

AIR MINISTRY

THE APPROACH TOWARDS A SYSTEM OF IMPERIAL AIR COMMUNICATIONS

MEMORANDUM by the Secretary of State for Air, laid before the Imperial Conference, 1926, together with the REPORT of the Imperial Air Communications Special Sub-Committee.



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GENERAL CONTENTS.

	PAGE
Prefatory Note	i
Report of the Imperial Air Communications Special Sub-Committee ..	ii
Statement on Imperial Air Communications made to the Imperial Conference, 1926, by the Secretary of State for Air	v
Memorandum laid before the Imperial Conference, 1926	xiii

PREFATORY NOTE.

So much interest has been aroused by the discussions on the development of civil aviation within the Empire which took place at the Imperial Conference, that a demand has arisen for the memorandum circulated by the Air Ministry to the Conference to be made available to the general public.

This memorandum has accordingly been reprinted together with the report of the Imperial Air Communications Special Sub-Committee and the statement on Imperial Air Communications with which the discussions were opened.

No one who studies these documents can fail to be impressed with the great future which awaits civil aviation in the British Empire, and with the benefits both political and commercial which should follow on the development of a complete system of Imperial air routes.

SAMUEL HOARE.

IMPERIAL CONFERENCE, 1926.

IMPERIAL AIR COMMUNICATIONS SPECIAL SUB-COMMITTEE.

REPORT.

In pursuance of a decision taken at the opening Meeting of the Imperial Conference on 19th October, 1926, the Imperial Air Communications Special Sub-Committee was set up to consider the subject of Imperial Air Communications and to report to the Conference thereon.

The Sub-Committee was constituted as follows :—

Great Britain.

The Right Hon. Sir SAMUEL HOARE, Bart., C.M.G., M.P., Secretary of State for Air (*Chairman*).

Major Sir PHILIP A. G. D. SASSOON, Bart., G.B.E., C.M.G., M.P., Under-Secretary of State for Air.

Air Vice-Marshal Sir W. G. H. SALMOND, K.C.B., K.C.M.G., D.S.O., Air Ministry.

Air Vice-Marshal Sir W. SEFTON-BRANCKER, K.C.B., A.F.C., Air Ministry.

Mr. G. G. WHISKARD, C.B., Dominions Office.

Brigadier-General F. H. WILLIAMSON, C.B., C.B.E., General Post Office.

Mr. H. E. FASS, O.B.E., Treasury.

Commonwealth of Australia.

The Hon. Sir NEVILLE HOWSE, V.C., K.C.B., K.C.M.G., Minister of Defence and Health.

Union of South Africa.

The Hon. N. C. HAVENGA, Minister of Finance.

Sir WILLIAM HOY, K.C.B., General Manager of Railways.

Colonel Sir PIERRE VAN RYNEVELD, K.B.E., D.S.O., Director of Air Services.

Newfoundland.

The Hon. W. S. MONROE, Prime Minister.

Canada.

Major-General J. H. MACBRIEN, C.I.C.M.G., D.S.O., Chief of the General Staff.

Commodore W. HOSE, C.B.E., R.C.N. Director of Naval Service.

New Zealand.

The Right Hon. J. G. COATES, M.C. Prime Minister.

Irish Free State.

Mr. P. MCGILLIGAN, T.D., Minister of Industry and Commerce.

India.

The Right Hon. EARL WINTERTON, M.L. Parliamentary Under-Secretary of State for India.

The MAHARAJA OF BURDWAN, G.C.I.F. K.C.S.I., I.O.M.

Colonies and Protectorates.

Sir JOHN E. SHUCKBURGH, K.C.M.G., C.B., Assistant Under-Secretary of State

Mr. F. G. L. BERTRAM, C.B.E. (Air Ministry)

Mr. L. G. S. REYNOLDS, O.B.E. (Air Ministry)

Mr. J. S. HUNTER (New Zealand Delegation)

} *Joint Secretaries.*

The Sub-Committee heard evidence from various experts of the Air Ministry in London in regard to certain matters discussed, including the technical aspects of airship development and the meteorological organisation required for the purpose of experimental flights with a view to the subsequent operation of regular airship services.

The Sub-Committee, having reviewed the present state of air communications in the Empire in the light of the comprehensive information supplied to the Imperial Conference by the Secretary of State for Air, have considered what concrete steps can be taken to further the development of Imperial air services in the immediate future ; and, as a result of their deliberations, submit the following report :—

I.—The Sub-Committee are convinced that the development of Imperial air communications, both by airship and aeroplane, is of sufficient importance to merit the early and continuous attention of the Governments of the several parts of the Empire.

II.—Accordingly, the Sub-Committee recommend that the Imperial Conference should place on record the following resolutions :—

The Imperial Conference, being impressed with the great benefits, both political and commercial, to be derived from the speeding up of Imperial communications by air—

(1) Takes note with satisfaction—

- (a) Of the prospective opening of a regular air service between Cairo and Karachi and an experimental service between Khartoum and Kisumu ;
- (b) Of the decisions of His Majesty's Governments in Great Britain and in the Union of South Africa to carry out a series of experimental flights to connect so far as possible with this latter service ; and
- (c) Of the decision of His Majesty's Government in Australia to arrange for flights by the Royal Australian Air Force from Australia towards Singapore to link up with similar flights of the Royal Air Force from Singapore towards Australia.

(2) Recommends that the development of other air services should receive the early consideration of the Governments concerned ; and that in this connection particular attention should be paid to the maintenance of existing and the construction of new aerodromes so far as local resources permit with a view to the ultimate creation of a complete system of Empire air routes.

(3) In view of—

- (a) The great potentialities of the airship ; and
- (b) The present lack of constructional and other facilities which must prove a serious obstacle to the early development of regular airship services—

recommends that the Governments of the Dominions concerned and of India should examine the possibility of erecting nucleus mooring mast bases to be available for demonstration flights in 1928–29 by the two airships now under construction, and of instituting such preliminary meteorological investigations as may be necessary to facilitate these demonstration flights ; and that His Majesty's Government in Great Britain should consider the erection of a second shed at the Royal Airship Works at Cardington.

(4) Recommends that an Imperial Air Conference should be held in 1928 or 1929—the precise date to be determined later—at some suitable Imperial centre, to report progress and to consider what further action can be taken for the development

of Imperial air communications ; and takes note with appreciation of the invitation of the Dominion of Canada that this Conference should take place in Canada.

III.—Finally, the Sub-Committee are of opinion that the present system of communicating information in regard to civil aeronautics should be continued and recommend that, with a view to ensuring still closer co-ordination throughout the Empire, exchanges should be effected from time to time between the Civil Aviation officials of Great Britain and the Dominions and India so far as limitations of staff and local considerations permit.

Signed on behalf of the Sub-Committee,

SAMUEL HOARE, *Chairman.*

2, Whitehall Gardens, S.W.1.

17th November, 1926.

NOTE.—The recommendations made in the report of the Sub-Committee were unanimously adopted by the Imperial Conference at its Fifteenth Meeting on 19th November, 1926.

STATEMENT ON IMPERIAL AIR COMMUNICATIONS MADE TO THE IMPERIAL CONFERENCE, 1926,

BY THE

SECRETARY OF STATE FOR AIR.

The subject for discussion is the question of Imperial air communications. I propose, with the approval of the Conference, to deal with it from the civil as distinct from the military point of view. I would, however, desire to point out at the very beginning of my remarks that the civil and military aspects are inextricably connected, and that the development of Imperial air lines, whether by aeroplane or airship, is a vital factor in the problem of Empire defence.

I start by stating two broad propositions that I believe will be accepted without argument or even discussion. Firstly, the Empire is in urgent need of better communications. Secondly, if the communications are to be improved, a sustained and united effort will be required.

At the very moment when better communications are urgently needed, improvements in sea and land transport are being made almost prohibitive by their increased cost. The Prime Ministers of Australia and New Zealand have still to spend over 60 days each upon the journey that they make to and from the Imperial Conference, and unless a sustained effort is now made to introduce new methods and to apply the results of invention and discovery, they are likely to continue to take over 60 days for many conferences to come. It is because the history of the development of transport is one long record of doubts and delays and difficulties that I venture to emphasise at the opening of my remarks the importance of a resolute insistence upon the need for new and improved methods. Let us take warning from the events of a little more than a century ago, when, upon the eve of the great railway development, a well-known author in the "Edinburgh Review" wrote:—"What can be more palpably absurd and ridiculous than the prospect held out of locomotives travelling twice as fast as stage coaches," and demanded that "Parliament shall in all railways, where sanctioned, limit the speed to 8 or 9 miles an hour," and when the use of steamships was officially discouraged "as calculated to strike a fatal blow at the naval supremacy of the Empire."

I am here to-day to press upon your attention a new method of transport that, although it has only been organised for seven years, is one of the most effective instruments for stopping the waste of time that is now weakening the vitality and retarding the development of Empire intercourse.

We have now reached a turning point, a most important turning point, in the development of airways and air communications. If we look back over the 23 years of flight, indeed if we only look back as far as the last Imperial Conference in 1923, we must be struck by the speed and the extent of the progress that has already been made. You will see in the comprehensive memorandum entitled "The approach towards a system of Imperial Air Communications" that I have circulated, a picture of civil air transport as it is to-day. You will note that wider and wider use is being made of it. Since the last conference the mileage covered by the regular air routes of the world has more than doubled. You will note the technical improvement that has been made with machines, engines, wireless and meteorology. Machines have become more powerful, more dependable, and, as I think the members of the Conference who made flights at Croydon last Saturday will admit, more comfortable.

As to safety, what better record could there be than the 5,000,000 miles flown by British services for four fatal accidents, and the million miles flown in Australia for a single fatal accident ?

Let me remind you in comparison with this record that the Press in 1845 commented with grim irony that "the largest item in railway returns bids fair to be the list of the killed," and even seven years later, in 1852, declared that "railway accidents are the staple of our newspaper reading."

What better proof could there be of the regularity of the services than the fact that to-day freight insurance premiums per £100 are by air less than half the premiums charged for surface transport ? What more conspicuous illustration could there be of the practicability of Empire air routes than the successive journeys of Sir Alan Cobham, and the series of long distance flights carried out by units of the British and Australian Air Forces ?

These results seem to me to show that after years of research and experiment and adventure we have reached a definite stage in the development of flying, from which we can in the near future make progress altogether out of proportion to anything that has been achieved during the last few years. There is to-day no technical or operational reason why by aeroplane or airship London should not be brought within a fortnight of the furthest cities and territories of the Empire. There is no technical reason why the journey to Canada should not be reduced to two and a half days, the journey to India five days, to Cape Town six days, to Australia eleven days, to New Zealand 13 days. These claims I can, of course, support by detailed and expert evidence at the Imperial Air Communications Sub-Committee meeting this afternoon. This morning I do nothing more than state them for the purpose of illustrating to the Conference the power of the new instrument that is now within our reach.

Having, then, stated these propositions, let me suggest to the Conference certain ways in which we can make fuller use of this new instrument in the near future. If I speak mainly of British policy and British services, it is not because I do not fully appreciate the remarkable progress that has been made with the air routes in Australia, or with air survey work in Canada. I deal chiefly with British routes and British policy because I am for the moment taking London as the terminus of the principal Empire air routes.

Hitherto, whilst certain European services have been safely and punctually operated for several years, there has been no civil air service plying between one part of the Empire and another. In the Middle East an air route between Egypt and Iraq has been regularly flown by military machines carrying mails and official passengers for five years. The route, 866 miles in length, has been methodically equipped with landing grounds and refuelling stations, and over it for five years have passed mails and official passengers in as many hours as it would have taken them days by pre-war transport. It was over this route that the Secretary of State for the Colonies and I made our journey to Iraq eighteen months ago, and it was by means of air transport that we were able to visit in the space of the short Parliamentary Easter recess almost every important point from Cairo to the Anglo-Persian oil fields.

You will see in my memorandum that we now propose to substitute in place of this military service a regular civil line for the carriage of freight and passengers, not only between Cairo and Baghdad, but between Cairo and Karachi. My wife and I propose to make the opening journey on this route at the end of the year, and already time-tables have been issued and passage booked for the subsequent flights. The service will in itself be of great interest, for it will enable us to test the demand for the saving of seven or eight days in the journey between England and India. Since there is as yet no air route between England and Egypt, a passenger will go by land and sea to Cairo or Gaza, and there change into one of the new three-engined aeroplanes. But the essential importance of the route greatly

transcends the saving of seven or eight days that will be made in the journey between England and India. Its real significance lies in the fact that it is the first section of the great Empire air route to the Far East. It is for us to consider whether the other sections could not be completed and a through air route created of incalculable importance for both military and civil communications. I do not wish at this stage to overburden the conference with details. The Sub-Committee upon Imperial Air Communications will have an opportunity of fully investigating the possibility of the project that I am now discussing. May I, however, in passing, offer certain suggestions for carrying this proposal into effect that the representatives of the Dominions may desire to consider at their leisure.

Would it be possible for the Government of India to consider the question of extending the service across India from Karachi to Bombay and Calcutta? Would it be possible for the Government of Burma to consider the possibility of carrying it a stage further, to Rangoon? Might it not then be practicable to link with the civil line experimental flights of the Air Force Flying boats that it is intended to station in the Far East, and might they not again join up with occasional service flights of the Royal Australian Air Force from Australia? I do not expect answers to these questions at a moment's notice. I do, however, hope that we shall be able to consider them in some detail at the Sub-Committee. If in the not remote future links can be inserted in some such way as I have suggested, a long chain of great tensile power will have been forged across the Empire's framework.

So also with Africa. Just as there must be an Empire air route to the Far East stretching to Australia and New Zealand, so there must be an Empire air route from London to the Cape, with branches diverging to the West African Dependencies. Here again a beginning, I admit a small beginning, is being made during the next few months. An enterprising pioneer, with the help of the Governments of Kenya, Uganda and the Sudan, has organised an experimental service covering 1,400 miles between Khartoum and Kisumu. As the route follows the course of the White Nile the machines will be hydroplanes. If this service is successful, from ten days to a fortnight will be saved in the journey between Khartoum and Uganda, and eight days between Khartoum and East Africa. Why should not the Northern and Southern links be forged in this African chain, and a through aeroplane service run at least experimentally between Egypt and Cape Town? This would mean the addition of the Northern link between Egypt and Khartoum and the Southern link between Kisumu and Cape Town. I am prepared to say that we will attempt in the course of the training programme of the Royal Air Force to arrange for a certain number of flights, carrying mails and official passengers, to link up with the civil machines at Khartoum. Would it be possible for the South African Government to consider whether the South African Air Force could not make a certain number of flights, linking up with the route in Kenya?

The first great African flight was brilliantly carried out by a famous South African pilot, whom we welcome here this morning. Whilst it would be impertinent for me to press unduly the South African Government, I hope that I may be allowed to say how greatly we should value the co-operation of the South African Air Force in the pioneer work of organising the route that has already been rendered illustrious by the flights of Sir Pierre Van Ryneveld, Sir Alan Cobham and Wing-Commander Pulford.

In the meanwhile we in Great Britain should be interesting ourselves in forging the link between London and Egypt. Already we have made considerable progress with the development of flying boats that will be suitable for the passage of the Mediterranean, and attention is being constantly given to the difficulties that have hitherto blocked the way to an England-Egypt service.

You will see from what I have just said that I am proposing for your consideration the creation of these two long distance air routes—the first to the Far East

and Australia and the second to Cape Town—upon what I will call a mosaic plan. We are all too hard up for any one of us to undertake the heavy cost of an air route to Singapore or an air route to Cape Town. If, then, we are to form these routes, we must each of us insert our particular stone in the design. I have suggested a way in which we might each take our share, and in which, what is no less important, military and civil aviation might co-operate at least for the pioneer work. If the Royal Air Force undertakes a certain number of service flights in conjunction with the civil lines, and the Governments of South Africa and Australia allow their Air Forces to co-operate with us, not only shall we be obtaining valuable military training for our service units, but we shall also be making possible the experimental transport of mails and passengers over a large section of the British Empire. My proposal, as you see, involves no subsidy, it involves nothing more than co-operation between one Government and another, and between military and civil flying. If a certain number of pioneer flights can be successfully carried out in this way, I am certain that the formation of regular civil lines will follow as inevitably as the Cairo-Karachi service has followed the military mail across the desert.

