

<u>AIRSHIP DEVELOPMENT PROGRAMME.</u>	<u>Page.</u>
Development of R.101 and R.100.	1
Novel Features.	2
Experimental work.	2-3
Airworthiness requirements.	3
<u>GENERAL DESCRIPTION OF R.101.</u>	4
Passenger Accommodation.	4
Power Units.	4-5-6
Useful Load.	6
Central Body of Hull.	6
System of Girder Work.	6
Transverse Frames.	6-7
New Materials.	7
Gasbag Wiring.	7
Gas Valves.	7
Fuel System.	8
Ballast System.	8
Forward Portion.	8
Stern Portion.	8A
<u>TESTS & TRIALS.</u>	8A
Kite Balloon Trials.	9
Flight Trials.	9-10
<u>GROUND ORGANIZATION.</u>	11
Dominion Bases.	11-12
<u>FUTURE OPERATIONS.</u>	13
<u>METEOROLOGICAL ARRANGEMENTS.</u>	14
England-Egypt-India Route.	14-14A
Other Routes.	14A
<u>COMMUNICATIONS ORGANIZATION.</u>	14A-15
<u>FOREIGN AIRSHIP ACTIVITIES.</u>	15
<u>TOWER MOORING OF AIRSHIPS.</u>	16-17- 18
<u>COMPARATIVE TABLE OF AIRSHIPS.</u>	19
<u>AIRSHIPS DIRECTORATE & SHIPS CREWS.</u>	20

STOP PRESS NOTE.

Note.

The shed trials were successfully completed yesterday (Tuesday) but it has been decided not to begin mooring trials before Saturday morning in order to finish some minor work on the ship. The flight trials will probably begin about 48 hours after the airship goes to the mooring tower.

Arrangements have been made for a party of 400 men to be available to "walk" the ship from its hangar to the mooring tower. These will include 200 employees from the Royal Airship Works, 150 R.A.F. airmen from Henlow, and 50 men from Bedford.

THE WORLD'S LARGEST AIRSHIPS.

DEVELOPMENT OF R.101 AND R.100.

When the present Airship Development Programme was sanctioned the objects consisted of :-

Experimental work, including flights by H.M. Airship R.33, to secure technical data as a preliminary to the construction of new airships.

The construction of two new five million cubic feet airships - one - R.101 - by the Air Ministry at the Royal Airship works, Cardington, and the other - R.100 - for the Air Ministry by the Airship Guarantee Co., at Howden, Yorks.

The development of the necessary ground organization to enable experimental flights to be carried out on the England-Egypt-India route.

The programme, in other words, was to test out the practicability of airships in the light of post-war knowledge as a vehicle of long distance transport. There was no intention, however, of inaugurating regular commercial services with the present ships but it was, and is, the hope that if the airships prove technically satisfactory steps will be taken which will lead to the establishment of regular airship lines.

When it was decided in 1924 to proceed with the construction of R.100 and R.101 the largest airship built at that time was little more than half the size of the new rigids. This decision called for the solution of many novel problems dictated on the one hand by the immense increase in size, and on the other, by the desire to instal engines using fuel other than petrol.

It should not be forgotten that R.101 and R.100 are the largest airships ever built and that it is only comparatively recently that the Zeppelin authorities and the American Government have decided to emulate British enterprise by embarking upon the construction of new airships of over 5,000,000 cubic feet, capacity.

If the British designers had been content to follow closely the Zeppelin system of construction, as practised in 1924, the new airships would have been finished long since; instead they proceeded to tackle the problems involved on new lines, just as earlier, British airship staff had made a material contribution to the operative side by the introduction of the mooring tower.

But the novelty of design meant a large amount of experimental work, and it is this that has mainly been the cause of the date of completion being later than was originally estimated.

The actual assembly of parts and erection has proceeded very smoothly.

Novel Features.

The two airships R.100 and R.101 are as stated above, completely novel in many respects, but they are not sister-ships, the designers of each airship having had, subject to certain general requirements, a free hand in the design.

Both airships represent a radical departure from previous British Airships, since they have to conform to more exacting airworthiness conditions, and have to provide accommodation for a large number of passengers for long journeys.

Some of these departures have been necessitated by the great increase in size, others represent progressive development which, though not perhaps making itself fully felt in the first airship, may well prove of first class importance in the future. The actual performance attained by these airships can only be judged after completion of flight trials, but it is not to be expected that the first airship of such a novel class can at once achieve the degree of comfort, regularity and reliability which is to be found in well established means of transport. It would clearly be misleading to take the performance of the present airships as the best that airships of this size can be made to give.

It is obvious that in such a novel design until experience is obtained performance must be subordinated to safety. In consequence a very large amount of experimental and research work was necessary before construction could commence, and this work in fact took some 18 months longer than was originally anticipated, and is one of the factors that has delayed the completion of the first airship until the present date. There is also reason to think that in any subsequent airships of the R.100 or R.101 type the structure weights could safely be reduced by several tons, as a result of the experience gained in the construction of these two airships.

It was originally intended that petrol should not be included in either R.100 or R.101. When it became clear, however, that owing to the amount of experimental work involved, a sufficient number of engines of the necessary performance, burning heavy oil fuel, could not be produced by the time the airships would be ready, it was decided to limit this feature to one airship only.

