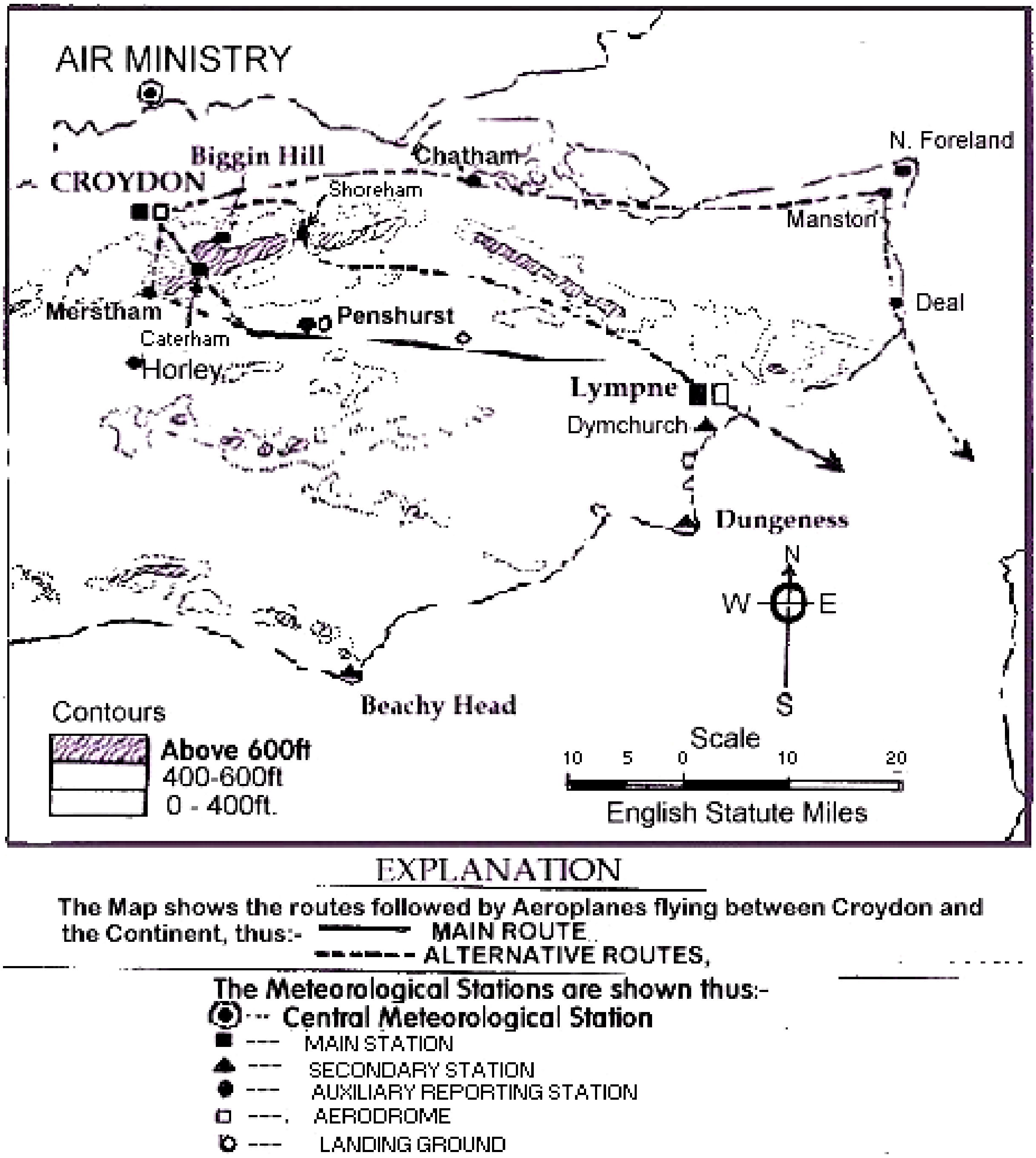


Fig.37: Arrangements for the 1919 'airline service'

Over the next twenty years, aviation expanded dramatically and a permanent teleprinter network replaced much of the telegraph and radiotelegraph traffic. The number of outstations increased to support the growing demands on the forecasting service, see Fig.38 (page 24).