There is another very important field where we need the co-operation of the Governments of the Dominions and the Dependencies in whatever part of the world they may be situated. If these routes are to be created and safely maintained, it is essential that landing grounds should be formed at the proper intervals, and that these landing grounds should be kept in good order. I cannot too strongly emphasise this need for good landing grounds, kept in proper condition. After each of his great flights, Sir Alan Cobham has declared that good landing grounds are a first condition of success. Will the Governments of the Empire, whether of the Dominions or Dependencies, take their share in providing suitable landing grounds upon the great Empire routes, and in keeping them in good order? I propose at the Sub-Committee to go further into this question and to provide the Members with a list of the principal landing grounds required upon the great Empire air routes, with a view to seeing whether each Government could not undertake the responsibility of keeping in order those within its territory.

I have now dealt in outline with the two main aeroplane routes, the route to the Far East and the route to Cape Town. Whilst I have purposely concentrated my attention on these two great trunk lines, I do not wish it to be thought that there are not wide opportunities for starting branch and internal lines. Australia has already pointed the way by her successful development of at least three long distant regular services. There are great opportunities for air communication in the West Indies; judging from Belgian experience in the Congo, almost incredible saving of time can be achieved by internal air lines in Africa; whilst nearer at home, with a comparatively short service, the Irish Free State could link Ireland with the great air routes of the Empire and the world.

I pass, however, without further comment upon the Empire aeroplane routes to the Empire airship routes, and to a field of research, experiment and trial that we have been extensively exploring since the last Imperial Conference. Certain of the delegates to whom this field of flying development may be less familiar than the field of the aeroplane, may harbour in their minds two grave doubts about the machine that is lighter than air. Why, they may ask themselves or me, should the Empire require both airship and aeroplane routes, and how can airships be ever immune from the catastrophies that destroyed the R.38, the "Dixmude" and the "Shenandoah"? Let me try in a sentence or two to give the answer to both these questions.

As to the first, airships will carry out the long distance non-stop air journeys of the future. The two airships that we are building should, with a normal load of freight and one hundred passengers, be able to fly without refuelling in good weather a distance of some 4,000 miles. The airship, being of great size and practically silent,

will be much more comfortable than the aeroplane for long distance journeys. How comfortable it can be made is illustrated by a model that I have had erected for the Sub-committee at the Air Ministry. The representatives at the Conference will find that accommodation is being planned for one hundred passengers, promenade decks, outside cabins, and ample smoking and dining rooms. The aeroplane and the airship are really complementary to each other, and it is necessary, in my view, to organise both aeroplane and airship lines, the long distance aeroplane lines being invaluable for short stage traffic and for strategic as well as civil purposes, and being particularly needed at the present time when our airship programme is still in an experimental stage.

Then there is the objection, and a very serious objection, raised on the ground of danger. There is the danger inherent in so large and fragile a structure; there is the danger of storms of unexpected and incredible ferocity; there is the danger of conflagration in a ship composed of highly inflammable material. How can dangers such as these be ever surmounted? I would like the Conference or the Committee to examine my experts as fully as possible upon all these points. I need not tell you that, being a very cautious person myself, I have examined them again and again upon them. They and I are very far from being reckless optimists. Indeed, our attitude towards this great problem has been well described by a well-known Cambridge scientist as an attitude of "healthy cold feet." What I would say without fear of contradiction is that great progress has been made both on the theoretical and practical side during the last two years, and that we can claim to have made the fullest possible use of scientific theory, of full-scale and model experiment, of the testing of materials, and, by no means least important, of the study of meteorology. We believe that we have discovered many of the weaknesses and surmounted many of the difficulties that occasioned the failures in the past. I will give you two or three instances of what I mean. The structure of both the airships that are being built will be incomparably stronger in the matter of material than the structure of any airship that has been built in the past. I hope that the members of the Conference will find time to visit our construction shed at Cardington, where they will see for themselves the great advance that has been made both in design and material over anything that has been previously attempted. As to weather, the pages of my memorandum describe in great detail the intensive study that the Meteorological department has made of the conditions of the air over these shores and on the route to India. You will find on pages 18 and the following a series of most interesting maps showing the scale and detail to which the study of weather conditions has been carried. Accurate climate and weather reports are quite essential to the development of airship routes, and not only from the point of view of safety; for it should be remembered that whilst from the point of view of safety it is essential that the airship should be able to avoid storms by means of weather warnings, it is no less necessary in the interests of speed and economy that the airship should make the fullest possible use of the prevailing winds upon the various routes.

There is another way in which the danger of sudden wind currents has been met. Representatives of the Conference will see at Cardington the newest type of mooring mast. The mooring mast is a post-war invention of great importance from the fact that it enables the airship to be easily moored without the risk involved of pulling a structure 700 feet long into a shed.

Then, again, we have tried to meet the danger of conflagration. The airship that is being built at Cardington will be equipped not with petrol but with heavy oil engines. This change shows a great advance in the way of safety, and particularly in the case of airships operating in tropical climates.

In all these directions, then, we have made a serious and scientific effort to avail ourselves of the lessons of the past, and to avoid the dangers that have hitherto been so formidable. Slowly but surely our programme has been developing. In a year's

time the two great airships should be completed. It is then proposed to carry out adequate home trials and subsequently to fly at least one of the airships regularly to and from India for a full period of trial in tropical conditions. When these trials are completed, it is hoped, if the Dominions so desire, to make demonstration flights to the capitals of the Empire. The details of this programme I hope to discuss fully at the Sub-Committee. To-day I desire only to emphasise one very important feature of it. If the demonstration flights are to take place to Australia and New Zealand, to Canada and South Africa, the co-operation of the Dominion Governments is essential. We cannot fly the two airships to the Dominions even for demonstration flights unless two conditions are satisfied. Firstly, there must be mooring masts to which the airships can be attached at the end of their journey. Secondly, there must be meteorological data upon which the choice of dates for the flight can be based, and a meteorological organisation for keeping the airship supplied with the necessary weather intelligence. These two conditions are vital to the programme and, what is more, they are very urgent. Although the expense need not be heavy, the provision of masts and meteorological organisations takes a considerable time to complete. I am advised that this provision will take as long as two years to carry into effect. You will at once see the bearing of this fact. If the programme of demonstration flights is to be carried out without delay, the orders for the mooring masts ought to be given immediately, and arrangements made without delay for the meteorological organisations. I have with me the estimates of cost for the masts and meteorology, and I am prepared to discuss them either at the Conference or at the Committee, according as is most convenient. I will now only say that the provision of both masts and meteorology does not involve any very large sums—the masts and their equipment may cost £70,000 apiece, and meteorology should not entail more than a relatively insignificant expenditure. I much hope, therefore, that the Dominions concerned will examine as sympathetically as they can my request that they should, by ordering without delay the masts and by organising the necessary meteorological services, enable us to carry out without check or hindrance a series of demonstration flights that may mean a revolution in the means of Empire communications.

There is a further and no less important side of airship development that I desire to discuss in detail at the Committee—the question of developing this stage of airship experiment into the further stage of commercial airship operation. I wish to see a commercial airship line started at the earliest possible moment between Great Britain and the various Dominions. When it can be started and how it can be started are questions that I suggest that we should discuss at the Committee. It may be that we shall find that the question must be kept under the closest attention during the remainder of the experimental period, and that further conferences are necessary between the Dominions and ourselves before the normal date of the next Imperial Conference. Will it be possible to hold some time between now and the next Imperial Conference an Imperial Air Conference at some suitable centre in the Empire, where we could discuss the quick developments that are constantly taking place, and in particular give our attention to the question of forming a commercial company or companies for operating airship lines? I am most anxious that we should not lose any opportunity for starting these lines. At present we are ahead of any other nation in the development of airships, and we have the chance of founding within the Empire an airship industry and the first airship lines. Let us hope that an experiment that means so much to the life of the Empire will prove successful, and let us lose no opportunity for co-operation in starting the airship lines.

There, then, I fear at very great length, is a picture of the Empire air route programme upon which I ask for your advice and co-operation. I do not believe that I am either a fanatic or a visionary in asking your support for these schemes. If they prove successful they may give a physical unity to the Empire that it has

never possessed before. Hitherto the invention of flying has brought more harm than good to the Empire and to the world. The aeroplane, the symbol of the terrible methods of modern warfare, has made these shores for the first time for centuries vulnerable to foreign attack. It has added to the budget of national expenditure, it has complicated almost every problem of defence. Let us try to redress this balance by insisting that the aeroplane shall be used not only for the purposes of destruction, but also for the objects of peace and goodwill. Hitherto the air has been the scene of glorious though terrible conflicts; it has been the background from which death and destruction have been hurled upon camps and cities. The purest of the elements was not intended for the destruction of civilisation by high explosive or poison gas. The invention of the flying machine, which the pioneers of successive centuries strove to achieve, was meant for something better than an instrument of concentrated frightfulness. With the horror of the last war in our memories and the limitless terrors of any future war in our minds, let us make the air a highway of peace, and the aeroplane an instrument, not for severing nations and destroying civilised life, but for making closer and more constant the unity of Imperial thought, Imperial intercourse, and Imperial ideals.

MEMORANDUM
LAI D BEFORE
THE
IMPERIAL CONFERENCE,
1926.

NOTE

BY THE

SECRETARY OF STATE FOR AIR.

The following memorandum deals so comprehensively with the question of Imperial air communications that I need only add a few lines to underline certain of its outstanding features. It seemed to me that the members of the Conference would desire to have in their hands a complete picture of the present position of this important question. I hope that the memorandum will provide them with what they require. It will at least show them that substantial progress has been made in many directions since the last Conference. The first section of the England-India aeroplane route is to be opened in January, when my wife and I are to make the first journey upon it; a series of long distance Empire air flights, military and civil, have proved the practicability of the great Empire airways; intensive concentration upon technical research and development, and upon the study of meteorology has greatly strengthened the foundations upon which future progress can be achieved. Particularly noticeable is the advance that has been obtained in the field of airship development. The following pages give a detailed account of the wide field of research, experiment and trial that has been covered during the last two years. I would venture to ask the representatives of the Conference to give their special attention to this description of our airship programme. I believe that a stage has now been reached in which the co-operation of the Dominions can be safely given, whether it be by the provision of mooring masts and meteorological facilities, or by the consideration of schemes for the development of future airship lines. I hope to develop these conclusions in greater detail during the course of the Conference.

S. H.

AIR MINISTRY.

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AIR COMMUNICATIONS.**

CONTENTS.

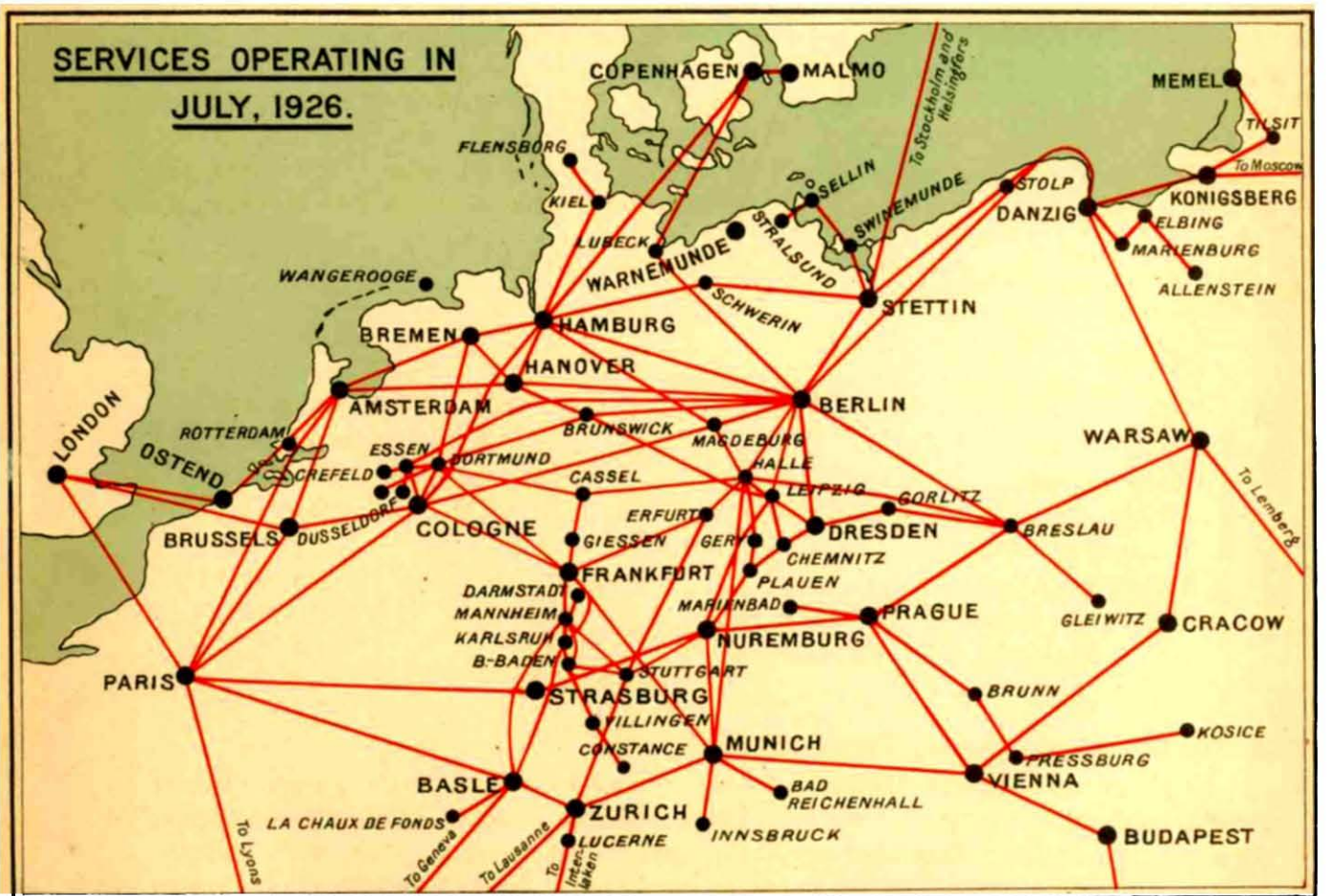
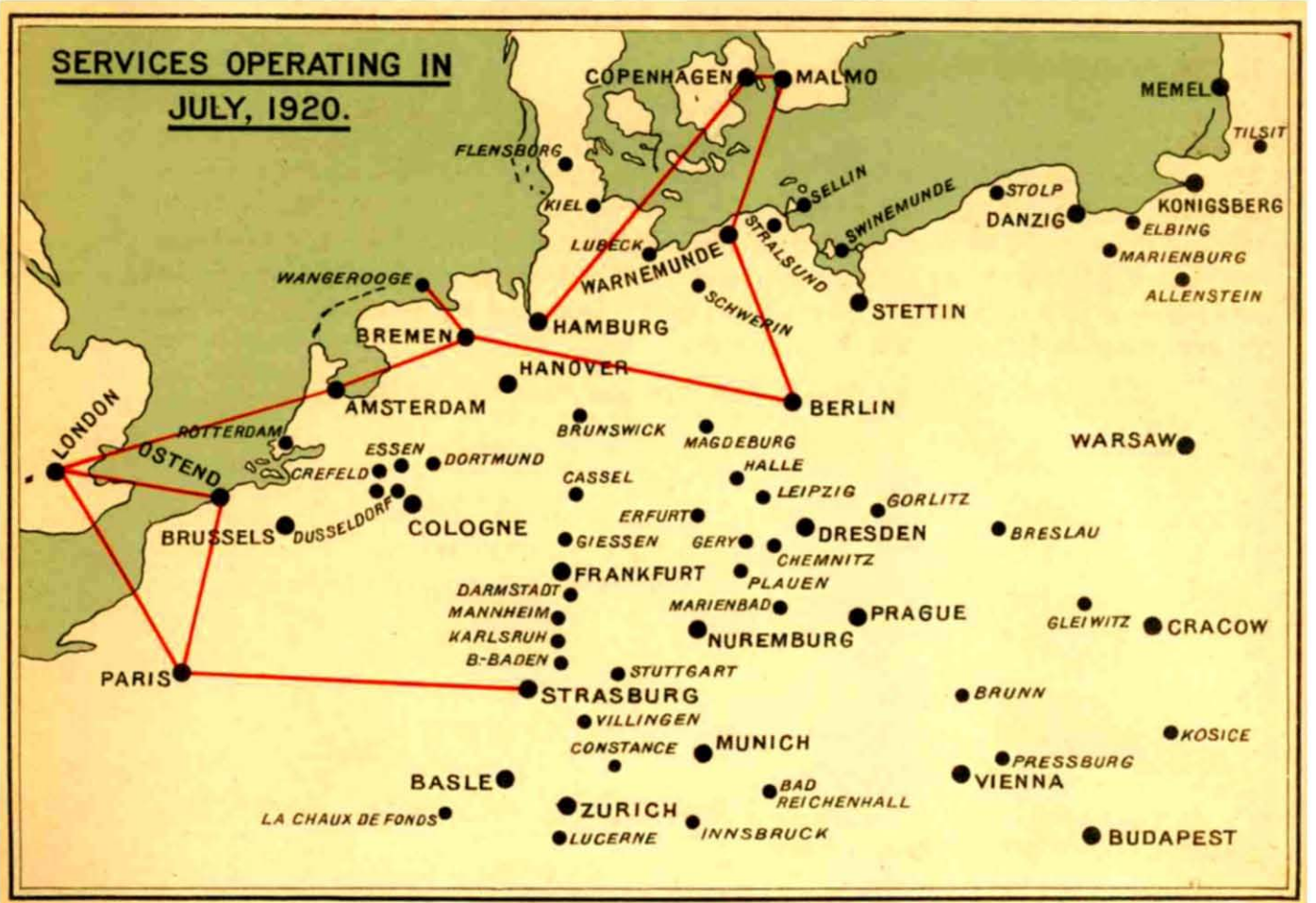
	PAGE
I.—The Rise of Aeroplane Transport, 1920–1926.	5
(1) The Expansion of Aeroplane Services.	
(2) The Technical Improvement of Commercial Aeroplanes.	
(3) The Growth of Ancillary Organisation.	
(4) The Increase of Regularity, Safety and Traffic.	
(5) The Importance of Aeroplane Transport.	
II.—The First Imperial Aeroplane Services	8
(1) The Application of Aeroplane Transport to Imperial Communications.	
(2) The Cairo–Karachi Service.	
(3) The Khartoum–Kisumu Experimental Service.	
III.—Progress towards the Establishment of Imperial Airship Services ..	10
(1) The Present Position of Airship Development.	
(2) Government Policy, 1919–24.	
(3) The Progress of Fundamental Research.	
(4) The two 5,000,000 cubic foot Airships.	
(5) The Provision of Airship Stations for the Experimental Voyages.	
(6) The Meteorological Investigation of the England–India Route.	
(7) The Progress of the Experimental Programme, 1924–26.	
IV.—The Future of Imperial Air Transport	22
(1) The Development of Air Transport.	
(2) Air Transport and the British Empire.	
<hr style="width: 30%; margin: 10px auto;"/>	
Appendix A.—The Aeroplane Transport Development of the Principal Nations	23
(1) The British Empire.	
(i) Great Britain.	
(ii) Canada.	
(iii) Australia.	
(iv) South Africa.	
(v) The West Indies.	
(2) France.	
(3) Germany.	
(4) United States.	
(5) Soviet Russia.	
(6) Holland.	
(7) Miscellaneous Services.	
Appendix B.—The Regulation and Administration of Civil Aviation	46
Appendix C.—Aeroplane Transport Operating Costs	52
Appendix D.—The Organisation of the Cross-Channel Aeroplane Services ..	54
(1) Air Navigation and its Auxiliaries.	
(2) The Organisation of Meteorological Services.	
(3) The Use of Wireless Air Traffic Communications.	
(4) Aerodromes and Landing Grounds.	
(5) The Lighting of Aerodromes and Air Routes.	