It may be pointed out that there would be no technical difficulty in re-engining either airship when improved heavy oil engines become available.

Experimental Work.

The main experimental work was completed two years ago, including the necessary flight tests by R.33. The flights provided technical material which had not hitherto been available to airship designers and, amongst other things, the comparison of the data obtained from full scale trials with R.33 showed that the wind channel tests of a model airship may be relied upon as substantially accurate for full scale. This was of great importance from a design point of view.

Experimental work in other directions has also proved valuable; in particular the tests on a complete experimental section of the new airship (R.101) at Cardington afforded a valuable check on the designer's

The gas capacity of R.101 is approximately 5,000,000 cubic feet, giving a lift of something over 150 tons. Her length is about 732 feet, her maximum diameter about 132 feet, her height including control car about 140 feet. The length diameter ratio is, it will be seen $5\frac{1}{2} - 1$. The shape was adopted after exhaustive model tests at the National Physical Laboratory which shewed it had good aerodynamic efficiency. Structural considerations have hitherto prevented the adoption of a really good shape but in the design of R.101 these limitations have been removed.

Passenger Accommodation.

The passenger accommodation is located on two decks inside the ship in the bottom portions of bays 6-7 and 7-8. The upper deck has an area (exclusive of the promenades) of 5,550 square feet. The lower deck has an area of 1,730 square feet which can be increased later if found necessary to approximately 4,000 square feet by means of side wing decks.

The upper deck carries a large lounge with promenades on either side, from which the passengers may obtain an outward view through windows in the outer cover. This deck also carries a separate dining room for 50 persons and a number of two-berth sleeping cabins. It also carries washing accommodation which consists of hand basins arranged in cubicles.

The lower deck carries the Captain's control room, and beneath this a control car projects outside the outer cover. There is open communication between the control room and the control car. There is a separate wireless cabin adjacent to the control room.

The kitchen with its electrical cooking arrangements is located on the lower deck, and a small lift communicates between this and the dining room on the upper deck.

The lower deck also carries the electric distribution room and a ventilating chamber. From this chamber an electrically driven fan circulates the air in the passenger accommodation through a large radiator fed by steam from two of the airship's main engines, and induces a proportion of fresh air from outside. When the heat is not required, the radiator is lowered outside the hull to be cooled in the ordinary way.

A corridor runs along one of the bottom longitudinal girders, and this will be used for communication for passengers between the passenger accommodation and the point near the nose of the ship from which they will enter the ship at the mooring tower. This corridor is slightly larger than that provided in an ordinary train.

Power Units.

The machinery of the airship is carried in five independent power units, each arranged to be self-contained and easily replaced by spare units. Such an arrangement avoids undue delays due to a breakdown in the machinery as a complete power car can be removed for overhaul or repair and another attached to the airship more quickly than an engine can be taken out of a car and replaced.

Two units are attached to Frame 4, two to Frame 9, and one on the centre line at Frame 11.

All these units have been run on a special test gantry before being attached to the ship. This gantry is so

constructed that the power unit can be inclined in order to represent the condition of the airship pitched up or down. An auxiliary engine and airscrew is arranged in front of the unit to throw a stream of air over it so as to produce as closely as possible the conditions of actual flight.

It was originally intended to fit variable pitch propellers to enable all the engines to be reversed. The development however of such an airscrew for the Tornado engine is not yet complete and consequently R.101 will in the first instance take the air with 4 engines to go ahead and 1 to go astern.

The effect of this arrangement in conjunction with the fact that the horse-power of the engine is lower than that for which R.101 was designed, means that while the airship on her trials should attain a top speed of about 70 m.p.h. with a cruising speed of about 63 m.p.h., she will not attain her design (top) speed of about 80 m.p.h. until more forward power is available.

Each unit contains a Beardmore Diesel Engine of 585 h.p. driving an airscrew. There is also a small auxiliary engine by which the main engine is started through a Bendix gear. This auxiliary also drives an air compressor in two of the units, the compressor being required for the transfer of fuel in the ship. In the other three units an electric generator is fitted in place of the compressor, this generator can be driven by the auxiliary engine when the ship is not underway. When, however, the ship is proceeding at speeds in excess of 60 miles per hour, the generators are driven by variable pitch windmills which automatically keep the speed of rotation constant. Great care has been exercised to provide good protection for the engineer in the car, and yet to allow free access to all parts of the engine so that reasonable repairs can be executed in the air without difficulty. For example, a cylinder head can be removed and if necessary replaced by a spare one. These results have been achieved within a car of relatively small cubic capacity (no greater than that of R.33's wing cars) and of very clean external form.