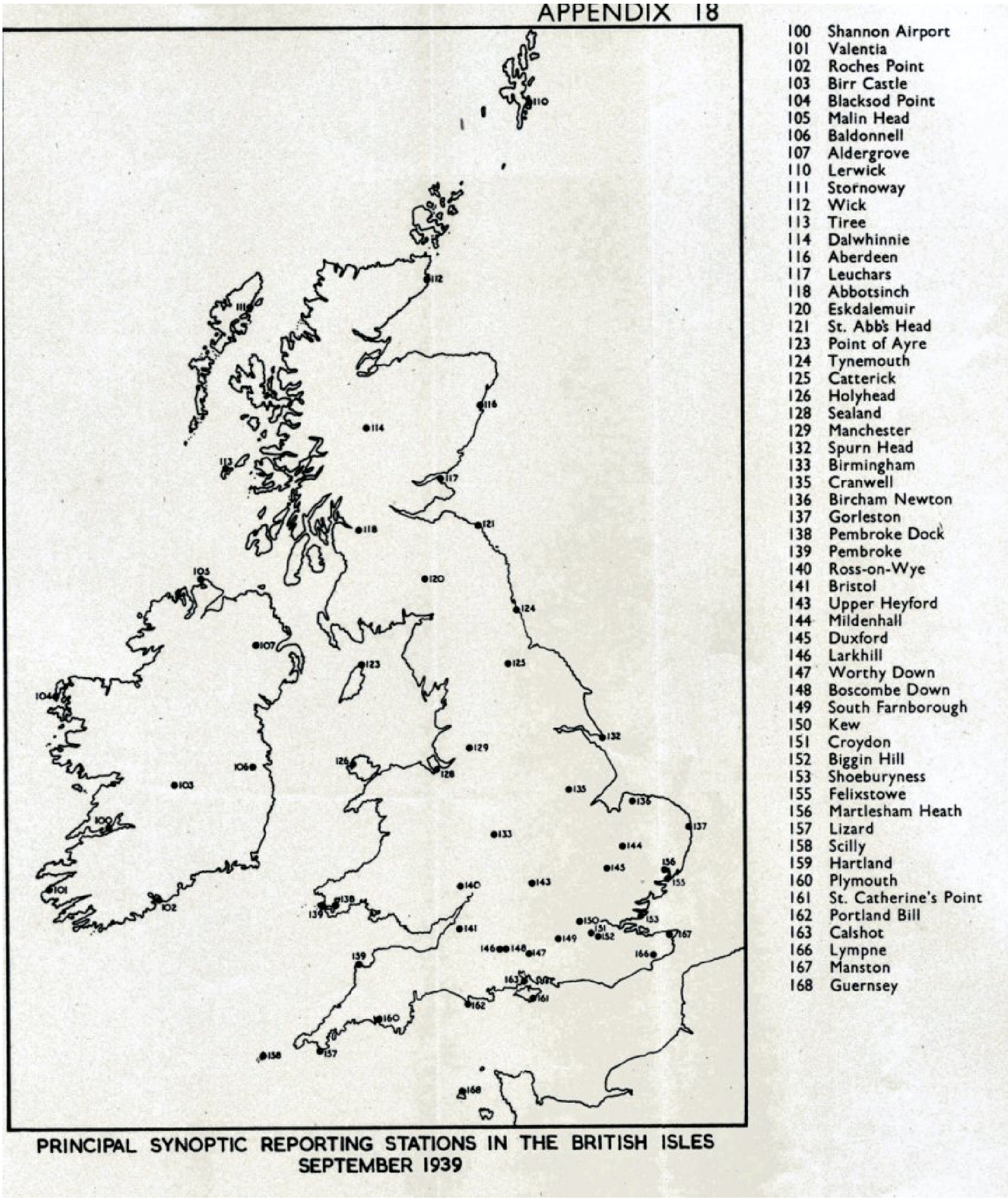


Fig.38: The outstation network in 1939.

AVIATION GOES INTERCONTINENTAL

In 1914, aeroplanes flew typically at 70-80 miles per hour up to an altitude of about 10,000 feet, but by 1918 they flew twice as fast and well over twice as high (Gibbs-Smith, 1953). Clearly, the technology had advanced considerably, but, through the Advisory Committee for Aeronautics, so had the knowledge of the environment the aviators exploited. At the beginning of the war, pilots would look out of the window to see if the weather was fit for flying, then trust to luck. But during the conflict, technology advanced and the critical support services such as meteorological observing, communications and forecasting developed to a level that enabled long distance flights to be planned: in particular the first non-stop flights across the Atlantic, both of which were completed by British aircraft and crews, supported by British science and technology. This was part of the legacy of the efforts put in during the Great War.

The first transatlantic flight was by Alcock and Brown, who flew a modified Vickers Vimy bomber from Newfoundland to an Irish bog, covering some 1890 miles at an average speed of about 118 mph. The flight was more successful than the landing (Fig.39)!

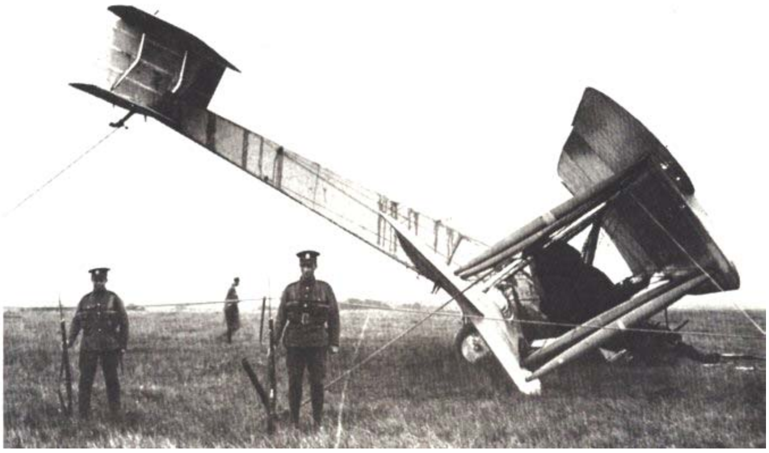


Fig.39: The first nonstop flight across the Atlantic

The second was the successful transatlantic flight of His Majesty's Airship R.34 between the 2^{nd} and 13^{th} of July 1919. This was the first flight to land safely on both sides on the Atlantic. (Fig.40).