	PAGE
Appendix E.—Notes on the Organisation of Airship Services	71
(1) The layout of an Airship Base.	
(2) Notes on a preliminary survey of main Airship Routes.	
(3) Meteorological Organisation in connection with the Development and Operation of Airship Services.	
Appendix F.—Some Special Uses of Aeroplanes	82
(1) Air Survey.	
(2) Forest Fire Protection.	
(3) Protection of Cotton and other Crops.	
(4) Destruction of Mosquitoes.	
(5) Investigation of Wheat and Timber Diseases.	
(6) Ambulance and Medical Duties.	
(7) Fishery Protection.	
(8) Observation of Shoals.	
(9) Prevention of Smuggling.	
(10) Conveyance of Administrative Officers.	
(11) Light Aeroplane Clubs and Private Flying.	

THE APPROACH TOWARDS A SYSTEM OF IMPERIAL AIR COMMUNICATIONS.

	PAGE
I.—The Rise of Aeroplane Transport, 1920–1926.	
(1) The Expansion of Aeroplane Services	5
(2) The Technical Improvement of Commercial Aeroplanes	5
(3) The Growth of Ancillary Organisation	5
(4) The Increase of Regularity, Safety and Traffic	6
(5) The Importance of Aeroplane Transport.. .. .	8
 II.—The First Imperial Aeroplane Services.	
(1) The Application of Aeroplane Transport to Imperial Communications	8
(2) The Cairo–Karachi Service	9
(3) The Khartoum–Kisumu Experimental Service	10
 III.—Progress towards the Establishment of Imperial Airship Services.	
(1) The Present Position of Airship Development	10
(2) Government Policy, 1919–24	12
(3) The Progress of Fundamental Research	13
(4) The two 5,000,000 cubic foot Airships	16
(5) The Provision of Airship Stations for the Experimental Voyages	17
(6) The Meteorological Investigation of the England–India Route	18
(7) The Progress of the Experimental Programme, 1924–26	21
 IV.—The Future of Imperial Air Transport.	
(1) The Development of Air Transport	22
(2) Air Transport and the British Empire	22

AEROPLANE SERVICES OF NORTHERN EUROPE



I—THE RISE OF AEROPLANE TRANSPORT, 1920–1926.

1. The Expansion of Aeroplane Services.

In the last six years aeroplane transport services have multiplied in every continent, so that the total length of the regular air routes of the world is now three times greater than it was in 1920. In Europe there are now 18,120 miles of air lines in place of 6,000 miles in 1920; in America 8,025 in place of 2,840; in Africa 3,641 in place of 887; while in Australia and Asia, where there were no air lines in 1920, there are now 3,267 miles and 1,323 miles respectively. Even more significant than the increasing length of routes has been the rapid increase of the miles actually flown by aeroplanes in regular commercial service.

Approximate Mileage flown over the Regular Air Routes of the World.

1919	..	..	..	1,170,000 miles.
1920	..	..	..	2,270,000 ..
1921	..	..	..	4,300,000 ..
1922	..	..	..	5,500,000 ..
1923	..	..	..	6,430,000 ..
1924	..	..	..	8,190,000 ..
1925	..	..	..	12,480,000 ..

It will be seen that the mileage of 1925 was over ten times greater than that of 1919 and nearly twice that of 1923.

2. The Technical Improvement of Commercial Aeroplanes.

Since 1919, when the first commercial aeroplane flew from London to Paris carrying two passengers, there has been a steady improvement in the comfort, load-carrying capacity and safety of commercial aeroplanes. The design of the machines has been gradually better adapted to the needs of commercial transport; the engines have been made more reliable and lighter for a given horse-power; and instruments have been devised to relieve the pilot of strain and to facilitate accurate navigation in clouds. The modern three-engined commercial aeroplane carrying 20 passengers and able to remain in flight with one of its engines out of action, has proved its capacity for maintaining regular services even in the difficult flying weather of North-West Europe. The following table indicates in detail some of the improvements which have been made in the last seven years:—

Performance of Commercial Aircraft.

	1919.	1926.
	<i>Handley Page</i>	<i>"Argosy."</i>
	<i>O/10.</i>	<i>With 3 Siddeley-</i>
		<i>Jaguar Engines.</i>
Horse-power	700	1,188
Gallons of petrol carried	215	248
Number of crew	1	2
Paying load	1,900	4,400
Number of passengers	10	20
Range in still air with full load, miles	400	400

3. The Growth of Ancillary Organisation.

The safe and regular operation of an air route depends not only on efficient aircraft and skilful pilots, but on good aerodromes, wireless systems, meteorological services and careful government regulation and administration. The great increase of commercial flying has therefore been accompanied by an equally important growth

of the ground organisation of the air routes, especially in Europe and the United States. The lead in the technical development of ground organisation in Europe has been taken by Great Britain, where steady progress has been made in the last seven years. During that time many technical improvements have been made in every branch of the organisation of the cross-Channel aeroplane routes. In particular, better aerodrome and route lights have been installed ; the wireless and meteorological systems have been improved and expanded ; while the London Terminal Aerodrome is at present being enlarged and remodelled. The organisation and functions of the various ancillary services are described in detail in Appendix D, and here it is only necessary to indicate that the system has already attained considerable complexity and efficiency. The whole of civil aviation is regulated in harmony with the International Air Convention by the Air Navigation Act of 1920, and by Orders-in-Council and Air Navigation Directions which are issued from time to time. By this machinery regulations have been made governing such essential matters as the certification of aircraft for airworthiness, the keeping of log books, and the licensing of pilots, ground engineers and aerial navigators. Wireless is used for all the communications of the air routes and 28,175 messages were passed in 1925. Of these many were routine wireless telegraph messages informing various aerodromes of the departure and arrival of machines ; many were meteorological messages ; while others were verbal communications by wireless telephony between pilots of machines in flight and the duty officers of aerodromes. An important use of the wireless system is that, by a method of taking wireless bearings, pilots may be told their exact position. Owing to the difficult flying weather which prevails over north-west Europe during a large part of the year a highly developed weather reporting system has been found necessary. The meteorological organisation compiles reports every hour and exchanges them with the corresponding continental systems ; a special short period weather forecast is also issued for every service leaving Croydon aerodrome ; and reports of sudden changes in the weather are sent to the aerodromes and aeroplanes likely to be affected. In these and other ways the ancillary services of an air route are becoming more specialised, more complex, more efficient ; and they are beginning to ensure to commercial aeroplane services the safety and regularity which harbours, lighthouses and wireless make possible to shipping.

4. The Increase of Regularity, Safety, and Traffic.

An examination of the history of certain aeroplane services will show beyond doubt that in the last seven years there has been a great improvement in safety and regularity and a large increase in traffic.

- (i) The aeroplane service between France and Morocco has a long history for an air transport service, having been established in 1919. The successful carriage of mails demands great regularity and, as the following table shows, this service has increased its load of mails every year.

Number of Letters carried between Toulouse and Casablanca.

1919	9,124
1920	182,000
1921	327,000
1922	1,407,352
1923	2,958,000
1924	4,026,000
1925	7,502,191

The number of letters carried has thus increased from under 200,000 in 1920 to more than 7,000,000 in 1925. Over half the letters posted in Morocco for France last year were sent by air mail although this involves the payment of an extra fee.

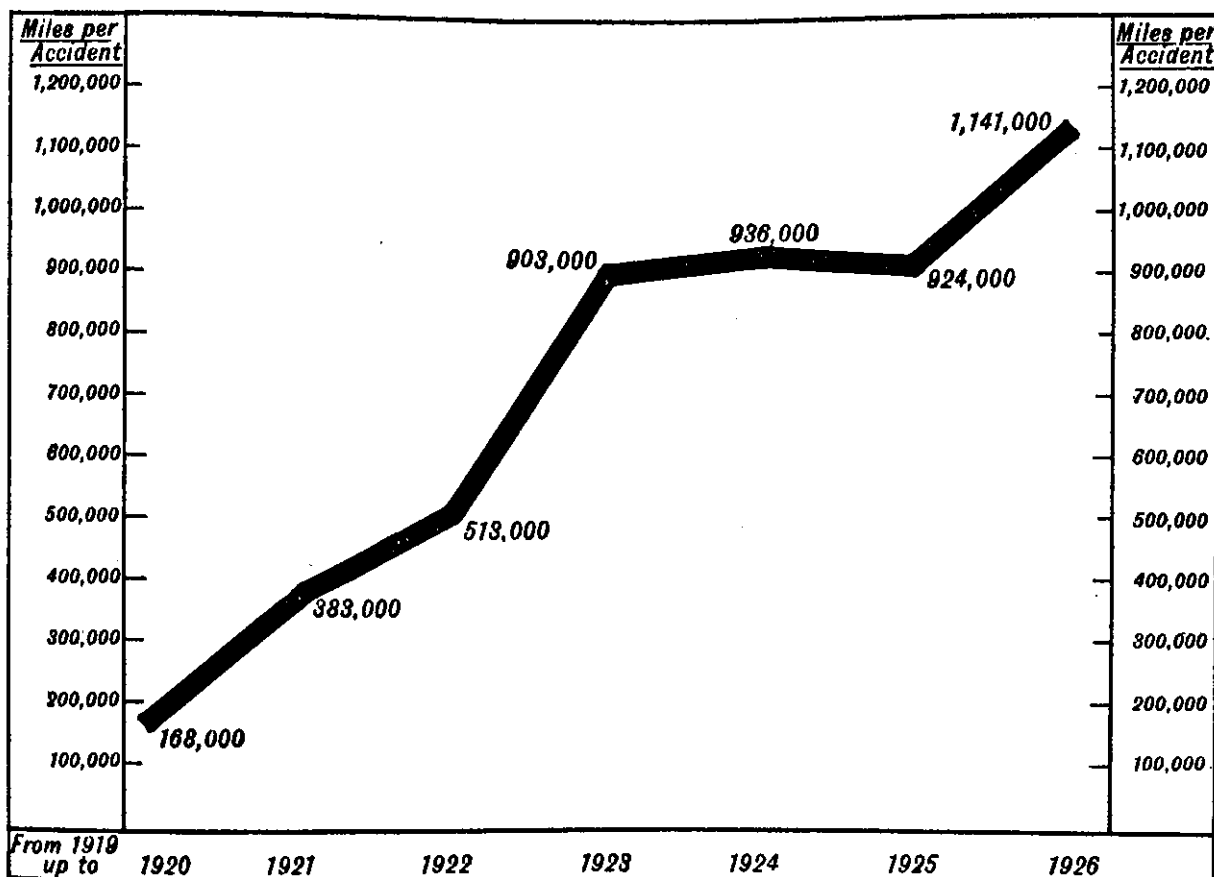
- (ii) In 1920 the United States Post Office began to operate a trans-continental air mail service between New York and San Francisco. The route, which crosses the Allegheny and Rocky Mountains, is 2,665 miles long, and the schedule time for the trip is 32 hours as against three days by the fastest train. Since 1924 a large stretch of the route has been flown by night, yet the service has a record of improving safety and regularity.

United States Air Mail.

<i>Period. **</i>	<i>Miles flown.</i>	<i>Miles flown per Pilot Fatality.</i>
Four fiscal years, 1918-22 ..	2,635,433	138,600
Four fiscal years, 1922-25 ..	7,891,099	789,110

It will be seen that in the second period the average number of miles flown per pilot fatality was nearly six times greater than in the first period.

- (iii) The British aeroplane services have always paid great attention to the technical points upon which the safety of aircraft depend and during the last seven years there have been only four accidents involving the death of passengers in the course of flying 5,000,000 miles. The following chart shows, for the periods from 1919 up to 31st March in the seven succeeding years, the total number of miles flown for each accident involving the death of passengers. It will be seen that, whereas the number of miles flown per fatal accident was only 168,000 in the period from 1919 to 1920, it has risen to over 1,000,000 during the period from 1919 to 1926.



The number of passengers carried by all the cross-Channel aeroplane services has been increasing at the rate of nearly 3,000 a year between 1920 and 1925; while the passenger traffic for the first six months of 1926 was 43 per cent. greater than that in the corresponding period of 1925.

- (iv) The aeroplane services of Australia have flown 922,278 miles during a period of four years, with only one fatal accident, which occurred at the beginning of the first service. The load of mails carried in 1925 was 26 per cent. greater than in 1924; the mileage flown was 34 per cent. greater, and 109 more passengers were carried.
- (v) The advantages of air transport have been recognised by underwriters who have reduced the insurance rates on goods sent by air to a point considerably below the corresponding rates for surface transport. The extent of the difference is shown by the following table:—

Freight Insurance Premiums per £100.