There are two important respects in which this engine unit differs from those of earlier airships:

- (1) The fuel used is a heavy fuel oil of which the flash point is considerably higher even than the oil used as fuel in ships' boilers. The specification of this oil has required considerable care because while a very high flash point has been achieved, it has been necessary to accept only oil which will not thicken at the low temperatures which will be experienced in flight. The oil actually used has a flash point of 210°F . and flows satisfactorily at temperatures down to 0°F .
- (2) The engine is of the water cooled type, but is arranged so that instead of circulating water through the radiator, steam only passes to a condensing radiator. This has the important advantage of enabling the radiator to be placed at any convenient distance from the car without involving the prohibitive weight which would result if the radiator and connecting pipes were filled with water. In those engine cars which are near the passenger space, arrangements have been made for delivering the steam to a radiator which will be used for heating the passenger accommodation. When this heating is not required, the steam radiator is lowered so as to project below the outer cover of the airship and be cooled by the passing air. When the passenger heating system is in operation, the cooling of

The Diesel type engine in addition to the greatly increased safety which it gives through the use of heavy oil, has the advantage of increased reliability through the elimination of carburettors and magnetos. It is also economical both as regards the quantity and the price of the fuel it consumes. A given quantity of oil fuel gives about 25 - 30% greater range than does the same weight of petrol, whilst the oil fuel costs approximately £5 a ton as against £25 for a ton of petrol.

Useful Load.

Until the airships have been put through their trials, no detailed figures can be given as to this - much depends for example on fuel consumption. As has been stated however in the House of Commons the useful load of R.101 has been to some extent sacrificed in order to embody certain experimental developments, which were felt to be of great importance for the future - e.g. the unbraced ring and the heavy oil engines. Consequently cabins for 52 only have at present been fitted. Details of the lounge, smoking and dining accommodation are given elsewhere.

THE AIRSHIP HULL.

The hull of the airship may be conveniently described as being divided into three portions, the central body, the nose and tail.

Central Body of the Hull Framework.

The central body consists of 10 large transverse frames of a novel type, numbered respectively 3 - 12 inclusive, connected by longitudinal members. There are 15 main longitudinals and 15 intermediate members, or reefing boom girders. The latter are not an essential part of the main structure but are provided for the support of the outer cover. This portion of the airship carries the passenger accommodation, all power cars and the control car.

System of Girder Work.

The main longitudinals and transverse girders are triangular members, having tubular booms of high tensile stainless steel.

Duralumin die stampings are used largely for main joints, and all members are interconnected by bolts. In addition to structural efficiency, ease of erection and the possibility of accurately calculating the distribution of stresses were some of the main objects of the design. Messrs. Boulton & Paul were responsible for the design and manufacture of the members and joints of the hull framework to specified geometrical dimensions and loads. A number of representative members have been tested to destruction at the R.A.E., Farnborough.

Transverse Frames.

The transverse frames of the airship will be seen to differ considerably from the conventional type of Zeppelin frame. The frames of R.101 are sufficiently stiff without the use of transverse bracing. In an experiment carried out with one of the largest of these frames it was hung up at a single point at the top and a weight of six tons was loaded on to the bottom of the frame. The effect of this was to cause an extension of the vertical diameter of only approximately 4" on a diameter of 130 feet.

This type of ring has many advantages for large airships, but it brings in its train a fresh problem in the design of a suitable bulkhead for separating the gasbags and preventing longitudinal surging of the lifting gas. This problem has been solved in R.101 by the parachute type of bulkhead.

The special type of girder which has helped to make this new departure possible has the advantage of extreme simplicity, cleanness of design and ease of assembly. With the earliest types of girder it was not possible to have a standard design of joint; the girders were fitted together and riveted in situ, in the best way which offered itself. In the present type joints are standardised by means of special end pieces into which the booms of the girders are bolted; and so rapid and simple is the process of assembly that each ring may be built up from its component girders by ten men in one week; and the whole bay by eleven men in a fortnight.

In ring No.5 there is access by means of ladders and stairways round the inside of the ring, to a cockpit in the top of the ship. In several of the rings ladders and stairways are provided up to the mid-height, from whence the crew can proceed along the ship on the longitudinal girders between the gasbags and the outer cover., for the purpose of inspecting the gas valves which are situated at the mid-height.

The fitting of fuel tanks and piping, ladders, transverse gasbag netting etc., into the ring, is done whilst the ring is still lying on the ground. In the same way the fuel and oil piping in the longitudinals is fitted in on the ground. Consequently, once a transverse frame is erected vertically into place (a very simple operation which occupies only about 20 minutes), no further installation work has to be done in the air, except for the joining up of the longitudinals between one transverse frame and the next, together with the fuel pipes etc.

Use of New Materials. The large increase in the size of the airship has made it possible to employ high tensile stainless steel in the construction of certain parts, and thus secure a saving of weight in the structure, since the type of steel used is strength for strength, lighter than duralumin. The use of steel was not possible in the older and smaller airships, because the gauge required would have been too thin for practical working. Duralumin forgings are used for the joints; and considerable research was necessary before a satisfactory technique could be evolved for the production of these joints, and for the drawing and rolling of the high tensile steel.

The problem of protecting from corrosion the large surfaces of steel and duralumin in the hull of the airship has required special attention. All steel used in the girders is stainless and is sand-blasted and covered with grey lacquer. All other steel parts are zinc-plated.

All duralumin is treated by a special process (known as the "Anodic" process) developed at the Royal Aircraft Establishment, Farnborough, which has been proved by experiment to give a very efficient protection.

Gas Bag Wiring. The type of gasbag wiring is also novel. The design of this has been largely governed by the parachute type of bulkhead previously referred to, which it incorporates. Its function is to constrain the gasbags and to transmit the lift of the gas to the hull framework. The system employed is more effective than were earlier designs in transmitting the lift directly to the main joints with a minimum tendency to distort the framework, whilst preventing surging of the gas towards one end of the ship when inclined.