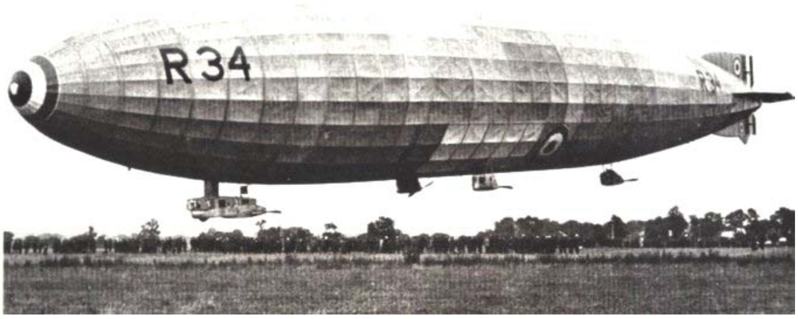


Fig.40: R.34 returns to Pulham from New York after the first return trip across the Atlantic

In charge of airships was Air Commodore Edward Maitland, whose writings suggest he was an influential advocate of the services that supported airship flying (Maitland, 1921a,b). Gendle and Maitland summarised the lessons learned during the early development of operational meteorology and how they could be applied to the coming age of international air transport.

So far as aviation and consistent observations were concerned, a network of 'Distributive Stations' was established, run by meteorologists. Meteorology had become a fundamental aspect of both military and civilian aviation, and the Meteorological Office's empire was growing.

THE START OF COMMERCIAL AVIATION

The main impetus for the development of meteorological services during the 1920s and 1930s was the expansion of commercial aviation. The first airline was formed in Germany in 1909, operating airships, and this continued to function until the First World War started.

Fig.41: The first scheduled airline passenger

The earliest scheduled airplane service lasted about five months in 1914, flying one passenger at a time across Tampa Bay, Florida, in a Benoit aircraft at a height of about five feet (Figs.41 and 42).

Then, during 1919, several companies were formed in England, France and Germany, taking advantage of war-surplus aircraft such as the modified DH9 (Fig.43) and demobbed pilots. From August 1919, Air Transport and Travel established the first daily international service between Le Bourget and Hounslow or Croydon, the latter becoming the main airport by 1922. But aviation forecasts still had to be issued as and when they were required, especially for the return flights to England.

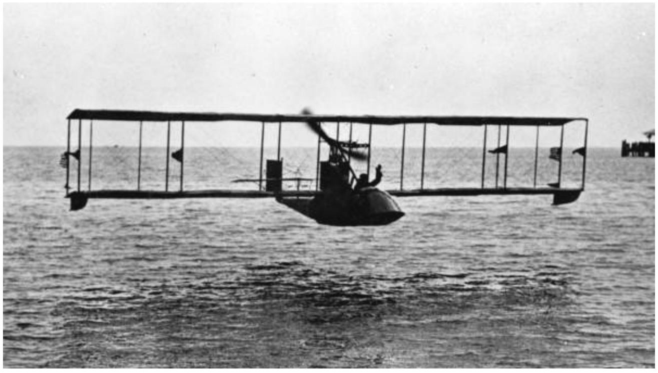


Fig.42: The Benoit flying across Tampa Bay

Fig.43: Early European airline service

GETTING ORGANIZED

Expecting an increase in the use of aircraft, the British government’s Committee of Imperial Defence established an Air Committee on 25 April 1912, but it had no executive powers and so achieved little. The increase in the use of aviation was so dramatic that on 15 February 1916 the War Committee formed a Joint War Air Committee to supervise the design and supply of material for the Army’s Royal Flying Corps (RFC) and the Navy’s Royal Naval Air Service (RNAS), to be known as the Air Committee. On 15 May 1916, this became the first Air Board, concerned primarily with military matters but still little more than an advisory body. Following the recommendations of a committee composed of Prime Minister Lloyd George and General Jan Smuts, the Air Force (Constitution) Act received the Royal Assent on 29 November 1917. This was the first step in setting up an Air Council which had executive powers to organize and plan the amalgamation of the RFC and RNAS and to transfer administrative functions from the Admiralty and War Office to a new ministry responsible for military aviation. An Order in Council of 2 January 1918 defined the composition and duties of members of the Air Council and a separate Air Ministry was formed. Then, on 3 January, the first Air Council was formed, with Lord Rothermere as the first Secretary of State for the Air Force (re-titled Secretary of State for Air from March 1918).

Amalgamation of the RFC and RNAS to form the Royal Air Force (RAF) took place on 1 April 1918.