	<i>Surface Transport.</i>	<i>Aeroplane Transport.</i>
	<i>s. d.</i>	<i>s. d.</i>
London to Paris	6 8	2 0
London to Amsterdam	6 8	3 0
London to Cologne	7 6	4 0
London to Zurich	7 6	5 0

This difference of insurance rates has caused considerable quantities of gold to be exported by air from England, and in 1925 over £10,000,000 of bullion and specie were carried by the cross-Channel services.

If space were available many other examples of improving safety and increasing traffic could be given from the history of the aeroplane services of the world.

5. The Importance of Aeroplane Transport.

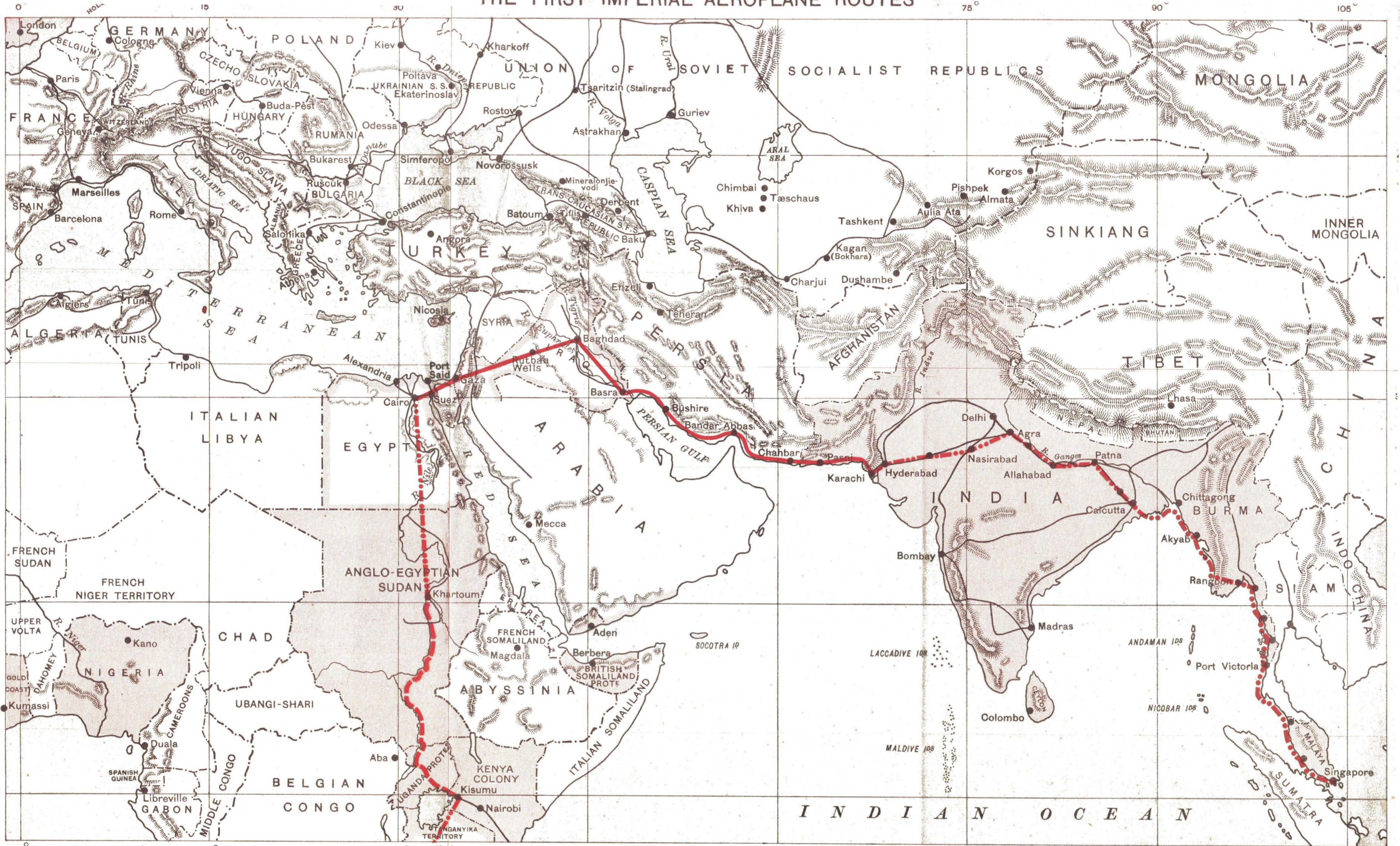
Aeroplane transport has now been in existence for six years. Year by year, the routes have grown longer; the amount of flying has increased; better machines have been produced; ancillary organisation has developed; traffic has expanded; safety and regularity have improved. In general the commercial aeroplane has emerged from the experimental stage and has proved itself a practical instrument of fast transport.

II.—THE FIRST IMPERIAL AEROPLANE SERVICES.

1. The Application of Aeroplane Transport to Imperial Communications.

Aeroplane transport having been proved and tested in the practical experience of several years is now being applied extensively by foreign nations to their special problems of communication. This subject is considered in more detail in Appendix A, but it is necessary here to draw attention to the important developments which have taken place in France, Germany, and the United States. Besides other important aeroplane lines, France has established a comprehensive aeroplane transport system in her North African Empire, Algeria, Morocco, and French Equatorial Africa are connected with each other and with France by fast aeroplane services. Germany is served by a close network of air lines connecting all her important towns, and one long service is operated between Berlin and Moscow. The establishment of an ambitious system of aeroplane services is contemplated in Soviet Russia; several services connecting important producing centres are at present in operation, and the officials of the Government make frequent use of aeroplane transport for travelling rapidly over the vast distances of the country. In the United States the post office operates a daily air mail service between New York and San Francisco, and several subsidiary mail and passenger services have lately been established. In the British Empire there are at present aeroplane services in Great Britain and Australia; but there are no civil aeroplane services connecting different parts of the Empire. It is to

THE FIRST IMPERIAL AEROPLANE ROUTES



Service to be put in operation January 1927.....
 Experimental Service to be operated during 1927.....
 Possible extensions in the future.....

be expected, however, that a new means of fast transport such as the commercial aeroplane will have important applications to the problem of Imperial communications; and, in fact, a beginning has been made by the organisation of a service which will connect Egypt and India and the approval of an experimental service which will operate between East Africa and the Sudan.

2. Egypt-India Aeroplane Service.

The main aeroplane route which it has seemed most desirable to develop as quickly as possible is that from England to Egypt, Iraq, India, and Australia; as it would obviously be too costly to establish the whole route immediately, His Majesty's Government have decided to begin at once with a service between Cairo and Karachi. It was decided to encourage the establishment of this section first for three reasons. First it avoids the climatic and international difficulties of Europe; secondly, it takes advantage of the comparatively quick steamship service between England and Egypt; and lastly it makes use of the experience gained in the operation of the air mail service between Cairo and Baghdad by the Royal Air Force, and enables this service to be suspended with consequent economy. A subsidy of approximately £95,000 a year for five years will be paid to Imperial Airways, Ltd., who are to maintain a service at least once fortnightly in each direction. The route is now in course of organisation, and meteorological, wireless and refuelling stations are being established at Cairo, Gaza, Rutbah, Baghdad, Basra, Bushire, Bundar Abbas, Charbar and Karachi. The chief physical disadvantages of the route are the extreme heat and the height of the Arabian Plateau, both of which tend to reduce the load with which an aeroplane can rise from the ground. The company, however, realise that machines with a great reserve of power are necessary, especially in view of the inconvenience and risk attending a forced landing in the desert or on the coast of the Persian Gulf. They have therefore decided to use de Havilland "Hercules" machines fitted with three air-cooled 425 h.p. Bristol Jupiter engines, any two of which will maintain the machine in flight with full load. Of the fleet of machines at present being built, enough will have been delivered to the Middle East by January, 1927, for a service to be begun in that month between Cairo and Basra. The remaining machines will be delivered during the following three months, and the service will be extended to India in April. The following time-table has been prepared by Imperial Airways, Ltd. :—

<i>Eastbound.</i>		<i>Westbound.</i>	
Wed.	13.00 dep. Cairo.	Thurs.	06.00 dep. Karachi.
„	16.00 arr. Gaza.	„	11.10 arr. Charbar.
Thurs.	06.00 dep.	„	12.10 dep.
„	10.15 arr. Rutbah.	„	16.15 arr. Bundar Abbas.
„	11.15 dep.	Fri.	07.00 dep.
„	14.10 arr. Baghdad.	„	12.15 arr. Bushire.
„	14.30 dep.	„	13.15 dep.
„	17.35 arr. Basra.	„	16.25 arr. Basra.
Fri.	06.00 dep.	Sat.	06.00 dep.
„	09.15 arr. Bushire.	„	09.00 arr. Baghdad.
„	10.15 dep.	„	09.15 dep.
„	15.45 arr. Bundar Abbas.	„	12.00 arr. Rutbah.
Sat.	06.00 dep.	„	13.00 dep.
„	10.15 arr. Charbar.	„	17.00 arr. Gaza.
„	11.15 dep.	Sun.	07.00 dep.
„	16.45 arr. Karachi.	„	10.00 arr. Cairo.

Passengers travelling all the way by sea reach Karachi on the 17th day, and those travelling by sea to Cairo and then by aeroplane will arrive on the 10th day, thus saving a week. Similarly the air route to Baghdad and Basra will take 8 days, while the sea route takes 23 and 22 days respectively. There seems little doubt that soon after the route is put into regular operation the traffic will be sufficient to justify a weekly service, and the company have undertaken to introduce this improvement as quickly as possible. When the company's staff have gained experience with the machines and the ground organisation, it is thought that night flying will be introduced; and it is expected that eventually the service will be made bi-weekly to connect with both the steamship lines serving Cairo. It is obvious that once this service is operating there would be great advantages in extending it beyond Karachi to Bombay, Calcutta, Rangoon, Singapore and Australia; and there would seem to be no technical difficulties in flying these routes by aeroplane and seaplane.

3. Khartoum-Kisumu Experimental Service.

This route, which is 1,400 miles long, follows the valley of the White Nile southwards from Khartoum as far as Lake Nyanza, where it branches in an easterly direction to Kisumu, which is the terminus of the Kenya and Uganda railway. The objects of the service are to bring Kenya and Uganda into closer touch with each other and with England and the Sudan. The Governments of Kenya and Uganda are assisting with grants of £2,500 each, and the Sudan Government with a grant of £2,000. The North Sea Aerial and General Navigation Co., Ltd. (which is associated with the Blackburn Aeroplane Co., Ltd.), will conduct 12 experimental flights in each direction in order to gain the experience on which plans for a permanent service may be based. There is at present no regular boat and rail service to East Africa, but assuming that the journey normally takes 20 days, the saving in time by travelling to Khartoum and then continuing by air to Kisumu would be 8 days. Between Khartoum and Uganda the saving of time by aeroplane transport would be from 10 to 12 days, and between Khartoum and Rejaf, at the southerly limit of the navigable Nile, 14 days. The promoters hope that the permanent service will carry part of the mail between Europe and East Africa; gold from the Kilo and Moto mines on the west side of Lake Albert Nyanza in the Belgian Congo; samples of coffee, maize and sisal for England; and some of the large number of settlers who return every year to Europe. This service would form a section of the main aeroplane route between Great Britain and South Africa.

III.—PROGRESS TOWARDS THE ESTABLISHMENT OF IMPERIAL AIRSHIP SERVICES.

1. The Present Position of Airship Development.

At the outbreak of the late war the airship as a means of transport was definitely in a more advanced stage than was the aeroplane. Between 1910 and 1914 five German airships, constructed for passenger traffic, had carried 42,000 passengers in 2,000 flights without a mishap to a single passenger. As a contrast with this the first successful aeroplane flight from London to Manchester was not performed until 1910, and even then no passengers were carried. On the other hand, by the end of the war the position had been reversed, and the technical progress of the aeroplane was definitely in advance of that of the airship. This was mainly due to the intensive development of the aeroplane during the war and the large volume of research devoted to its special problems. The theoretical work carried out during the war on the problems of airship design and construction was far less in quantity and less continuous. For this there seem to have been two main reasons. Firstly, as German experience has shown, the large rigid airship cannot successfully operate in the face of an organised aeroplane and anti-aircraft defence, and consequently its utility in

the late war was greatly restricted. The second cause was the high degree of success attained at the end of the war by the Zeppelin Works in evolving the later designs from the earlier ones. The rigid airships built in England during the war were practically all copies of Zeppelin airships and were equally successful—*e.g.*, the R.34 and R.33. The success attained by these methods militated against intensive theoretical investigation; but their inherent limitations and defects were brought to light by the collapse of the R.38 in 1921. It then became clear that before large airships could be built and used as a regular means of fast long-distance transport (and it is the large airship that is required for this purpose), airship design and construction would have to be placed on a sound scientific basis and tested by experimental flights under the trying conditions of the tropics. None the less, it must be remembered that airships of the Zeppelin type have carried out many noteworthy operations and individual flights. Of these, the most important were, perhaps, the passenger service already mentioned and the numerous raids made on London during the war, which, in themselves, constitute an impressive record from the point of view of mere flying. In addition the following flights should also be mentioned:—

- (i) *German L.57, 1917.*—This airship left Jamboli in Bulgaria at 8 o'clock on the morning of 21st November with a crew of 22 men and a military load of 10 tons, and arrived at the Daka Oasis in East Africa at midnight of the next day. It flew back to Jamboli on 25th November, having flown without landing a distance of 4,200 miles in 96 hours.
- (ii) *British R.34, 1919.*—In June a reconnaissance flight was made from East Fortune to Dantzig over the North Sea, the Cattegat and Baltic. A gale was encountered on the return voyage, the after-engine broke down completely, and although flying through the air at 40 knots the ship was actually going astern over the sea for 8 hours. The flight lasted 57 hours.
- (iii) *British R.34, 1919.*—In July R.34 flew to America in 108 hours. She was really too small for the transatlantic crossing being unable to carry enough petrol to make a fast flight. The ship remained moored in America for four days and then flew back to England in 75 hours. The total distance was 6,400 miles and it was flown in 183 hours.
- (iv) *German 'Bodensee,' 1919.*—From August to December this ship made 103 flights, covering 32,000 miles and carrying 2,450 passengers. Her operations were suspended in December under restrictions imposed on German aviation by the Peace Treaty.
- (v) *German ZR.3, 1924.*—On 12th October ZR.3 left Friedrichshafen in Germany and flew to Lakehurst in the United States in 80 hours 45 minutes. This was a distance of 5,000 miles and the average speed was 62 miles an hour.
- (vi) *United States 'Shenandoah,' 1924.*—This ship carried out a programme of transcontinental flying during which she visited Texas, California and Chicago before returning to Lakehurst in New York State. She flew 8,100 miles in 22 days and remained for a time moored at the mast in each city she visited.
- (vii) *Italian 'Norge,' 1926.*—In June this small airship of only 660,000 cubic feet capacity was flown over the North Pole under the leadership of Roald Amundsen. The total distance flown was approximately 6,175 miles, which was divided into five stages beginning at Rome and ending at Alaska. The length of the actual flight across the Pole between Spitzbergen and Alaska was 2,450 miles.

Airships have thus flown long distances in the tropics of Africa, the sub-tropics of America, in the stormy north-west of Europe and over the North Polar regions. There have, however, been three important airship accidents which it is necessary to consider in some detail :—

- (1) *British R.38, 1921.*—The R.38 was designed on specially light lines to fly at a height of 25,000 feet for military purposes, and failed on her fourth trial flight owing to structural weakness. The report of the Aeronautical Research Committee on the accident stated that, having regard to her size and speed, R.38 was considerably weaker than previous British rigid airships, and that during design the stresses due to aerodynamic forces had been overlooked.
- (2) *French 'Dixmude,' 1923.*—This airship, like the R.38, was built specially light to fly at height for military purposes. The facts of the accident are extremely obscure; and, although it was attributed by the French Court of Inquiry to lightning, airships have on occasion been struck by lightning without such disaster, and it is at least probable that the true cause of the accident may have been similar to that of R.38.
- (3) *United States 'Shenandoah,' 1925.*—The Court of Enquiry found that the final destruction of the airship was due primarily to large unbalanced external aero-dynamic forces arising from high velocity wind currents. The airship at the time was cruising over an area of the United States where severe squalls are known to occur; and, owing to the unusual movements of storm areas 25 to 50 miles to the northward, the meteorological officer had suggested a change of course to the south some hours before the accident occurred. This advice was not, however, acted upon. The Court of Enquiry concluded that "although the disaster to the 'Shenandoah' indicates that a rigid airship can probably be destroyed through external aerodynamic forces only, and that such forces can arise from air currents unaccompanied by visible signs recognisable by aerologists in the present state of knowledge, it is the opinion of the Court that such conditions and combinations are unusual and such a conclusion does not, therefore, throw doubt upon the safety and utility of rigid airships to a materially greater degree than does the fact that other types of craft for navigation in the air or on the water are likewise subject to destruction through unusual dangers which cannot invariably be foreseen and provided against."