Gas Valves. The gas valves are situated on each side of the gas bags. These valves are of an entirely novel character and are designed to act as combined automatic and manoeuvring valves, that is to say, they will automatically relieve the pressure in the gasbags when these bags become full, or they can be operated by the Captain of the ship from the Control Car in such a manner as to release gas, if he so desires, even when the bags are not full. The possible dangers to airships from the very rapid vertical currents which occur in thunder-storms are fully appreciated, and these valves are designed to deal with a much more rapid rate of rise, about 4,000 ft. per minute, than was previously

Fuel System.

The large tanks which will be seen, each hold 224 gallons (equivalent to 1870 lbs.) of special fuel oil. In a few special positions tanks of half this size are fitted. The fuel from any of the tanks can be run down into special pressure tanks from whence it can be blown by compressed air to any part of the ship. This is a new feature in airships and is designed to facilitate the feeding of the main engines and the trimming of the ship.

Certain of the tanks are fitted with special discs and circular cutters (working on a similar principle to that employed in cigarette tins) for the purpose of rapidly emptying the contents in an emergency.

A certain number of tanks will be seen on the passenger decks. These tanks are intended to supply compensating weights when the full complement of passengers is not being carried or when disembarking passengers, but they can also be used to increase the airship's total fuel capacity for long demonstration or reconnaissance flights without passengers.

The tankage provided for fuel exclusive of the tanks above referred to, will carry nearly 29 tons of heavy oil. The tanks provided in the passenger accommodation would bring the total fuel capacity up to something over 37 tons, approximately 10,000 gallons, if no passengers were carried.

Ballast System.

Provision is made to carry 8 tons of water ballast in emergency bags (from which it can be quickly released) and 7 tons in tanks similar to those used for the fuel. The water in these tanks can be transferred to any part of the ship by means of compressed air. It is not anticipated, however, that so much water for ballast will normally be required and therefore if desired, the water tanks (not bags) can be filled with fuel oil bringing the total fuel capacity up to 44 tons.

Forward Portion.

Forward of Frame 3, the nose of the ship consists of three simple flat transverse frames, numbered C, 1 and 2 respectively and the intervening longitudinals.

At Frame 2 is located a fair sized platform carrying hatches from which the trail rope and handling lines of the ship can be lowered.

At Frame 1 is located a closed in drop gangway, by means of which the passengers will enter the ship from the mooring tower.

Between Frame 0 and the nose cap is located a small cabin which carries the winches for the mooring ropes, and also connections to the main supply of electric current, water, gas, air and fuel when the ship is riding at the mooring tower. The nose cap itself consists of a tubular structure carrying a very strong spindle, to which is attached the cone used for mooring the airship to the tower. This spindle is capable of resisting a lateral load of 30 tons.

Special instruments indicate in the Control Car the lateral and vertical forces exerted at the mooring attachment.

Stern Portion.

The Stern portion of the ship consists principally of three special frames, numbered 13, 14, and 15 respectively which carry the fins and flaps. Aft of this is a light tail piece about 60' long, made of conventional Zeppelin type girder work.

Each of the four fins, including its flap has an area of approximately 2200 sq. feet. Each of the flaps has a span of about 44 feet and in order to assist the coxswain in the control car in the operation of these large surfaces, auxiliary Servo-motive power is provided. The machinery for this, which includes Vickers-Janney Variable Speed Gear, actuated by an electric motor, is located in the bottom fin. The ships can also be operated entirely by hand from this position should there be any failure of the control cables passing through the hull to the control car.

TESTS & TRIALS.

A very complete series of tests have been carried out on the equipment of R.101 during the course of construction.

These include tests of:-

1. Fuel and water ballast containers, pipe lines, etc. including the transfer of fuel and water from one part of the ship to another. Rate of discharge of water ballast etc.
2. Electrical Installation for lighting, power and cooking.
3. Rudder and elevator controls for operation by power and by hand.
4. Gas valves, for automatic and hand operation.
5. Wireless Installation.
6. Engine units including running of each power car when in position on the airship. This is in addition to extensive tests on the special gantry and engine acceptance tests at the Maker's Works.
7. The mooring and handling equipment including mooring force indicators in the bow.
8. Fin loading.

When the airship is air-borne, that is when all erection staging and suspensions etc. have been taken away, and the ship is maintained in equilibrium by the lift of the gas, lift and trim trials are carried out to ascertain the actual lift of the airship and to check the correct distribution of all fixed and movable weights about the centre of buoyancy.

Kite Balloon Mooring Trials.

A kite balloon flown from the mooring tower has been found to be an extremely useful, practical and inexpensive method of training the tower crew in the handling of the ground wires, control of the winches etc. It is proposed to supply one to each base for this purpose.

The landing officer and a certain number of men for each base abroad will also receive training in the mooring operations of R.100 and R.101 at Cardington during the home trials of these airships before proceeding overseas.

An Officer and men from Canada have been under training at R.A.W. during the current year.
Flight Trials.