It was announced in the House of Commons on 12 February 1919 that a Department of Civil Aviation would be formed under the Minister for Air, and by the end of the month the Air Navigation Act had extended the scope of the Air Council to cover all matters concerned with air navigation. Civil flying in

Britain was formally restored with the issue of Air Navigation Regulations on 30 April 1919, which authorized civil flying from 1 May.

On 1 July 1919, the Meteorological Office formally became part of the new Air Ministry, combining the previously separate services run by the Office, the Air Ministry, the Royal Engineers and the Admiralty. Hence, the new organization was directly involved with both the planning and implementation of official weather services for all aviators as well as the general public. The Director of the Meteorological Office was directly responsible to the Controller-General of Civil Aviation, with the advice of the Meteorological Committee, but he was not happy with the plan, as can be seen form the Office's Annual Report of 1920.

On 13 October 1919, 36 states became parties to the Paris Convention set up by the League of Nations to regulate international flying. Article 34 of the Convention made provision for the creation of a permanent International Commission for Air Navigation (ICAN).

LIFT-OFF

In Britain, airships attracted little interest until rigid Zeppelins appeared in the skies over England during World War I, and this encouraged some attempts to build copies, but with mixed success. A new branch of the Air Ministry was formed in 1919 to deal with all questions arising out of the transfer of certain surface and airship stores, such as the Pulham airship station from the Royal Air Force to the Controller-General of Civil Aviation "for the purpose of carrying out experimental operational investigations into the commercial possibilities of airships". At that time, Pulham had been a very busy station as one of the main naval airship bases during the war. In fact, there were several airship bases between 1908 and 1931: Cardington in Bedfordshire, Pulham in Norfolk, Cranwell in Lincolnshire, Howden and Selby in Yorkshire and (where Vickers tried to launch their efforts) Barrow-in-Furness in what is now Cumbria. There were also some bases north of the border in Scotland.

An early project of the Air Ministry was to set objectives for the flight of His Majesty's Airship R.34 in July 1919 (Fig.40, page 25):

- firstly, the acquisition of information and data concerning conditions over the Atlantic during extended flight, not only from the point of view of the airship pilot but also from the point of view of the meteorologist;
- secondly, to demonstrate the possibilities of large rigid airships with regard to carrying out long overseas voyages.

At 1.42 a.m. on 2 July 1919, the bugle sounded 'let go' at East Fortune near Edinburgh and R.34 set off to fly across the Atlantic and back.

The consensus of those on the flight was that large rigid airships were much steadier over the sea than surface ships, and much safer from the dangers of icebergs (NB: the *Titanic* disaster had occurred only seven years before). The flight of the R.34 in 1919 also demonstrated the potential benefits of generally available directional wireless bearings for navigation fixes.

Those concerned with the R.34 flight noted the need for meteorological data over the oceans as a routine, perhaps from cable repair ships, which were widely scattered and tended to remain in one spot for a relatively long time. They expected "the captains of the future Airship Liners will become wily and cunning masters of the art of selecting the right wind and the right height, and, by means of their air knowledge alone, will save many hours ... on passage".

Another of the interesting things that was noted in 1919 was that cloud was wetter higher in the cloud than low down, noticed because the extra moisture over the surface of the airship altered the weight and the lift. This observation was later confirmed by cloud physicists.

The success of the R.34 and the established record of Zeppelins persuaded the Government that rigid airships were the future transport links with the Empire. Hydrogen was the favoured lifting medium because helium was much too expensive and available only from America.

IMPERIAL DREAMS

Having had all these ambitious ideas, the Air Ministry suddenly decided, or was told, that the airship scheme was not economically viable, so, in September 1920, there was an Air Ministry order to cease all airship work. By the autumn of 1921, a few airships were in store but most had been broken up, which could have been the end of the dream. But, in 1922, Vickers proposed a fleet of six civil airships rather along the lines of the proven Zeppelins, to circumnavigate the globe and “to link the Empire”.

Nobody took much notice of Vickers' ideas but then, a couple of years later, in 1924, the Labour Government under Ramsey MacDonald issued proposals for the construction of two experimental airships; and once it was a Government idea, things changed. The Government’s idea was that there should be two airships. A private enterprise was created to build one of them (HM Airship R.100), effectively in competition with a state-run project to build the other (HM Airship R.101).

The State project had to start from scratch because many of the Government experts, ex-Admiralty airship people and the like, had been killed in the R.38 crash in August 1921.

Vickers, however, still had a nucleus of production experience and some limited design resources. Their chief designer was B.N.Wallace, an engineer; and his assistant and calculator was N.S.Norway, a mathematician. Both achieved wider fame later in their lives. Barnes Wallace helped design the Wellington bomber and played a leading role in making the swing wing functional; he was also behind the idea of the 'bouncing bomb' and responsible for many other inventions. Mr. Norway set up the Airspeed Aeroplane Company after 1930 and produced one of the first aircraft that went into the official Royal Flight. He also wrote one or two good stories under his first two names – Neville Shute! While the engineers were busy designing, it was realized just how important meteorology was to aviation in general and, particularly, to airship operations.