Of these three major accidents, two occurred with airships designed on specially light lines for military purposes, and the third in a storm comparable to those which bring disaster to ships at sea. On the other hand airships have a record of practical achievement over a period of years. They have definitely proved their capacity on occasion to fly fast and continuously by day and night through great distances over sea and land while carrying relatively heavy loads.

2. Government Policy, 1919–24.

(1) *Airship Policy, 1919–24.*—After the war it was realised that, unlike aeroplanes, airships were particularly adapted to long continuous flights over large distances, and that they were likely to prove of special value to the British Empire, the different parts of which are separated by great oceans. It was desired, therefore, to encourage airship development. Accordingly, in 1919, the Royal Air Force carried out with R.34 the Baltic and Transatlantic flights mentioned above; the first mooring mast experiments were undertaken with R.24 at Pulham; the construction of R.38 was continued at the Royal Airship Works; and R.36 was completed and fitted with a passenger car by Messrs. Beardmore and Company, Limited. In 1920, however, when a reduction of expenditure was enforced on all Government Departments, the Air Ministry reluctantly closed down the airship branch of the Royal Air Force, and it was decided to endeavour to maintain airship

construction and operation solely on a commercial basis. From 1919, onwards, various proposals were put forward for the commercial operation of the Government fleet and the construction of further airships. Amongst others who formulated schemes were Sir Alan Anderson, a director of the Orient line, and Mr. A. H. Ashbolt, Agent-General for Tasmania. The main features of some of these proposals were considered by the Imperial Conference of 1921, but none were finally adopted by the Government of the day. Thus, at the end of 1921 there was a possibility that airship operation in this country would be finally closed down and the airships and stations disposed of; but in March, 1922, fresh proposals were received from Commander Burney. Negotiations with Commander Burney proceeded during 1922 and 1923, since the outline of his scheme appeared to afford a satisfactory solution of the problem. When, however, the scheme came to be translated into a series of formal contracts, certain technical and financial difficulties impressed the members of Mr. Ramsay Macdonald's Government. A Cabinet Committee was therefore appointed to reconsider the position. The enquiry went to show that if airship development was to proceed upon a sound technical basis, it was inevitable that the Government should undertake the research and experiment which the disaster to R.38 had shown to be necessary, and His Majesty's Government, therefore, decided to adopt the programme of airship development which is now being carried out.

(2) *The Experimental Programme, 1924.*—The experimental programme adopted in 1924 was to extend over three years and to cost £1,350,000. It is now, however, estimated that the cost will be between 1½ and 1¾ million pounds. The purpose of the programme was to make a real advance in airship development and thoroughly to test the capacity of modern rigid airships as a standard means of long distance transport. In general, the programme consisted of a period of research and investigation in preparation for two practical operations:—

- (i) The construction of two airships of such improved speed, range and load-carrying capacity as would enable them to make long voyages overseas with a substantial margin of lifting power; and
- (ii) The carrying out of successful flights to and from an overseas terminal, in order to demonstrate that the airships were suitable for the work for which they were designed.

It was held that once this programme had been successfully carried out the further development of airships would be assured and it was recognised that the practical progress of the experimental programme might well prove to be of decisive importance in the history of airship development. It was, therefore, decided to develop the programme in a spirit of scientific caution, holding considerations of prudence and safety to be of paramount importance. Two airships were to be built, one by the Air Ministry (R.101) and one by the Airship Guarantee Company (R.100). This ensured competition in design and provided that a purely accidental failure of one ship should not terminate the whole programme. Elaborate researches and experiments were to be made; new sheds and masts were to be erected in England, Egypt, and India; and the weather conditions of the route were to be carefully investigated in their application to airship navigation. During the last two years work has been proceeding under this programme, and in several departments there has been practical progress which it is desirable to consider in some detail.

3. The Progress of Fundamental Research.

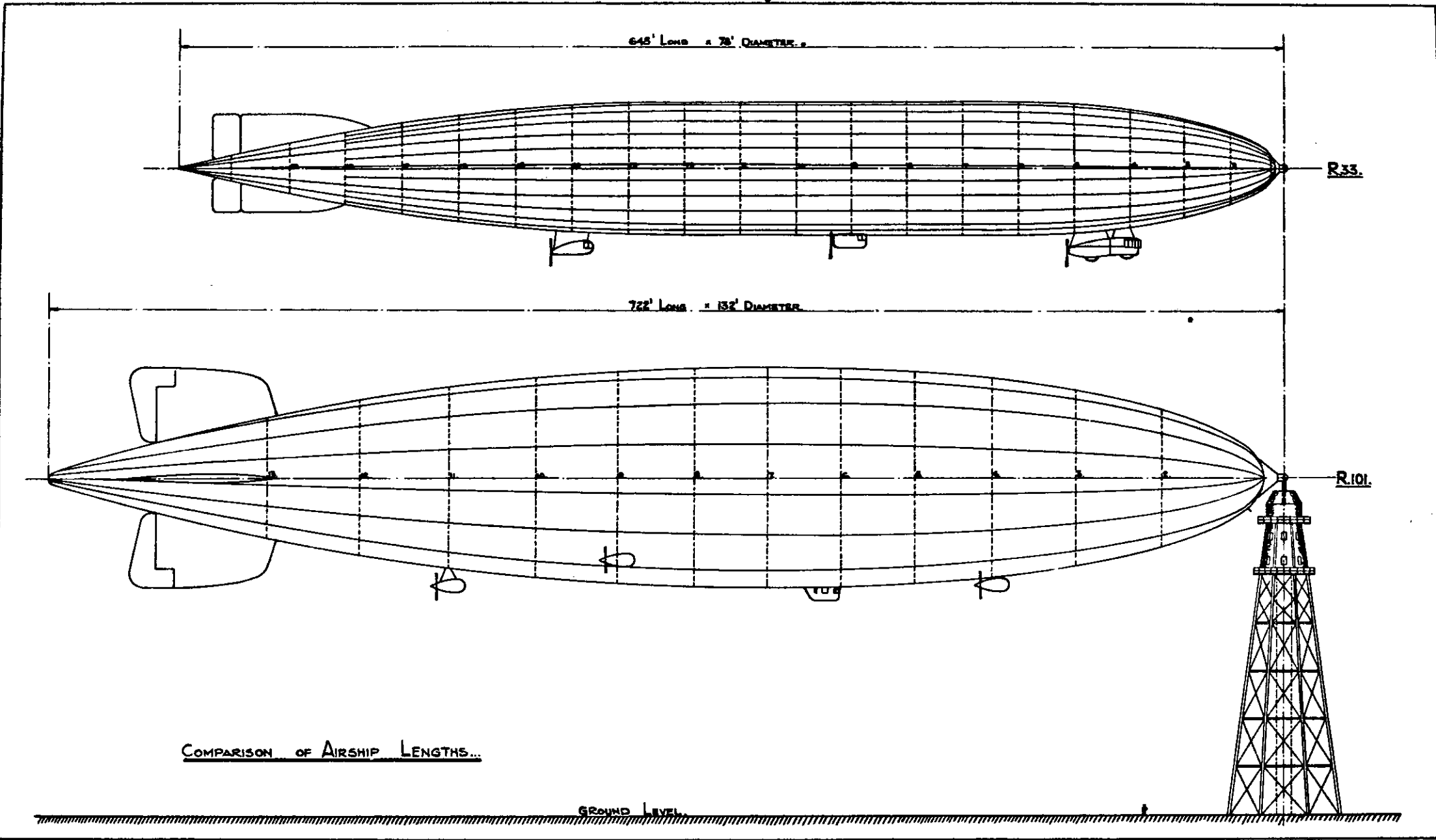
(1) *The Development of the Theory of Airship Design in England, 1921-24.*—It has already been stated that the considerable success attained by Germany in the development of the Zeppelin airships by the end of the war tended to obscure the need for fundamental research work. It seems clear that the later Zeppelins were evolved from the earlier types by a process of slight but continuous variation,

and that the German methods were empirical to a degree which no longer persisted in other branches of aeronautical engineering. In England the large rigid airships up to and including R.37 were little more than copies of Zeppelins. The design of R.38 represented a departure from the older types, but was based rather on the empirical knowledge of her designers than on fundamental research. The collapse of this airship during her trials in 1921 was investigated by the Accidents Investigations Sub-Committee of the Aeronautical Research Committee. The Committee found that the design staff, in working out the calculations of the strength of the airship, had disregarded the aerodynamic forces to which the airship would be subjected. They stated that research by both model and full scale experiment was essential to determine and verify these forces, and that "in the construction of such an airship, reference to first principles of design was necessary, and that for progressive development of airships in size and speed, it was not sufficient to place exclusive reliance on a comparison with existing ships, using the routine methods adopted for R.38." As a result of this report a series of important theoretical investigations was undertaken, under the supervision of the Aeronautical Research Committee on behalf of the Air Ministry, into two main problems :—

- (i) What are the forces acting upon an airship while in flight as the result of her motion through the air (aerodynamic forces) ?
- (ii) What is the distribution of the strains and stresses in the structure of an airship caused by these aerodynamic forces and by the static forces imposed by the loading of the airship ?

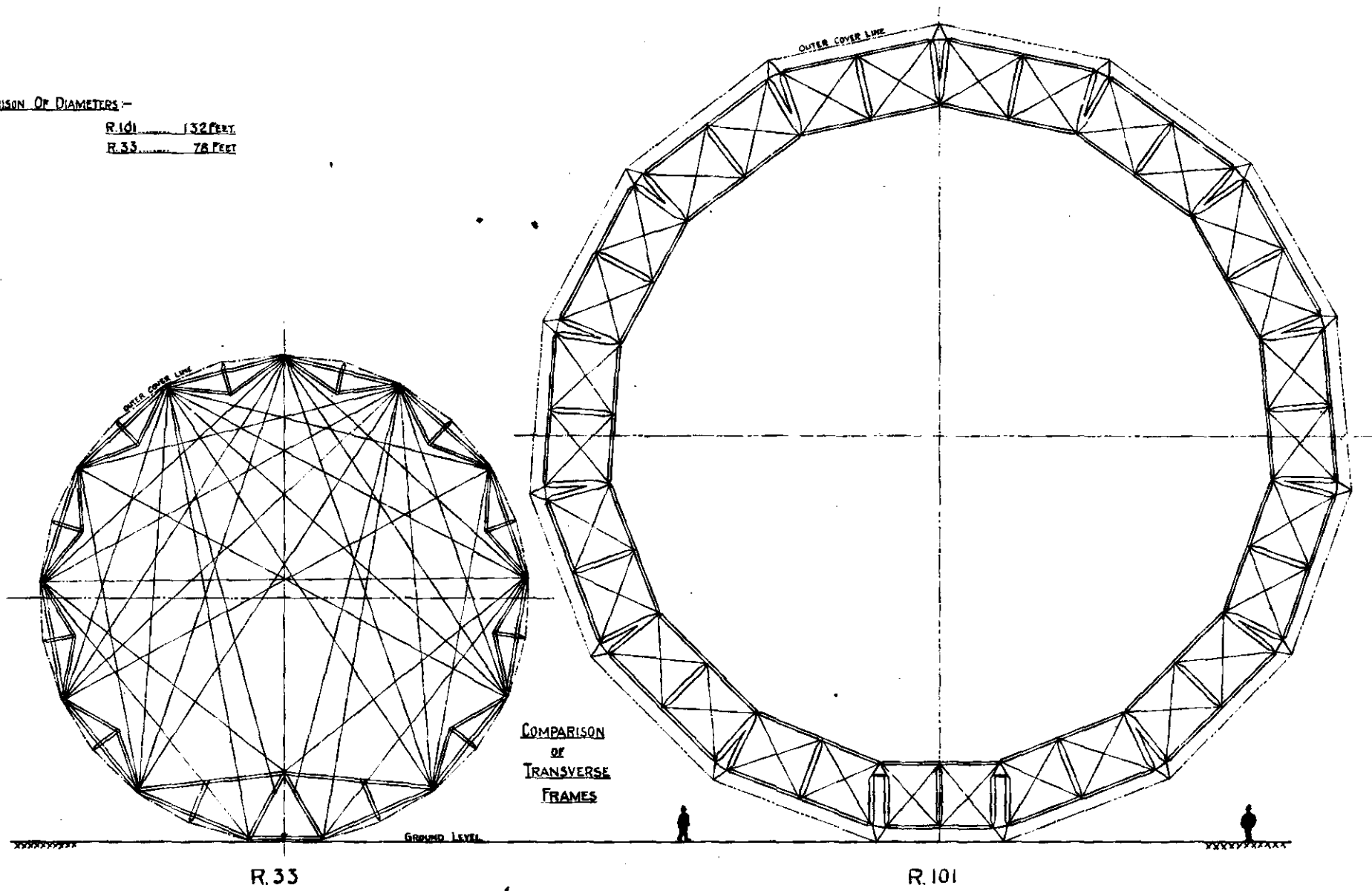
The practical object of this investigation was to develop a method of accurately calculating these forces and strains so that the designer might know what should be the strength of the structure necessary to resist them. By 1924 appreciable progress had been made, and there was available a considerable body of theoretical knowledge, so that it was possible to lay down in general terms the principles which should govern the airworthiness of airships from the structural point of view. Further important investigations, however, remained to be made ; in particular, the full scale research recommended by the Aeronautical Research Committee. The carrying out of this research was consequently the first item in the Government's programme.

(2) *The Calculation of Aerodynamic Forces.*—In order to investigate the nature of the forces which the rapid motion of an airship through the air causes to act upon her hull, experiments were made with model airships in the wind tunnels at the National Physical Laboratory, making use of the technique which has long been successfully used to elucidate problems of aeroplane design. These experiments eventually led, in 1925, to the selection of a shape of hull which for a given volume has half the resistance of older airships. These important results were subject to the one uncertainty that it was not known how accurately the behaviour of a full size airship would correspond to that of its model. This was a fundamental difficulty, and its removal was one of the main objects of the full scale research included in the Air Ministry's experimental programme. R.33 was therefore inflated and equipped with an elaborate system of instruments designed to measure the forces exerted by the air on the hull, fins and rudders of the airship in flight. Disposed over the surface of the ship's hull were 300 specially designed holes which were connected by rubber tubes to batteries of pressure gauges distributed at convenient points inside the ship ; and all these gauges were photographed simultaneously by illuminating a system of electric lights governed from the control car. In one long flight of 20 hours in November of last year 42 readings were taken covering straight, pitched and circling flight at different speeds and with various rudder and elevator angles. The results of this experiment with R.33 were then worked out and compared with those given by her model in the wind tunnel. The slight differences between the two



COMPARISON OF DIAMETERS:-

R.101 132 FEET
R.33 78 FEET



COMPARISON
OF
TRANSVERSE
FRAMES

indicated the extent to which reliance could be placed on model figures, and a standard for use in calculating the behaviour of other airships from model tests. The aerodynamic forces to which the two new airships will be subjected can now be assumed with much more confidence from the experiments on their models in the wind tunnel. Further experiments of this kind will, however, be necessary, and it is intended to equip R.101 with similar pressure gauges and to check the calculations based on the behaviour of her model by observation of the actual aerodynamic forces as recorded in the completed airship in flight.