The trials of the two airships will, it is anticipated, occupy 3-6 months at home, and will be carried out from the R.A.W. Cardington. These flights will be of a progressive nature, and will ultimately be extended to the bases abroad. The shed trials of R.101 have been carried out and those of R.100 are nearing completion. The home flight trials of the two airships will follow each other.

No special tests will be carried out on the first flight as this will be used simply for the purpose of observing how the various means of control function, and obtaining a general "feel" of the ship from a flying point of view.

When the airship is at the mooring tower, the operation of the winches in the airship for the mooring cables will be observed. Also, all the refuelling and ballasting arrangements will be tested. The general behaviour of the bow spindle and cone when locked in the mooring tower cup will be specially observed.

The entrance gangway from the mooring tower will be in position and the opportunity taken of considering the best way of embarking and disembarking passengers.

During the flight special notice will be taken of the running of the engines, any vibration in the ship's structure, noise in the passenger car, ventilation, heating of passenger car and similar attendant details.

The most important items in the flying trials proper are :-

1. Speed trials.
2. Measurement of drag by deceleration of the airship.
3. Measurement of turning circle, controllability and stability of airship.
4. Measurements of strains and stresses in structure members by special electrically recording strain gauges.
5. Gas valve tests (including automatic release of gas at pressure height).
6. Tests of the pressure control system, which is designed to regulate automatically the pressure on the outer cover during any conditions of flight, and to provide for the ventilation of the interior of the hull as a whole.

GROUND ORGANISATION.

The works services approved in the original airship programme consisted of the enlargement of the existing shed at the Royal Airship Works and the provision of a mooring tower there; the provision of an airship tower in Egypt at Ismailia complete with hydrogen plant and all necessary equipment; and the provision of a similar base in India at Karachi, with the addition of a large repair shed. The Government of India have provided the land for the base at Karachi and refunded import dues on the material for the equipment. They have also paid for the mooring tower.

In 1927 it was decided to transfer to Cardington and enlarge one of the existing sheds at Pulham, so that during the trial flights (which will be carried out from Cardington) a shed should be available there for each airship.

The first shed and tower have been completed for some time and No.2 Shed is now complete.

The base in Egypt is completed and the base in India will be finished by the end of 1929. The shed is almost complete, and the erection of the tower, commenced in September, 1928, is progressing satisfactorily.

Dominion Bases.

As the result of the last Dominion Conference held in London in November, 1926, the Dominion of Canada and the Union of S.Africa agreed to erect mooring tower bases in their respective countries.

At the request of the Dominion Governments, members of the Airship Department and Meteorological Department, and Directorate of Works and Buildings, visited Canada, South Africa, Australia and New Zealand to survey and advise the respective Governments as to sites for Airship Bases.

The opportunity was taken on the tour to visit also West Africa, St. Helena, East Africa, Cocos Islands, and Ceylon, with a view to finding sites for future developments.

The Canadian Base is situated at St. Hubert, Montreal, and has been planned to combine both heavier-than-air and lighter-than-air aircraft operations. It is under the control of the Director of Civil Aviation in Canada and will be administered as a civil aerodrome.

The tower structure was manufactured in Canada and has been erected.

The tower head has been made in England and was shipped to Canada in July, 1928.

Good progress has been made in the construction of the base, and it will be ready for operations by the end of the year.

The Union of S.Africa have selected a site for an airship mooring tower base at Groutville, about 38 miles north of Durban. This land has been surveyed and preliminary estimates have been prepared, but no actual construction work has commenced.

The Commonwealth Government of Australia approved of the purchase of a suitable site for a base near Perth, W.A. at the time of the visit of the Airship Mission, but further action is not intended to be taken until after the trials of R.100 and/or R.101.

Bases Available.

The airship sheds and mooring towers available for demonstration with R.100 and R.101 on the routes to the East and in the Dominions are :-

England.

Cardington: No.1 Shed. Length 812', height 157') complete &
 Width 180') ready for
 No.2 Shed. -- do --) operations.
 Mooring Tower. Complete and ready
 for operations.

Egypt.

Ismailia. Mooring Tower. Complete and ready
 for operations.

India.

Karschi. Mooring Tower. Erection commenced Sept. 1928.
 Shed. Length 850', height 170'
 Width 180'.
 Will be completed and ready for
 operation by the end of 1929.

Canada.

St. Hubert. Mooring Tower. Will be completed and ready for
 operations by the end of 1929.

S.Africa.

Groutville, Mooring Tower. Site surveyed.
 Nr. Durban.

Future Operations.

The recent flights of the Graf Zeppelin have demonstrated the saving in time that can be achieved in airship travel. The following table is based on the assumption that a speed of 50 miles per hour is made good over the ground, - which is less than that made good by the Graf Zeppelin.