NEW DEVELOPMENTS

The Air Ministry decided to develop a national policy for air travel. This involved nationalising the existing facilities at Cardington in Bedfordshire and nearby Shortstown to create a Royal Airship Works. Effectively, Shortstown was the place where Shorts were building balloons and airships for the Navy during the First World War. However, the company had been nationalised, at an arbitrarily fixed price, which irritated Oswald Short. His company had something of a reputation, Short Brothers being one of the first aeronautical manufacturing companies in the world.

For airships, the most important aspect of meteorology was the structure of winds, especially at low level. It is, indeed, still a matter of active interest for aviation, but for airships being handled on the ground or parked on masts it was vital. Climatology was important along proposed routes and also to help plan acceptable landing sites.

There was also a need for aviation weather forecasts. Meteorologists needed to work out how to forecast the weather over extended distances and provide the data required for making in-flight decisions. To help with this, Cardington’s staff became Britain’s leading experts in applying the then-new concepts of air masses and fronts.

To meet these needs, an Airship Division of the Met Office was formed, becoming operational in January 1925. Investigations were carried out by the Division’s staff, with one study, using several anemometers at Cardington, leading to an important Met Office Geophysical Memoir about the structure of low-level winds. Indeed, research into boundary-layer low-level meteorology still continues at Cardington.

In addition to policy and administration, the headquarters part of the Airship Division investigated weather world-wide, eventually becoming the Special Investigations Division during World War II, studying all aspects of aviation and military climatology. One of the first decisions made in the Division was to analyse a retrospective series of charts to obtain a picture of the weather over a large area. Charts for a whole year starting on 1 April 1924 were analysed retrospectively and helped show what data needed to be available during operational flying.

The first station of the Airship Meteorology Division to be manned was the re-opened meteorological hut at Pulham in Norfolk. This had been open for a while in 1919 and re-opened on 23 February 1925. Its staff went into action in April, when the R.33 was transferred from Cardington to Pulham, the report of this in the *Meteorological Magazine* stating: “This good beginning is a favourable omen for the future of the Imperial Airship Service”. The following month in the *Meteorological Magazine*, it was reported that within a few days of getting there, the R.33 had broken away from its mooring mast and drifted out over the North Sea. Fortunately, there were few people on board and a skeleton crew managed to recover the airship.

By March 1926, the Met Office at Cardington was the primary centre for airship work and staff were detached to Pulham or Howden only as required. By then, a meteorological office had been built at Cardington – consisting of a tower with a radio aerial and an anemometer on top of the tower at a height similar to the one where airships were parked a few hundred yards away (Fig.44). To examine problems of world-wide flying, Maurice Giblett accompanied an Air Ministry survey team on a world tour in 1927 to investigate places suitable for airship operations.

By 1929, a plan had been drawn up, covering routes from the UK to Canada, South Africa, India, Australia and New Zealand (Fig.45). These were fairly ambitious plans, for which surveying had taken place in 1927. The copy of the plan (below) shows the meteorological organization set up to cope with the routes to be flown. For example, flights to India would be covered by meteorological centres at Cardington, Ismailia and Karachi (which were airship bases with meteorological centres); and there were various radio broadcast points to relay data.

One of the new challenges was the handling of synoptic data over unfamiliar extended areas. One solution was a chart, labelled Form 2206, which covered the route from the United Kingdom to India with key observing stations named. It was marked with squares so that it could be cut into sections, thus making it manageable as the in-flight data were received by radio. When the sections were put together, a fuller picture of the synoptic situation was obtained.