(3) *The Calculation of the Strength of Airships.*—When the aerodynamic forces which act on an airship are known it becomes possible to consider the way in which these forces distribute themselves through the airship structure and therefore how strong the various parts of the structure must be made. In consequence of the report of the sub-committee which investigated the accident to R.38 a Panel of the Aeronautical Research Committee was appointed, under the Chairmanship of Mr. R. V. Southwell, to investigate “certain questions relating to the structural strength of airships.” The Panel reported, analysing in considerable detail the nature of the stresses to which airships are subject, and in 14 technical appendices treated the whole question in the light of existing knowledge. This report, however, dealt only with the purely theoretical problem of stress calculations and it was necessary to check the theoretical conclusions by actual experiments. For this purpose, at the recommendation and under the auspices of the Aeronautical Research Committee, Professor Pippard carried out, on behalf of the Air Ministry, an investigation of “redundant structures” consisting of a series of experiments on a specially simplified model. The results generally supported theoretical conclusions, and when airship construction was again started there was sufficient material available to enable the Airworthiness of Airships Panel of the Aeronautical Research Committee, under the Chairmanship of Professor Bairstow, to lay down in general terms the structural requirements for the airworthiness of airships. The report of this Panel specified certain factors of safety which were considered necessary in various parts of an airship structure to provide for all normal flying manœuvres and conditions, and will govern the construction of the two new airships. During the present programme experiments have also been carried out at Pulham with special strain gauges on the hull of an old, but sufficiently representative, airship further to test the theoretical conclusions as regards the new airships; strength tests, not only of the individual members, but of a complete transverse ring have been or will be carried out by the two designing staffs; and at the Royal Airship Works a complete section of R.101 was erected in the summer of 1926, and submitted to stringent tests, with satisfactory results. It may therefore be said, that every possible experiment, test and check has been made in the initial stages of the new designs. It is intended, further, to equip R.101 with special instruments which, during flying trials, will simultaneously record the actual stresses at a large number of important points in her structure.

(4) *The New Basis of Airship Construction.*—It will be seen that in consequence of the work of English scientists there has been a considerable development in the theory of airship construction in recent years. As a result of this theoretical progress the strength required in different parts of the airship structure can be calculated with far greater confidence than before. Simultaneously, the advance to greater size has rendered practicable the use of materials and methods of construction which were not previously possible. Indeed it may be said that airship construction, on the side both of theory and practice, is now being developed in a way which for the first time makes full use of knowledge available from the aeronautical engineering experience of the past.

4. The Two 5,000,000 cubic foot Airships.

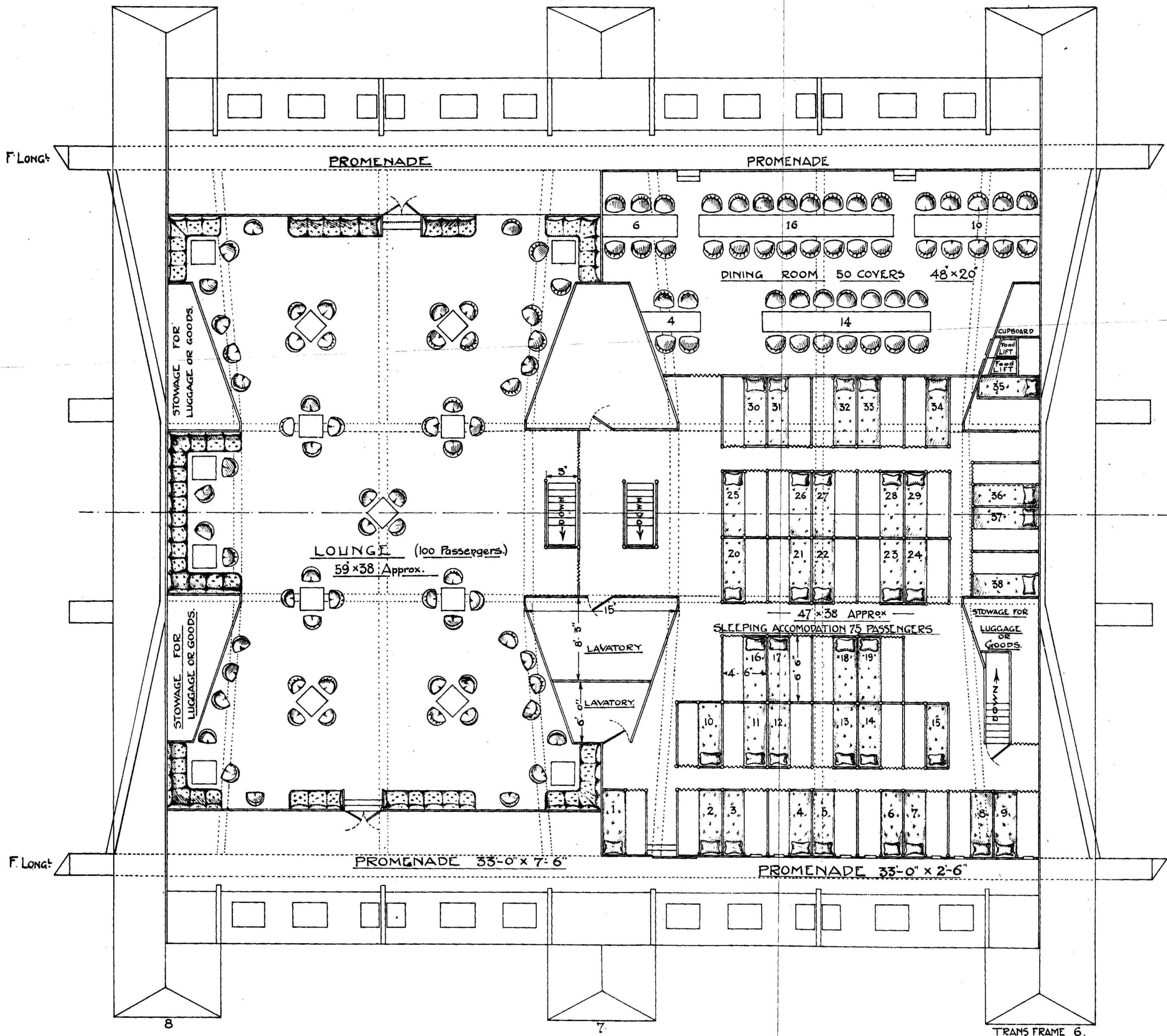
(1) *Dimensions and Estimated Performance.*—The airship being constructed by the Airship Guarantee Company will be known as R.100, and that being built at the Royal Airship Works will be called R.101. Both airships have a maximum diameter of approximately 130 feet, but R.101 is somewhat longer than R.100, having a length of 730 feet as compared with 709 feet. The large size of the airship has made practicable the use of steel in the girder work of R.101; while in the hull of R.100 a new form of duralumin girder is being used which is claimed to be more effective than any duralumin girder previously used in airship work. The full speed laid down in the contract for R.100 is 70 miles an hour at 5,000 feet, with a cruising speed of 63 miles an hour; and the same requirements are being called for in the case of R.101. These speeds have been put on a conservative basis, and it is hoped that they will be exceeded by both airships. At this cruising speed the airships should be able, without refuelling, to fly in still air a distance of some 4,000 miles with a normal commercial load.

(2) *Engines.*—The use of petrol in an airship has long been recognised as a potential source of danger, and for commercial airships the substitution of a less inflammable engine fuel is regarded as of the first importance. Two lines of experiment have been pursued—the use of a mixture of kerosene and hydrogen, and the use of heavy oil in a compression ignition engine of the Diesel type. Some progress has been made with the hydrogen kerosene engine, but it is not anticipated that it will be developed in time for the trials of the two new airships. The practicability of a heavy oil aircraft engine had already been the subject of research and experiment at the Royal Aircraft Establishment, Farnborough, before 1924. When the present programme commenced, the Air Ministry decided to develop this type of engine for R.101, and the work was given to Messrs. Beardmore and Company, Limited. Although a successful railcar engine was quickly produced, and is now in commercial use in Canada, the problem of combining strength and lightness has made the development of the aircraft engine proceed more slowly. It is confidently hoped, however, that heavy oil engines will be available for both airships on their trial flights. Another problem of considerable interest to the commercial future of airships which is being attacked is the recovery of water from the exhaust gases of the engine.

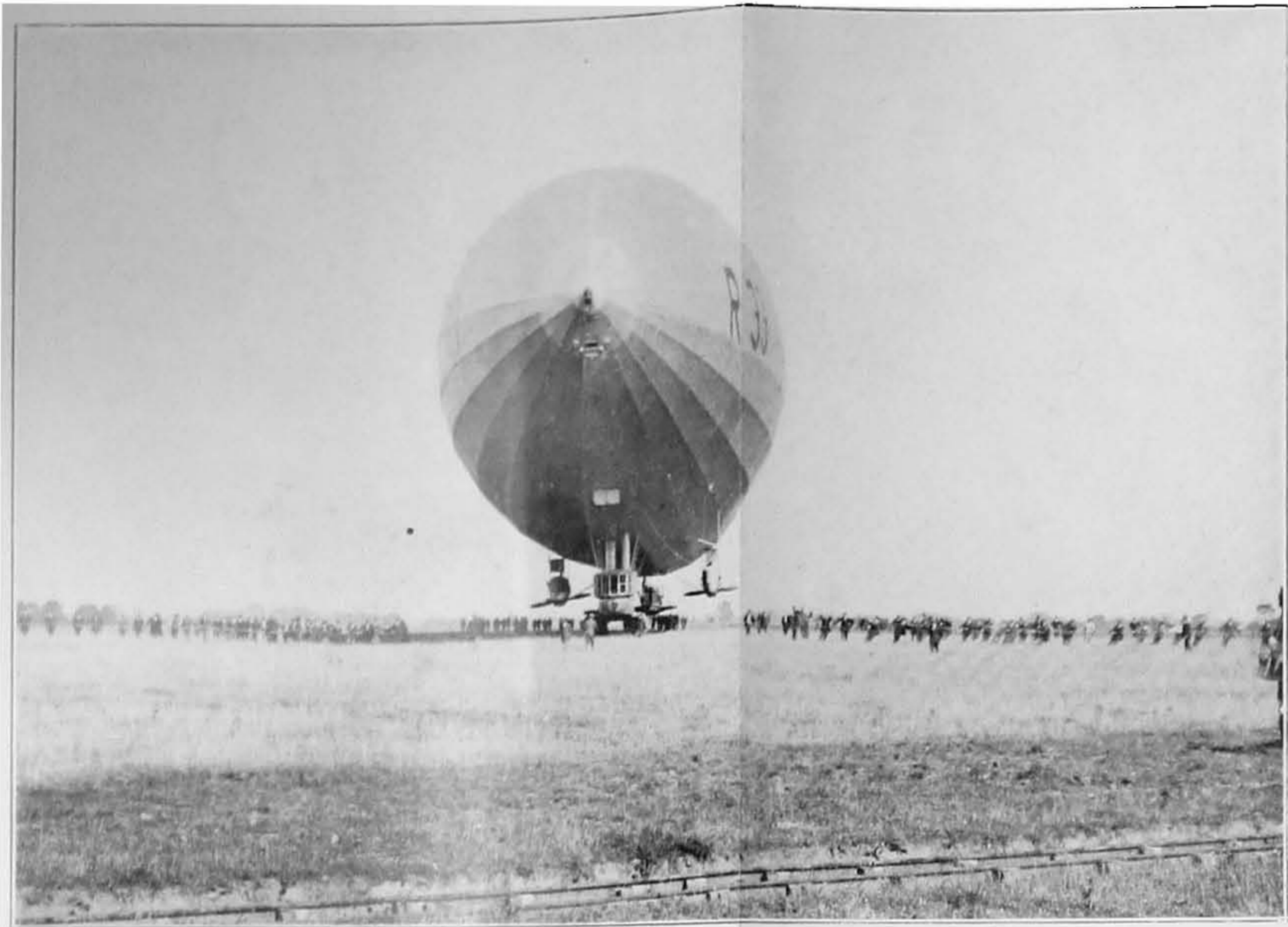
(3) *Passenger Accommodation.*—Both airships are being designed to carry approximately 100 passengers, luggage, and 10 tons of mail; and the accommodation provided will be far more comprehensive than that of any previous aeroplanes or airships. It will include sleeping cabins with two or four berths, promenade decks, lounges and smoking room; and dining rooms capable of seating 50 people at a time. Special arrangements are being made for ventilation and heating, and there will be fully equipped kitchens capable of serving normal meals for the passengers and crew. A suggested disposition of passenger quarters in the space available on the upper deck of R.101 is reproduced on the opposite page, from which it will be seen that the extent of the accommodation would have no little resemblance to that of a steamship. In point of comfort, however, a large airship has two advantages over an ocean-going vessel: the airship flies with considerably less rolling and pitching; and there is no vibration since the engines are carried in cars slung away from the main structure.

5. The Provision of Airship Stations for the Experimental Voyages.

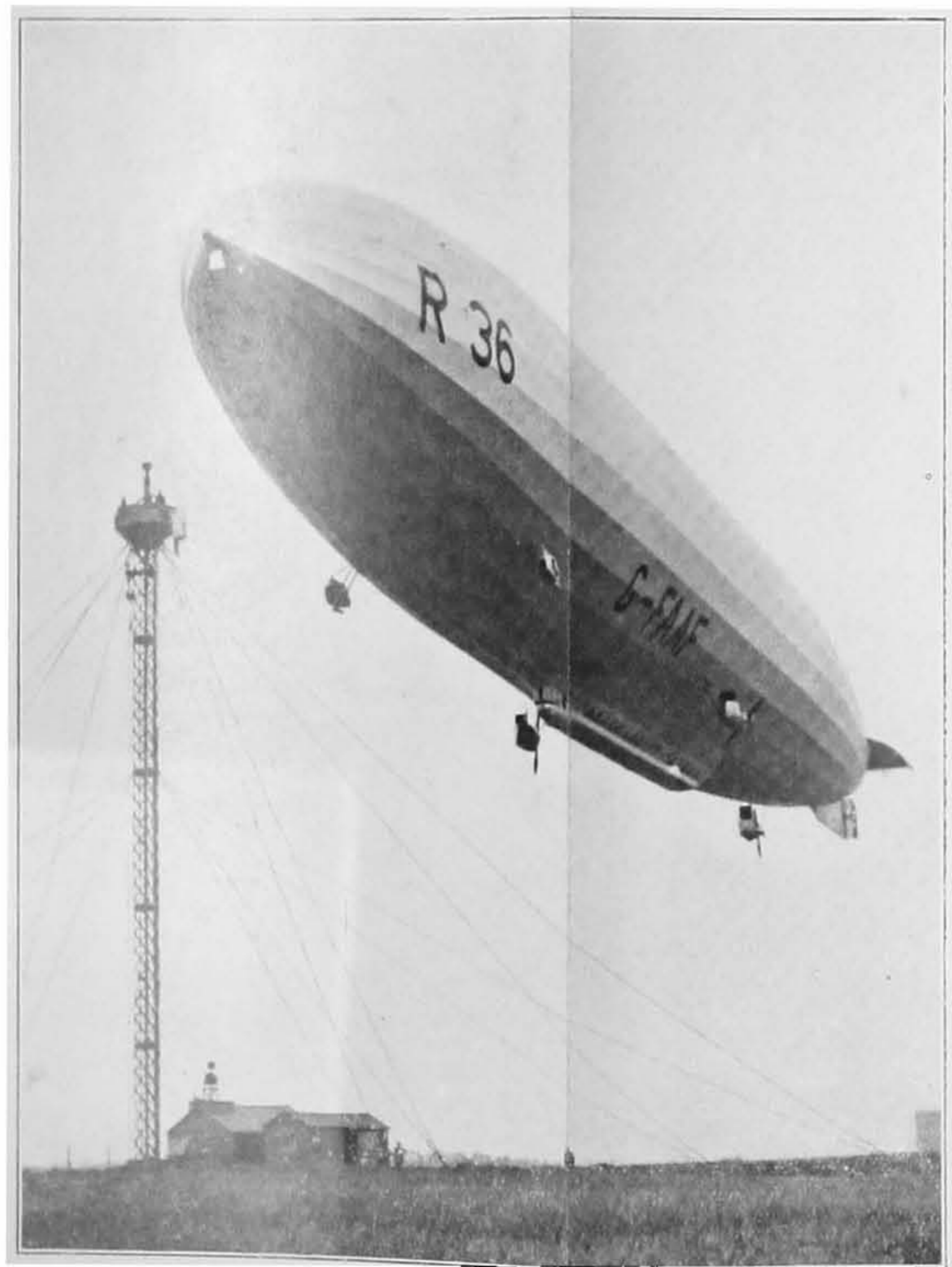
(1) *The Development of the Mooring Mast, 1919–25.*—The chief cause of the irregularity of airship flying in the past has been the difficulty of handling ships on the ground and the risk involved in taking them in and out of the sheds in anything but light winds. Regular operations were obviously impossible with an airship which in the face of a very moderate wind had to be laboriously manœuvred by several hundred assistants into the shed, from which it could only emerge when the weather was calm. In order to solve this problem considerable attention has been given in recent years to the development of a system of mooring airships at masts. The first real attempt to do this was made at Pulham in 1919 with the airship R.24, and a mast