Route.	Times.		Saving days.
	Steamship.	Airship.	
	Days.	Days.	
England - Egypt.	6	2½	3½
On to Bombay.	15	5	10
" " Perth.	28	11	17
" " Sydney or Melbourne.	30	12½	18
England - South Africa via West Africa.	20	6½)	13½
do. via East "	20	6)	
On to Australia.		10½	
Australia - New Zealand.	6	1½	4½
England - Canada.	6	2½	3½
India - Australia.	22	6½	15½
" - " via England.	24	9	15
Australia - Canada via S. Africa - England.	48	15¾	32½

It is, however, fully realised that such comparisons are only valid when the airship has shown itself able to operate with reasonable regularity and punctuality. Given meteorological organisation such as has been arranged for. Its ability to do this will depend mainly on two factors - the sturdiness of the airship itself and the reliability of its engines, combined in both cases with that economy of weight which is essential for any successful aircraft or aero engine. It is not claimed that these problems have been completely solved by R.101 or the Tornado engine, both the first of their respective types. It is, however, hoped that flying trials will show that they do constitute a real step towards the solution of the problem that their designers had to face - particularly as several possible improvements in the matter of weight reduction have already suggested themselves.

The first thing is, however, to put the two airships through their flying trials in this country. A further operational programme, to test their capacity for regular flying on a definite route, has been provisionally drawn up. But until the airships have successfully passed through flying trials in this country nothing can usefully be said as to future operations.

METEOROLOGICAL ARRANGEMENTS.A. England - Egypt - India Route.

1. Investigation. Comprehensive investigations on meteorological conditions have been carried out and have produced much valuable information. Among the numerous investigations the more important are:-

- (a) Preparation of daily charts showing distribution of wind and weather along the whole route from Cardington to Karachi for use in investigating the variety of conditions to be met on individual flights. This is the first time that detailed synoptic charts have been drawn covering this large area linking up conditions over Europe and the Mediterranean with those in India.
- (b) Preparation of charts of the upper wind along the route.
- (c) Investigation of frequency of thunderstorms along the route.
- (d) Investigation of the detailed structure of the wind at Cardington in relation to airship mooring. A special installation consisting of a network of 4 specially adapted anemometers is in operation and much valuable information has already been gained showing the rate at which eddies travel, their extent and the rate of change of wind due to them.
- (e) Investigation of temperature conditions at the sub-tropical base at Ismailia, Egypt. A special mast 200 feet high has been erected on the airship base at Ismailia equipped with electrically recording thermometers at different levels and data are to be obtained during the remaining hot weather this year for the information of the airship operating staff prior to the airship's first visit to Ismailia next year. A similar installation is provided at Karachi by the India Meteorological Department.

2. Organization. When an airship flies to India from England it will be served by Meteorological centres at Cardington, Malta, Ismailia, Baghdad and Karachi.

- (a) Cardington. A special meteorological building has been erected providing an elevated forecast room fully equipped with meteorological recording instruments and with a wireless receiving room for taking in the meteorological data on which the forecasts will be based. The special features of the building are that the duty officer, while working in the forecast room on his weather charts will at the same time have a clear view of the sky in all directions and will have under his direct observation instruments recording continuously all the essential meteorological elements. In particular an anemometer mast rises above the forecast room to a height comparable with that of the top of the mooring tower and records in the forecast room the wind at that height.

The Cardington Office is staffed with trained scientists aided by a technical staff and is sufficient to maintain a continuous day and night watch. It will serve the airship during local operations, during periods when moored at the tower and also during the first section of long distance flights from England.

- (b) Malta. The Meteorological Office at Malta, (Branch of the Meteorological Office of the Air Ministry) will serve as a link en route to Egypt.
- (c) Ismailia. An observing station of the Meteorological Office of the Royal Air Force, Heliopolis (Branch of the Meteorological Office of the Air Ministry) has been put into operation on the airship base and a temporary forecasting centre will be established there for the initial Airship flights.
- (d) Baghdad. The Royal Air Force Meteorological Sections will serve as a link en route to India.
- (e) Karachi. A special forecast centre has already been established on the airship base by the India Meteorological Department and is preparing for reception of the airship; the meteorological staff there is at present mainly engaged in investigating conditions along the Persian Gulf and at the base.
- (f) Aden. If the alternative route by the Red Sea is used there will be a link at Aden.

Each of these centres will be associated with a wireless station providing a chain along which meteorological information can be exchanged between any pair of forecasting centres and between any forecasting centre and the airship in flight.

B. Other Routes.

Certain general investigations have been carried out relating to conditions along routes to all the Dominions.

The Superintendent, Airship Services Division, Meteorological Office was a member of the Airship Mission which visited the Dominions in 1927 and during the visit not only advised on meteorological conditions as affecting the choice of airship bases, but also conferred with the Dominion Meteorologists both as to conditions affecting flying in their areas and as to the organization it would be necessary to provide for flights to these Dominions.

As a result special meteorological work for Airships is being generally initiated.

During a visit to England of the Director of the Canadian Meteorological Service and the Chief of the Weather Bureau, Washington, conferences were held at the Air Ministry between them and the Director of the Meteorological Office. At these conferences the general principles were agreed relating to the meteorological organization for Trans-Atlantic demonstration flights.

Further, at the recent Conference of Empire Meteorologists held in London, the question of the necessary organization and investigations in the countries on the various Airship routes throughout the British Empire was discussed, and preliminary proposals formulated to meet future development.

COMMUNICATIONS ORGANIZATION.

The Airships R.100 and R.101 are fitted with W/T equipment for long wave transmission and receiving up to 1000-2000 miles range. An auxiliary set having a range of 200-400 miles and a telephone range of up to 100 miles will also be installed. The call sign of R.101 will be G-FAAW. and of R.100 G-FAAV. These are also the registration marks.