Fig.44: Custom-built Met Office at Cardington

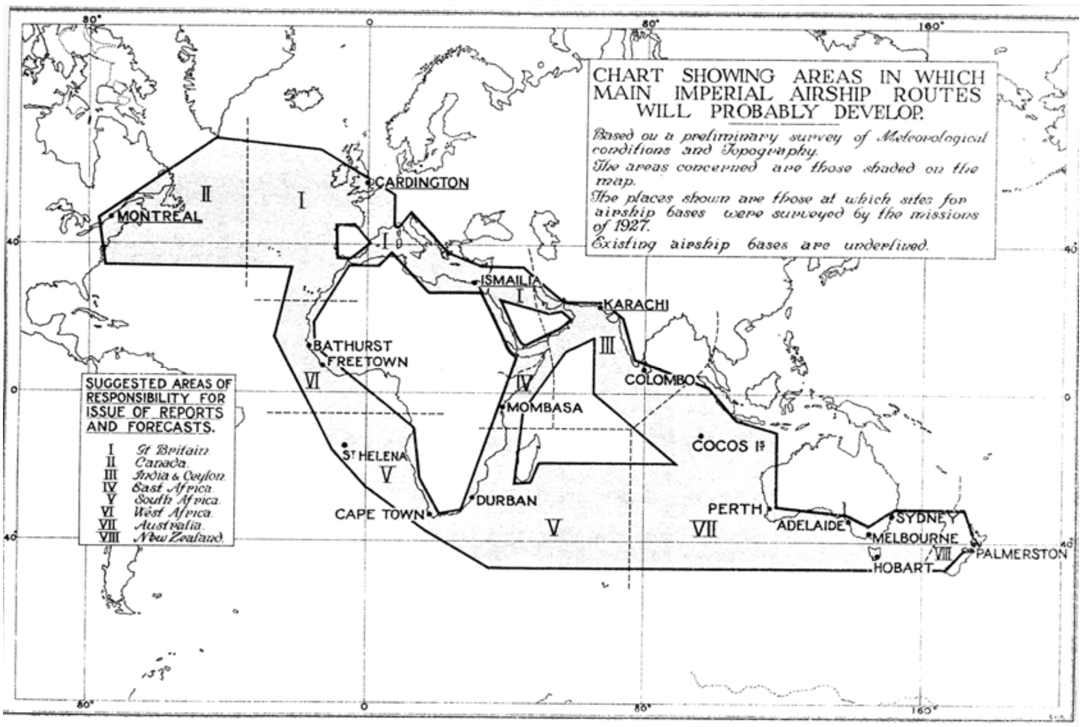


Fig.45: Meteorological services for planned airship routes

Cardington staff also decided to try and send pictures and words by radio, and an interesting experiment was carried out. On 20 March 1929, a photograph transmitter was attached to the R/T transmitter at Cardington and charts and forecasts were sent via the transmitter at Daventry live to a meeting of the Royal Meteorological Society, where they illustrated a talk by R.A.Watson-Watt (*q.v.*). Fig.46 is a facsimile of what is probably the first radio facsimile chart and forecast, something that many think started after the Second World War.

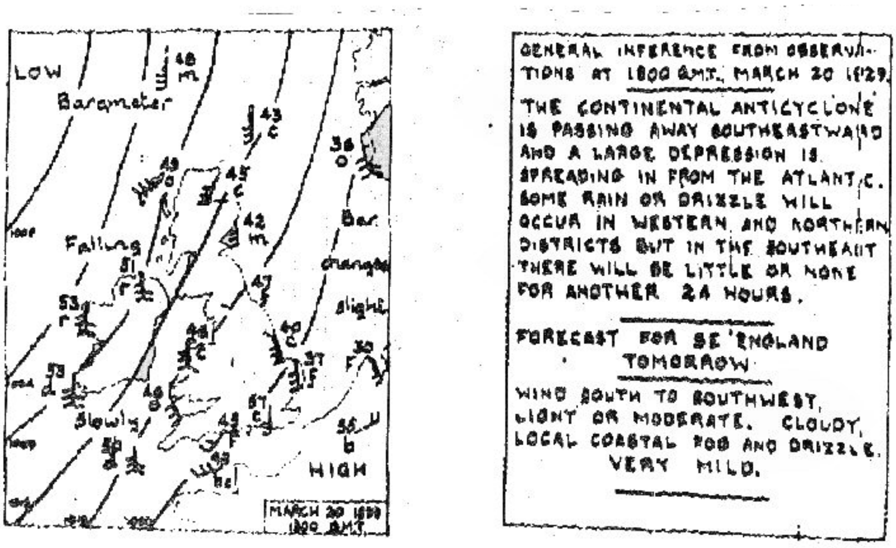


Fig.46 The pioneering radio facsimile

DREAMS SHOW PROMISE

As a result of much work by designers and engineers, some rather graceful silver airships had been built. Fig.47 shows the R.101 (built by the Royal Airship Works) near the mooring tower at Cardington. To try and improve the lift, they had another section inserted before the craft took off for India.

R.100 (Fig.48) looked rather similar to R.101 but was a different design from Vickers, with the mathematician Neville Shute Norway carrying out calculations for chief designer Barnes Wallis. The aircraft flew without serious incident to Canada and back in the summer of 1930.