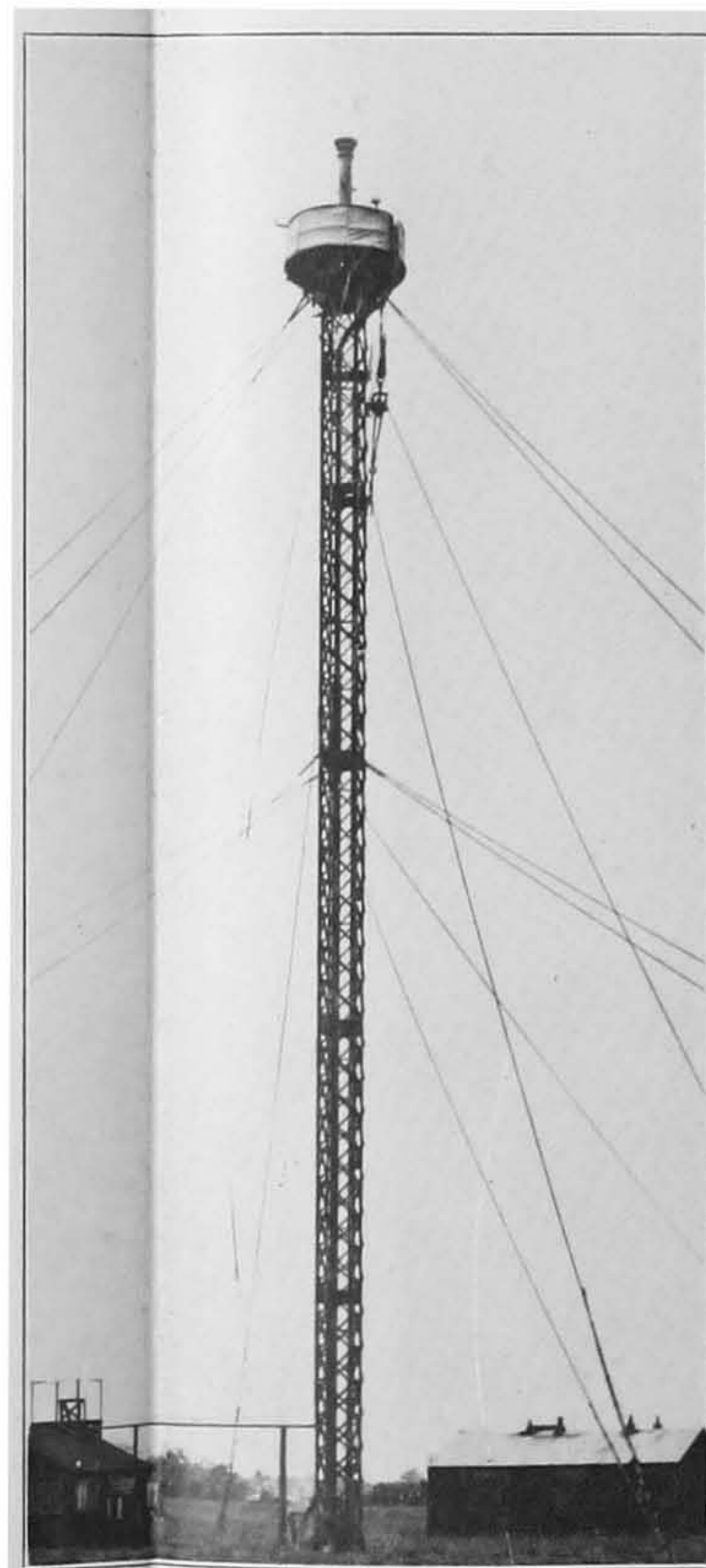
R. 101. SUGGESTION FOR PASSENGER ACCOMMODATION (UPPER DECK).



An Airship being brought to her shed by a landing party of 250-300 men.



An Airship landing to a Mooring Mast operated by a crew of ten men.



The old Mast at Pulham.



The new Mast at Cardington.

These photographs have been reproduced to scale and show the actual relative sizes of the two Masts.

designed and erected to the order of the Air Ministry by Messrs. Vickers, Ltd. During these trials the airship remained at the mast for periods of 21, 42 and 4 days and weathered a maximum wind of 43 m.p.h. Difficulty was, however, experienced in landing to the mast and to obviate this a different system of landing was devised, a new head was constructed at the Royal Airship Works, and further trials were carried out in 1921 with R.33. These trials covered a period of four months. A variety of weather was experienced, including rain, hail and snow, but no difficulty was found either in landing, leaving or riding at the mast in winds up to 28, 40 and 51 miles an hour respectively. The same system of mast mooring has been adopted in the United States, and both the 'Shenandoah' and 'Los Angeles' have carried out operations in climates ranging from the temperate conditions of New York to those of the Southern States. Since the adoption of the system only two mishaps of any consequence have occurred. The 'Shenandoah,' owing to the weakness and breakage of a fin and the faulty design of a bearing which jammed when she began to roll, wrenched herself free but returned safely to her shed. In the case of R.33, which was not designed for mast mooring, the airship was struck by a violent side gust during a heavy gale; a girder in the nose and certain bolts on the masthead failed under stress, and the airship broke away from the mast, but returned safely to Pulham after fighting the gale for some 30 hours over the North Sea. In both these accidents there were failures of the airship while at the mast for which it is thought that a comparatively small increase of strength can provide; and the problems of mooring are being taken into account in the designs of the new airships. In temperate climates the critical and expensive operation of bringing an airship to the earth and housing it in a shed after every flight is a thing of the past. An airship can now be moored to a mast by a mast crew of ten men; and it should be able in the future to operate from the mast for long periods, refuelling and changing engines and even gasbags while moored at the mast. The airship shed should then be more analogous to the dry dock of a surface ship than to its ordinary harbour.

(2) *The Airship Stations of the England-India Route.*—In order to provide the conditions for safe experimental voyages to India and back it was considered essential to construct a mooring mast at Cardington, in addition to the shed in which R.101 is to be constructed, a mooring mast for refuelling at Ismailia, and a shed at Karachi. The masts at Cardington and Ismailia are nearly completed and work has been begun on the shed at Karachi, the site for which has been presented by the Indian Government, together with a grant-in-aid of import duties of four lakhs of rupees. The masts under construction are of a new and improved design. They are nearly twice as high as the mast at Pulham from which the R.33 operated; and they are designed to resist a pull at the mast head six times greater than that which the Pulham mast can resist. Powerful and sensitive winches are operated by oil-fired boilers and controlled electrically from the top of the mast; pumps are installed capable of delivering fuel at the rate of 2,000 gallons an hour and water ballast at the rate of 5,000 gallons an hour to the moored airship; and a fast lift is located in the centre of the mast structure.

(3) *Further Mast Mooring Investigations.*—We have no first hand experience of the problem of landing an airship at a mast and of maintaining it there under the varying conditions of temperature prevailing in the tropics. Actual experiments are necessary to establish a technique and to determine what equipment is required. It is one of the objects of the present programme to supply information on these points as an essential preliminary to the operation of airships on those Empire routes which lie through the tropics. In addition, it has been thought desirable to investigate in detail some of the weather conditions which may affect an airship landing and riding at the mast. A specially devised system of electrically synchronized anemometers is being installed at Cardington to obtain information as to the changes of speed and direction of the wind in gusts. It is also in contemplation to carry out experiments in Egypt and India to measure the variations of temperature which occur between ground level and 250 feet, *i.e.*, variations which would affect mast mooring.

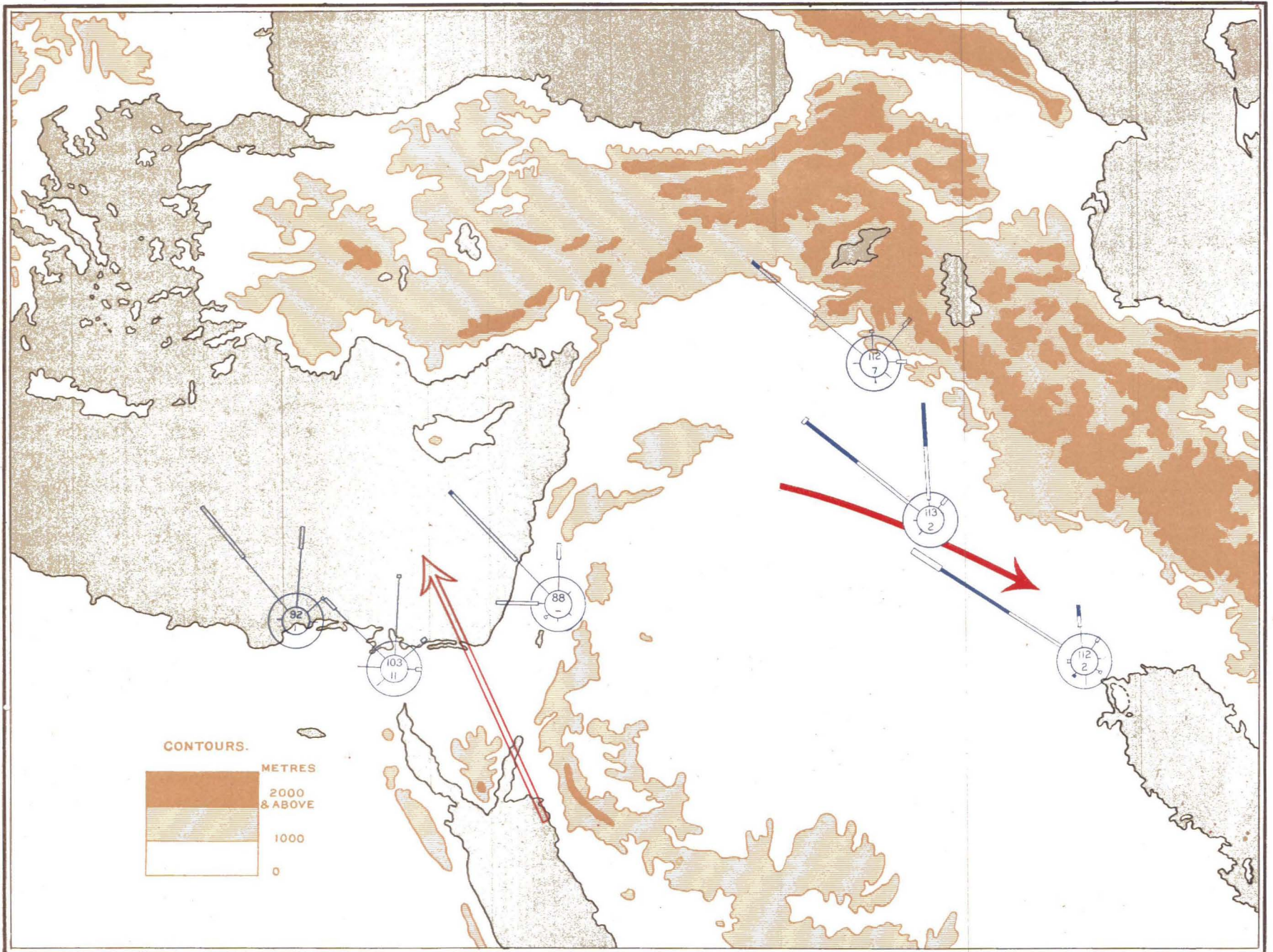
6. Meteorological Investigation of the England-India Route.

(1) *Weather Conditions in relation to Airship Navigation.*—Most forms of transport are in some degree affected by weather conditions ; but to the airship or the aeroplane a study of meteorology is all important, since it is the study of the element in which aircraft move. The air and its currents (the winds) are to aircraft what the oceans and their currents are to ships. The task of charting the sea has proceeded for generations because of its importance to the sailor. In the same way, the upper air must be charted if aerial transport is to be carried out with regularity and safety. If comparisons are to be made, the task of the meteorologist would seem, if anything, to be more difficult and complex than that of the hydrographer, since winds attain far greater velocities than do ocean currents and vary in direction and intensity with far greater rapidity. For the same reason aircraft, although they fly at speeds more than twice as great as that of the fastest steamship, may be affected to a greater extent by adverse winds ; on the other hand, by making use of favouring winds they can correspondingly increase their speed. For example, an aircraft cruising at a speed of 60 miles an hour through the air, would, against a head wind of 20 miles an hour, only make good a speed of 40 miles an hour over the ground ; but with a 20 miles an hour wind behind her, her speed over the ground would be 80 miles an hour. In the same way a high wind, even of gale strength, should cause no more danger or discomfort to an aircraft in flight in free air than an increase of speed in an ocean current to a surface vessel in mid-ocean. There are, however, certain atmospheric disturbances, such as tornadoes or water spouts and violent vertical currents associated with thunderstorms and line-squalls, which do constitute a potential source of danger to airships. It will be the duty of the meteorological service to warn airship commanders when such dangerous weather conditions are to be expected on any given route. With such a warning, supplemented by ocular or instrumental observation from the airship herself, the high speed and great range of the large airship should generally enable her to fly round rather than through disturbances of this type. It is particularly on long distance airship flights that such alterations of routes will be made in order to avoid adverse, and utilise favouring, weather conditions. It will, in fact, be the rule rather than the exception for the commander of an airship to choose his route between any two points for each separate flight having regard to the meteorological conditions prevailing at the time. He will only be able to do so when the areas through which lie all possible routes have been thoroughly studied beforehand, and when there is an adequate ground organisation for transmitting reports of the prevailing weather conditions and probable changes, at frequent and regular intervals.

(2) *The Progress of the Investigation of the England-India Route, 1925-26.*—A special division of the Meteorological Office was established early in 1925, and a considerable amount of work has already been done. First, using general experience and readily available existing summaries of meteorological information, the probable flying area between England and India was chosen. It will be seen from the map opposite page 72, in Appendix E, that this area covers almost the whole of France and a large part of the Mediterranean ; while beyond Egypt there are alternative provisional areas, one by Iraq and the other by the Red Sea and Aden. Next a programme of work was drawn up for the intensive investigation of the chosen area, providing for an exhaustive search of existing meteorological records and the supplementing of these by special observations in certain parts of the area. The following are some examples of the work already done :—

- (i) Monthly summaries and charts of the upper winds over the Mediterranean, the Middle East and Iraq have been made, using data from 30 stations involving the classification of some 120,000 individual readings. A chart of these winds is prepared for each month for four levels above the ground (1,500 feet, 3,000 feet, 6,000 feet and 10,000 feet). A part of one of the charts is reproduced on the opposite page. The observations used for the

MAP SHOWING THE PERCENTAGE FREQUENCY OF WINDS OF DIFFERENT DIRECTIONS & SPEEDS AT 1,500 FEET ABOVE THE GROUND OVER LOWER EGYPT, TRANS JORDANIA & IRAK IN JULY.



G.S., G.S. 3810

War Office, August, 1926.