Direction finding apparatus and also a short wave transmitter and receiver will be fitted to one of the airships for experimental purposes.

At a later stage a wireless picture receiver may be installed to receive weather maps transmitted from the main Meteorological Fore-

Communications during the trials and demonstration flights will be maintained through the following stations:-

1. Home Trials.

Air Ministry stations at Cardington and Kidbrooke.

2. England and Egypt India Route.

Air Ministry stations at Cardington, Kidbrooke, Malta, Ismailia, Baghdad, Aden and the Indian Government station at Karachi.

3. England & Canada route.

Air Ministry stations at Cardington and Kidbrooke, Canadian Government stations at Cape Race St. John, Ottawa and Montreal. The Admiralty Station at Bermuda may also be utilised and possibly the U.S.A. station at the Airship base at Lakehurst.

On all routes it will be possible to maintain communications with the airship through this chain of stations for transmission of weather reports and other messages. The ground stations will also be able to communicate with each other to deal with meteorological information, arrival and departure messages etc. Use may also be made of stations controlled by the General Post Office, who have offered their assistance,

BRIEF PARTICULARS OF FOREIGN AIRSHIP
ACTIVITIES.

America. Two airships of 6,500,000 cu.ft. capacity are to be constructed by the Goodyear Zeppelin Corporation, Akron for the U.S.A. Navy, for completion by 1931 and 1932 respectively. A new airship base on the Pacific Coast has been authorised.

A small metal clad airship of 200,000 cu. ft. has been constructed by the Detroit Aircraft Corporation for the U.S.A. Naval Authorities. It incorporates many new interesting features of design, and as soon as the trials are completed, proposals are under consideration for the construction of a metal clad airship of 3,000,000 cu. ft. capacity to run demonstration flights between San Francisco and Honolulu.

Germany. The Zeppelin Company are erecting two large sheds, one at Friedrichshafen and one at Lowenthal. The former will be used for constructional purposes, and the latter as an Operational Station.

The Berlin Municipal Authorities have purchased the Staaken (Berlin) Airship Base from the Zeppelin Company, and intend erecting a Mooring Tower there.

The Zeppelin Company have under construction a 5,500,000 cu. ft. airship, and are also understood to be negotiating with American and German finance houses, with a view to inaugurating a Trans-Atlantic Airship Service.

THE TOWER MOORING OF AIRSHIPS.Development of Tower Mooring.

Airship operations during the War emphasized the limitations imposed on the utility of airships when operated from sheds. Although airships could fly in practically any weather, they could only be handled in and out of sheds under favourable weather conditions, and for this purpose a landing party of 200 to 300 men was required. The mooring tower has been designed to make regular airship operation practicable whether for Service or commercial purposes.

Before tower mooring could become a standard practice, two problems had to be solved; firstly, whether an airship could ride at a tower in bad weather; secondly, how an airship in free flight in the air could be brought to the tower by mechanical means and moored by the bow to a fixed point on the top of the tower without imposing excessive loads on the airship.

The experiments carried out with R.24 at Pulham in 1919 gave an answer to the first question - the airship remained at the tower for three weeks, riding out winds of 35 m.p.h. and gusts up to 43 m.p.h. with heavy rain. As regards landing to the tower, the 1919 experiments were not so successful. In the system then used, the airship was hauled into the tower by a single rope, on a path as nearly horizontal as possible; this method of approach was very difficult, attended by unnecessary risk, and gave rise to "surging" as the airship neared the tower. The existing system was accordingly devised to overcome these difficulties, and was successfully tried out at Pulham on the R.33 in 1921, over a period of four months, when the airship landed without difficulty in winds up to 28 m.p.h.

The essential features of the Air Ministry system are:-

- (a) At the top of the tower there is a movable receiving arm which projects vertically, but can swing through an angle of 30° from the vertical. The mooring wire runs through a steel cone on the bow of the airship and through the centre of this arm - which is free to follow the movements of the airship. When the airship is hauled in, the bow cone is automatically locked into a receiving cup at the top of the arm. Thus the airship can be brought to the tower in a direction more nearly approaching the vertical than the horizontal, and from a height.
- (b) In addition to the main rope which passes through the receiving arm, two side guys are attached from the nose of the airship through anchor blocks on the ground at a distance of 750 ft. from the tower. This prevents surging and yawing.

Seven towers of the Air Ministry type have been erected by the United States Government and have been in successful operation up to the present time.

The process of landing to a mooring tower.

When about to land the airship approaches the tower up wind at a height of 600 to 1,000 ft. The main wire is first let down and secured to the tower wire by the ground staff. The airship is then ballasted up until this wire is taut and nearly vertical. It is then hauled in and when the airship is within about 600 ft. of the towerhead the side guys are let down and secured. Hauling in then takes place with three winches until the cone on the nose of the airship engages in the cup on the receiving arm of the towerhead. The arm is then locked in the towerhead in a vertical position. The receiving cup is still free to revolve horizontally on the towerhead, and the airship cone being carried on the airship on a universal joint gives the airship freedom of motion in all directions. The whole operation is carried out by a staff of only twelve men.