Fig.47: R.101 near the mooring tower at Cardington

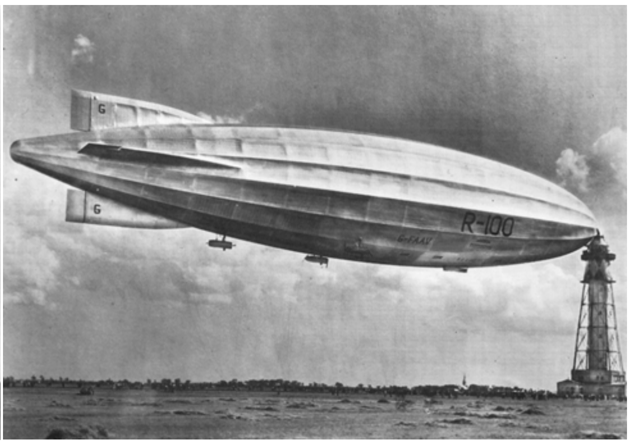


Fig.48: R.100 completed a successful transatlantic flight

SHATTERED DREAMS – NEW DREAMS

After initial flight trials, R.101 took off soon at 6.24 p.m. on 4 October 1930 on its first international trip to India. Against the better judgement of some, the airship left in deteriorating weather and crashed at five minutes past two the following morning near Beauvais in France. Among the 48 people who lost their lives was the Superintendent of the Meteorological Office Airship Division, Maurice Giblett, one of the rising stars of the Met Office. Back in the early 1990s, one of the visitors to the National Meteorological Library was Mr Brian Oddie, an Olympic runner and a physics graduate who joined the Airship Division at Cardington in 1926. He told me that he was actually speaking to Maurice Giblett on the evening before they took off and Giblett was most apprehensive about the decision to press on. From various accounts of the loss of the R.101, one gets the impression that high-ranking politicians and civil servants put pressure on the captain, Major Scott, to take off when he did. Scott was a dynamic man and an experienced flyer, who probably knew that the people in power were ignorant of the old adage about there being “old pilots and bold pilots but no old bold pilots”. The Airship Division of the Met Office finally closed down at the end of 1931.

The loss of the *Hindenberg* in 1937 in America proved the death-knell for passenger-carrying airships.

Training in balloon handling was provided at Cardington, where No.1 Balloon Training Unit was formed on 9 January 1937. Balloon Command was formed on 1 November 1938 under the auspices of Fighter Command. By the time it closed down in 1943, the Balloon Training Unit had trained some 10,000 RAF and WAAF operators and 12,000 operator drivers. Balloon Command as a whole stood down in February 1945.

By the end of World War I, aeroplanes flew typically at 75-150 miles per hour at an altitude of a few thousand feet over distances of 200-300 miles, but airships could stay aloft for days and travel at least a couple of thousand miles non-stop.

The calamity of the ruined potential airship service must have encouraged the men of Imperial Airways, who favoured aeroplanes, and the designers at companies like Handley Page, de Havilland and Short Brothers. Airmail services were introduced in about 1919 across the English Channel and became generally available to the public in the late 1920s, when most of Europe and some of the Empire was covered. Then, in 1934, an air mail service from London to Australia was started.

While Handley Page produced the classic long-distance airliners of the day, the aeroplane and aerodrome technology rather limited the size of passenger aircraft. The HP42 (Fig.49) and HP45 proved reliable and safe, with a luxurious cabin, but their range was poor and they flew at only about 100 mph. The possible solution to the size and weight problem was the development of flying boats, particularly the Boeing ‘Clipper’ and the Short ‘C’ class and Empire models (Fig.50).

Fig.49: Handley Page classic airliner

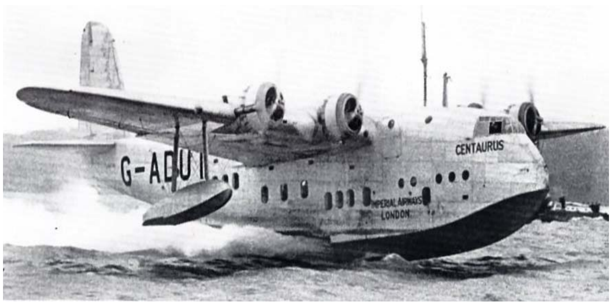


Fig.50: Shorts’ flying boats covered many international air routes during the 1940s and early '50s.

By the end of the 1930s, specialist aeroplanes could fly at more than 450 mph, reach altitudes above 55,000 feet and cover distances of 7,000 miles, but routine airliners were more likely to cruise at around 200 mph over a distance of 2,000 miles and below 10,000 feet. The first pressurized airliner became operational in 1940, foreshadowing the civil aviation boom after World War II.

METEOROLOGICAL LANDMARKS

The concept of fronts was published in the meteorological literature in 1919 and Sir Napier Shaw visited Bergen in May 1920 to discuss the ideas of the Scandinavians with Vilhelm and Jacob Bjerknes. For this trip, he was accompanied by A.H.R.Goldie, C.K.M.Douglas and L.F.Richardson. International scientific contacts had, of course, been interrupted by the Great War. Then, from October 1925 to March 1926, Jacob Bjerknes spent six months attached to the Met Office to demonstrate the use of the Bergen School’s theory of cyclones. The archived Central Forecast Office charts of the 1920s show a few fronts, but it was the best part of a decade before fronts appeared regularly and much longer before the public saw them, although Cardington was in the forefront of using the new techniques. Even in 1935, Richard Corless, the superintendent of the Forecast and Aviation Services Division, still sounded unenthusiastic about fronts when speaking to the Conference of Empire Meteorologists.

In 1922, Richardson’s book *Weather prediction by numerical process* was published and has since been recognized as a seminal work. At the time, it failed to have any impact on day-to-day working meteorologists, but it did emphasize the importance of upper-air data. Vertical soundings by aircraft were already being made at various RAF stations (e.g. Andover). Then, in 1924, a dedicated Meteorological Flight was formed at Eastchurch which soon transferred to Duxford and later (1936) moved to Mildenhall when another flight was formed at Aldergrove. This expensive method of gathering vital data was overtaken during the 1930s by one of the most important advances for practical forecasting, the invention and development of the radiosonde.

In 1925, for the first time, a ‘standard atmosphere’ was internationally accepted for aviation design and operating purposes, this being the ICAN (International Commission for Air Navigation) atmosphere that became in 1947 the ICAO (International Civil Aviation Organization) atmosphere.

1926 also saw the introduction of ‘NS Form B for tephigram’, a thermodynamic diagram for the reduction of observations of the upper air. The importance of upper-air data had become clear. However, the quantity was insufficient at that time, but for practical weathermen of the future the ‘Tephi’ (pronounced tee-fie) was one of the most significant advances of the 1920s.

One of the most important practical advances during the inter-war period was in communications. The system of using telegrams and the telegraph was gradually overtaken by the use of radiotelephony, but the greatest advance was the teleprinter network, initiated in 1935.

RECORDS

Records of the activities of meteorologists during the First World War are very limited, the remit of the National Meteorological Archive being to keep original officially observed data and official synoptic charts. The stations in France were never deemed permanent or officially inspected to ensure they conformed to standards of exposure. We are lucky that someone, presumably Gold, thought it worth archiving the diaries of forecasts issued to Service Units on the Western Front between 24 October 1916 and 30 March 1919 (Gold, 1916-1919) (Fig.51). These illustrate clearly how forecasts changed during this period. Gold thought it worth recording some of the lessons learnt and published "Aids to forecasting; types of pressure distribution, with notes and tables for the fourteen years 1905-1918" (Gold 1920). Also, for the first time, he outlined the needs of meteorology and aviation in the *Journal of the Scottish Meteorological Society* (Gold, 1919).

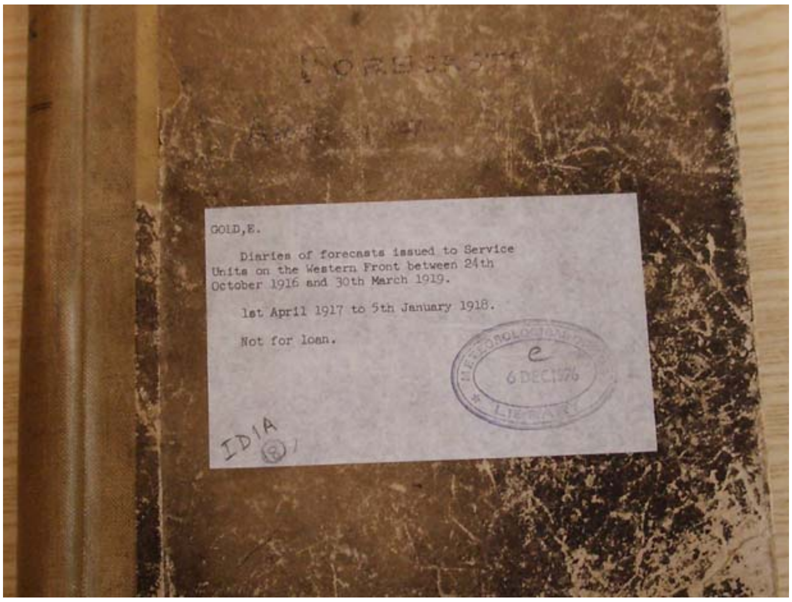


Fig.51: Ernest Gold's first log book

He went on to become the leading light in the development of international meteorological services, especially for aviation.

During World War I, there was a major transformation in the world of meteorology – in techniques, methods, scientific approaches and operational appreciation. Tasks like calculating gradient winds from the spacing of isobars became a standard procedure, based on Gold's paper of 1908. This was also explained in the *Meteorological Glossary*, which was issued for the first time during the war and retained in various editions until the sixth in 1991.

Another major innovation came from the recognition that existing codes were totally inadequate to provide the data for military forecasts, so a new code was created for use by 'Meteor' stations, with figures added for visibility, the form and amount of low, medium and high cloud, relative humidity, present weather, past weather, rainfall twice a day and maximum and minimum temperatures. The form was agreed with French meteorologists and, with little change, included, in 1919, in the International Convention for Air Navigation (with the concurrence of the USA). After adoption by the International Meteorological Organization, only minor changes were made in the next 25 years. It was an unsung major contribution to international meteorology.

AND FINALLY

The pictures of people mentioned in this paper were mostly taken in their more mature years; we could find no pictures of them during the Great War. Met men were in the Royal Engineers, so would have looked something like the men in the searchlight unit in Fig.52, and those that flew with the Royal Flying Corps may well have been scruffier (Fig.53)!

Fig.52: A Royal Engineers unit

Fig.53: RFC pilots

ACKNOWLEDGEMENTS

Several items shown are photocopies made when the original material passed through the National Meteorological Library and Archive prior to 1998. They were collected out of personal interest with no expectation of publishing or reproducing them, thus their provenance was not noted and sources cannot be quoted.

I wish to thank former colleagues and staff of the National Meteorological Library who supplied copies of many references and pictures, especially Mick Wood and Graham Bartlett. I am also very grateful to Peter Davies and Brian Booth, who are researching details of all the names on the Met Office Roll of Honour.

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