When the airship is riding at the tower the airship cone is secured to the towerhead cup by a number of locking pins, the mooring wire being replaced by a slipping pennant. When the airship is about to leave the tower, the locking pins are withdrawn first, and the pennant is then slipped.

Tower Structure and Accessory Buildings.

At the foot of the tower is a machinery house for the winches. Three winches are installed at Cardington but a modification in the side guy control will permit of the use of two winches only at future towers. The winches are provided with remote controls to enable them to be operated from the towerhead. There is also an underground fuel tank to hold 10,000 gallons of fuel, with a pump capable of raising 2,000 gallons per hour to a height of 400 ft. There are also two pumps for pumping ballast water to the airship at the rate of 5,000 gallons per hour each, against a head of 250 ft. A 12 inch gas main runs up the tower for the re-gassing of the airship.

The tower itself is a steel frame structure 200 ft. high and 70 ft. across at the base. It is designed to take a pull at the top of 30 tons in any direction. In the centre of the tower there are stairs and a passenger lift which will take 11 passengers and an attendant to the passenger platform 170 feet above the ground, in less than a minute. The passenger platform is 40 feet in diameter and above it is a conical turret 25 ft. in diameter in which is housed the towerhead and machinery.

In the foregoing notes, details have not been given of the mechanism, but full particulars can be supplied if desired.

The "Stub" Mooring Mast.

The foregoing notes all refer to the high mooring tower of the Air Ministry type, where the point of attachment at the airship's nose is about 200 feet from the ground. The Americans have, however, recently made certain experiments with a low mooring mast about 70 feet high, i.e. little over the distance from the ground to the mid-diameter of an airship of the size of R.100 and R.101. With this type of mast a landing must first be made to the ground, and the airship's nose is then attached to the top of the mast (the same type of

attachment being used as for the high tower) whilst the after car is secured to a trolley which is free to run on a circular track round the mast, but cannot be lifted off the ground. This type of mast has been successfully used on several occasions, and is being further developed in the U.S.A. The main advantages claimed for it are that it is cheaper than the high tower and eliminates all risk of undue pitching when the airship is moored. On the other hand in its present form it involves a landing to the ground, with its attendant disadvantages which the higher tower makes unnecessary.

COMPARATIVE TABLE OF AIRSHIPS.

Nationality	Airship.	Capacity cu.ft.	Gross lift tons.	Length feet.	Diameter feet.	Height feet.	No. of Engines.	B.H.P.	Horse Power)
British.	R.9.	889,300	25.6	526	53	76.6	3	2 at 180) 1 at 250)	610
"	R.33 & R.34.	1,960,000	59.5	640	78.75	91.5	5	250 Maori Sunbeam.	1,250
"	R.38.	2,724,000	82.7	694.5	85.5	92	6	350 Cossack Sunbeam.	2,100
"	R.100.	5,000,000	156	709	131	133	6	700 Rolls-Royce Condor.	4,200
"	R.101.	5,000,000	152	732.3	131 ft. 3 in.	140	5	585 Beardmore "Tornado".	2,925
.S.A.	Los Angeles	2,599,110	71.43 Helium	658.4	90 ft. 3 in.	104 ft. 5 in.	5	400 Maybach.	2,000
"	New ships under construc- tion. 2	6,500,000	180 Helium.	785	132 ft. 9 in.	146 ft. 5 in.	8	Not known.	4,480
German.	Graf Zeppelin	3,708,000	129	776	100	113	5	530 Maybach.	2,650
"	New ship under construc- tion.	5,500,000	167	Details not known.		Not known, probably 600 Maybach.		5,000 (approx.)	

The Airship Directorate.

Squadron Leader R.A.B. Colmore, Deputy Director of Airship Development, is in charge of the Airship Directorate under Air Marshal Sir John Higgins, Air Member of Council for Supply and Research.

The Directorate is divided into five divisions.

Lieutenant Colonel V.C. Richmond, the chief designer of R.101 is in charge of research and design. His chief assistant on the research side is Squadron Leader F.M. Rope and Wing Commander T.R. Cave Browne Cave with Mr. Fitzgerald, on the engine side.

Major G.H. Scott, C.B.E., A.F.C., is the officer in charge of Airship flying.

The Works Manager is Mr. R.S. Hubbard.

Flight Lieutenant S. Nixon has been responsible for the ground organisation at home and abroad.

The Secretary and Accountant is Mr. D. J. Evans.

The Ships' Officers.

Major G.H. Scott, C.B.E., A.F.C., the officer in charge of Airship flying, will be responsible for the flight trials of both airships. Squadron Leader E.L. Johnson, A.F.C., R.A.F.O., will be navigating officer on each ship during flying tests.

Each airship will have a crew of 50 officers and men.

Flight Lieutenant H.C. Irwin will be Captain of R.101 and with him will be Lieutenant Commander W.G. Atherstone as 1st Officer, and Flying Officer M.H. Steff as 2nd Officer.

Squadron Leader R.S. Booth is to be Captain of R.100 and Captain G.F. Meager 1st Officer.

A crew is normally divided into 3 watches, of which 2 watches are already engaged and trained for each airship. The third watch, which will be drawn in each case from men employed on the construction of the ships, will be transferred to the operational side when flight trials begin.