The interpretation of the "wind roses" is as follows:—The total length from the inner circle to the other extremity of each arrow, which is to be taken as flying with the wind, shows the total percentage frequency of winds from that particular direction. The frequencies of winds of various speeds are indicated by widening and shading the arrows in accordance with the following scheme:—

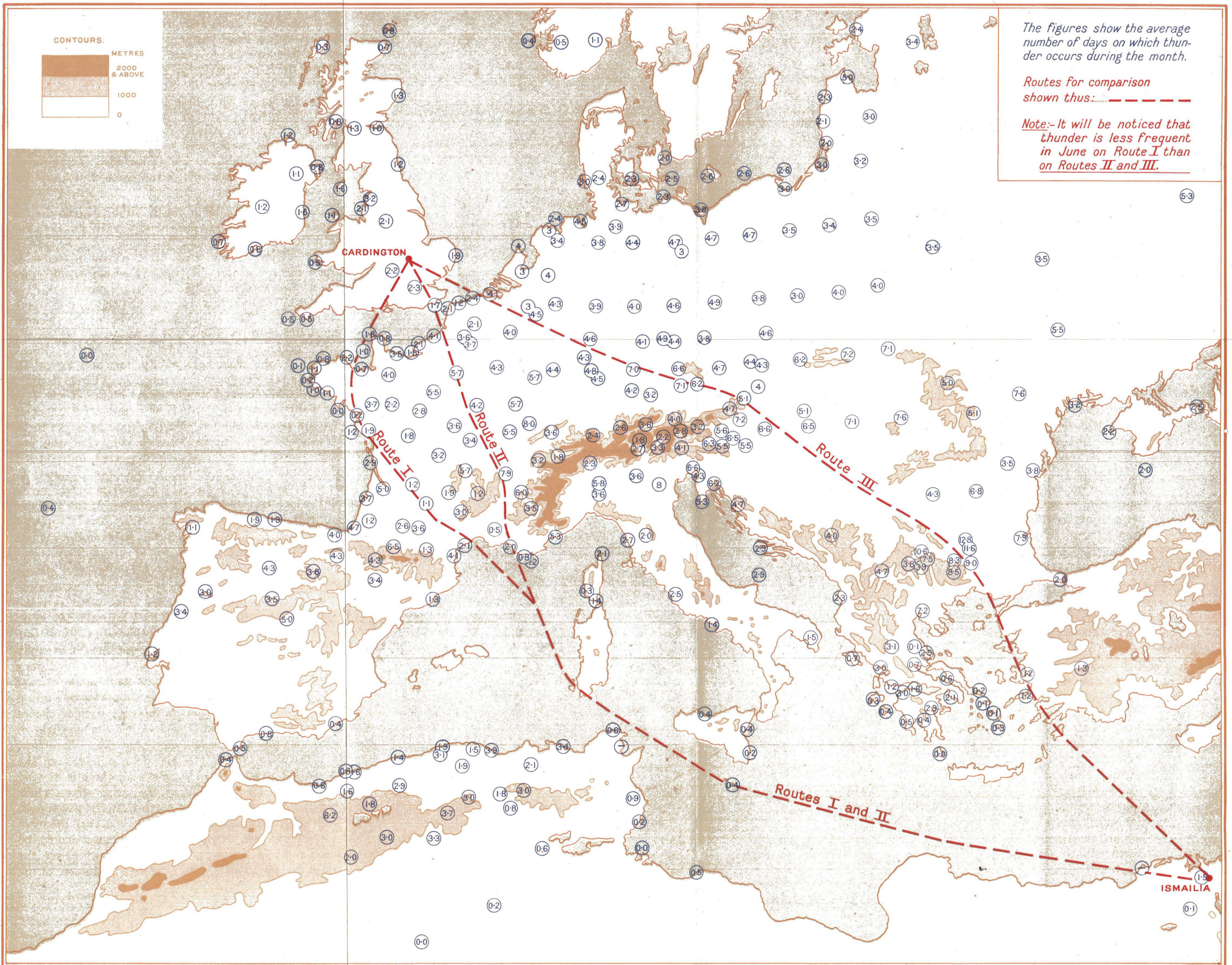
—————	4 to 15 miles per hour.
=====	16 to 31 " "
—————	32 to 47 " "
—————	48 miles per hour and above.

The circles supply a scale for readily estimating the approximate frequency of winds from any direction, the distance between the circles representing 5% of the whole number of observed winds on which the "wind rose" is based. The figures in the circle are:—

- Upper figure Total number of observations used for that "wind rose."
- Lower figure Percentage of these which were "calms" (here defined as 3 miles per hour or less).

THE RED ARROWS INDICATE THE MOST DESIRABLE ROUTES, SO FAR AS WINDS OVER THIS AREA ARE CONCERNED, FOR AN AIRSHIP FLYING EAST (→) OR WEST (←) IN JULY.

MAP SHOWING THE FREQUENCY OF THUNDERSTORMS DURING THE MONTH OF JUNE ON THE ENGLAND-EGYPT SECTION OF THE ENGLAND-INDIA AIRSHIP ROUTE.



section shown are those which have been made at Royal Air Force meteorological stations during four years. It will be seen that the prevailing winds over this area in July are from the north and the north-west, and that they are markedly stronger over Iraq than over northern Egypt. In flying east in July an airship could take advantage of this disposition of the winds by flying over Iraq, thus increasing her ground speed by the assistance of the wind, which as will be seen from the chart is frequently as high as 32 to 47 miles an hour. An airship flying west, however, would wish to avoid such high contrary winds and in order to do so might, as far as the area illustrated is concerned, fly up the Red Sea to Suez, where the north-west winds are much less strong in July.

- (ii) A detailed examination has been made of the monthly distribution of thunderstorms, employing up to the present observations at some 550 stations over a period of years, in some cases more than 50, and in two cases 100. A part of one of the series of 12 charts in course of preparation is reproduced on the opposite page. The method of representation is to place the figure representing the average number of days of occurrence of thunder in the month of June against the station where the observations were made. The averages are given to one decimal place: thus the figure 0.1 is to be interpreted as meaning that, on the average, thunder only occurs on one day in the course of ten Junes. Three routes are shown on the chart between England and Egypt, all avoiding high land, Route III being nearest to the "Great Circle Route," which is the shortest. Considering thunderstorms alone, Route I is readily seen to be normally superior to Route II in June, since it traverses areas with a lesser frequency of thunder. Further data have yet to be collected, but there are sound reasons for believing that the low frequencies shown at stations near the combined portion of Routes I and II over the Mediterranean are typical of the whole of this stretch. Thus it is seen that in June Routes I and II are both normally much superior to Route III, which traverses large areas in which the thunder frequency is from three to five times that of the area where the routes start in England. Route III encounters over the Balkans the highest frequencies shown on the map.
- (iii) Work has been begun on the preparation of a series of daily weather charts, using data for land stations extracted from the daily bulletins of some 20 countries and for sea areas from ships' logs. One chart is being prepared for each day for a whole year. The chart for each day in its initial form exhibits on an average over 4,000 meteorological facts relating to some 750 observing stations. The object of these charts is to study in the light of past experience the variety of *actual* weather conditions which may be encountered during individual flights, both as bearing on the problem of airship operation and navigation, and as providing initial experience for the forecasters before flying begins. A part of one of these charts relating to the weather at 7 o'clock on the morning of 16th February, 1925, is reproduced opposite page 20. The chart indicates a squally disturbance which extends along a line from the south of England down the west coast of France and which is moving slowly eastwards. In front of this, over France, are rather strong winds from a southerly point, and in its rear are north-westerly winds over the Bay of Biscay. From these observations it is obvious that the most favourable winds for an outward voyage from Cardington would be found off the west coast of France; and this route would have the additional advantage of taking the airship into the area in the rear of the

disturbance, which on this occasion was safer than that in front of it. Knowing from the study of the charts relating to previous days how these weather systems were changing, and assuming that an airship left Cardington at midnight on 15th-16th February and flew over this route at an air speed of 60 knots, then the progress for the ensuing 12 hours would have been as follows :—

Time.	Section of Route.	Wind.	Average speed made good over the ground allowing for wind.	Weather.
0000-0350	Cardington to Lizard.	Calm, increasing to N.W. 20 knots.	Knots. 57	Mainly fair, some mist.
0350-0700	Lizard to off Bordeaux.	N.W. 30 knots.	83	Mainly fair.
0700-0950	Off Bordeaux to Toulouse.	W. 22 knots.	76	Fair.
0950-1100	Toulouse to off Narbonne.	Calm	60	Fair.
1100-1200	Off Narbonne to Lat. 42° 30' N. Long. 4° 6' E.	N. 5 knots.	62	Fair.

Thus in 12 hours the airship would have cruised 900 nautical miles, having made good an average speed of 75 knots over the ground. If there had been no meteorological information available the navigator would naturally have taken the shorter route from Cardington to the Mediterranean *via* Paris and Lyons. On working out this route with the aid of the weather charts it appears that the airship would have passed through an area of low cloud and rain, with the added risk of an approaching squally disturbance; and that after 12 hours' flying, as a result of the contrary winds encountered over France, she would have reached a point on the south coast of France 80 nautical miles short of that reached by taking the longer route. Having arrived at mid-day on the 16th at a point off the south coast of France, the navigator would have had to consider what course to shape for Egypt, taking into consideration the wind and weather over the Mediterranean and its probable changes. The most important feature of the weather over this area was a line of disturbance extending from the north of Italy southwards to the African coast, flanked on the east by a belt of very strong southerly winds. The navigator would have learnt from his weather forecast that this disturbance was likely to move north and that by keeping to the south he would probably experience improved weather and decreasing winds. He would, therefore, have taken the route by Malta shown on the map. A study of the weather charts for the succeeding days shows that, having done this, serious bad weather and adverse winds would, in fact, have been avoided and the airship would have been approaching Ismailia at mid-day on 17th February. The total distance from England to Egypt by this route is 2,350 nautical miles, the time taken would have been 37½ hours and the average speed over the ground 62¾ knots.

These examples give an indication of the amount and kind of work which has already been done. It remains to complete the series of charts for each month of the year for the whole area of the route and to produce the final form for the use of airship navigators. When the charts are sufficient normal routes for the easterly and westerly voyages will be chosen for the year; and it is thought that these routes would be followed in accordance with the meteorological situation of the day indicated the desirability of following a particular route.

(3) *Meteorological Arrangements for the Experimental Flights to India*—The investigational work which has been described is a preparation for a meteorological daily reporting and forecasting organisation which will be set up along the whole route to India on the occasion of the experimental voyages of the new airships. This organisation will be similar to that provided for the voyage of His Majesty's airship R.33 in 1925 and the Rome-Pulham-Oslo expedition and the Polar voyage of the Italian 'Norge I' in 1926. Frequent observatories and meteorological stations surrounding the area of the route will be communicated by wireless to the airship in flight, together with special advice from ground stations and centres situated at points along the route. With the aid of this information charts and forecasts will be prepared in the airship and will be considered by the captain in shaping his course. The preparation of the necessary organisation has been started, but a great many arrangements remain to be made before the project is completed over the whole route to India.

7. The Progress of the Experimental Programme, 1924-26.

Work under the experimental programme has now been proceeding for 18 months. The varied and complicated problems of airship construction and operation have been approached by a cautious and scientific method, and a considerable amount of practical progress has been made. Important principles into the principles of airship construction have been carried out and tested successfully to the test of full-scale experiment. Two new airships of great size, speed and carrying power have been designed and are in the final stages of production. The problem of the recovery of water from the exhaust gases has been attacked; and a heavy oil engine is being developed with a view to the use of petrol as an engine fuel. The new sheds and mooring masts which were necessary for the safe navigation of the England-India route are in an advanced stage of construction. A comprehensive meteorological investigation of the route has been proceeding, and has already resulted in the collection of a considerable amount of special meteorological knowledge which will enable the experimental flights to be made with a greater prospect of safety and success than would otherwise be possible. It remains to build the airships; to overcome the mechanical difficulties of the heavy oil engine; to finish the sheds and masts; to complete the meteorological investigation; to establish the meteorological and wireless organisation; to carry out the home trials; and to fly the two airships to India and back. When the experimental programme has been successfully completed there can be no doubt that airship design and construction will have been placed upon an experimental and more practical basis; and the way will then be clear for carrying out further experiments which are required to establish the practicability of airship operation throughout the Empire.

IV.—THE FUTURE OF IMPERIAL AIR TRANSPORT.

1. The Development of Air Transport.

It has been shown in this memorandum—

- (1) that regular aeroplane services are a proved method of fast transport, and are constantly improving and expanding.
- (2) that France, Germany, and the United States have already achieved considerable air transport development, and that the first Imperial aeroplane services are in course of organisation.
- (3) that though the large airship is not yet a proved instrument of regular transport, airships have demonstrated their capacity to make long continuous flights carrying relatively heavy loads.
- (4) that the technical problems of airship development are being approached in England by a method of cautious and scientific investigation which is at present yielding encouraging results.

In the light of these facts it is reasonable to suppose that aeroplane services, being already on a solid technical basis, will continue to increase; and it may be considered at least likely that the resources of modern science and industry which have been successfully employed in developing the aeroplane will also eventually succeed with the airship. If in fact this happens air transport will receive an impetus the greatness of which it is important to realise. First, a balanced system of air transport would become possible. Airships would be able to operate over the main long-distance routes of world communication, while aeroplanes would be able to form local air transport systems which would feed the main terminal airship stations. Secondly, the comfort of air transport would be enormously increased by the standard of passenger accommodation possible on large airships. Lastly there would be a really large saving of time on long journeys between different parts of the world.

2. Air Transport and the British Empire.

The following table indicates the magnitude of the saving of time which would result from the operation of airship services between different parts of the Empire. The table is based on a speed made good over the ground of 50 miles an hour :—

Route.	Total Times.		Saving.
	Steamship.	Airship.	
England—Egypt ..	6 days	2½ days	3½ days
On to Bombay ..	15 ..	5 ..	10 ..
On to Perth	28 ..	11 ..	17 ..
England—South Africa—			
<i>via</i> W.A.	20 ..	6½ ..	13½ ..
<i>via</i> E.A.		6 ..	—
On to Australia ..	—	10½ ..	—
Australia—New Zealand	6 ..	1½ ..	4½ ..
England—Canada ..	6 ..	2½ ..	3½ ..
India—Australia	22 ..	6½ ..	15½ ..
India—Canada—			
<i>via</i> England	24 ..	9 ..	15 ..
Australia—Canada—			
<i>via</i> South Africa and England	48 ..	15¾ ..	32¼ ..

Regular transport services of this order of speed would place the system of Imperial communications upon an entirely new basis. It would then be possible to develop very greatly, and in several spheres, an Imperial co-operation based upon frequent personal consultation.

*A Map of the World, showing Existing and Proposed
Imperial and Foreign Air Routes, is enclosed
inside the cover of this Memorandum.*

APPENDICES.

	PAGE
Appendix A.—The Aeroplane Transport Development of the Principal Nations.	
(1) The British Empire	23
(i) Great Britain.. .. .	23
(ii) Canada.. .. .	29
(iii) Australia	29
(iv) South Africa	32
(v) The West Indies	32
(2) France.. .. .	34
(3) Germany	36
(4) United States	38
(5) Soviet Russia	40
(6) Holland	43
(7) Miscellaneous Services	44
Appendix B.—The Regulation and Administration of Civil Aviation	46
Appendix C.—Aeroplane Transport Operating Costs	52
Appendix D.—The Organisation of Cross-Channel Aeroplane Services.	
(1) Air Navigation and its Auxiliaries	54
(2) The Organisation of Meteorological Services	57
(3) The use of Wireless Air Traffic Communications	62
(4) Aerodromes and Landing Grounds	64
(5) The Lighting of Aerodromes and Air Routes	67
Appendix E.—Notes on the Organisation of Airship Services.	
(1) The Lay-out of an Airship Base	71
(2) Notes on a Preliminary Survey of Main Airship Routes.. .. .	74
(3) Meteorological Organisation in connection with the Development and Operation of Airship Services	77
Appendix F.—Some Special Uses of Aeroplanes.	
(1) Air Survey	82
(2) Forest Fire Protection	86
(3) Protection of Cotton and other Crops	87
(4) Destruction of Mosquitoes	87
(5) Investigation of Wheat and Timber Diseases	88
(6) Ambulance and Medical Duties	89
(7) Fishery Protection	89
(8) Observation of Shoals	90
(9) Prevention of Smuggling	90
(10) Conveyance of Administrative Officers	90
(11) Light Aeroplane Clubs and Private Flying	91

APPENDIX A.

The Aeroplane Transport Development of the Principal Nations.

I.—THE BRITISH EMPIRE.

GREAT BRITAIN.

I.—The Early Experimental Air Mails.

In September, 1911, the first "United Kingdom Aerial Post" was run between London and Windsor. The experiment did not last long, but it demonstrated the possibilities of the aeroplane as an instrument of fast transport and showed also that those possibilities would never be realised until flying could be made reasonably independent of the weather. It was not until after the war that the next experiment was tried. In the winter of 1918, the Royal Air Force established a Military Air Mail Service in conjunction with the British Army Post Office in France; but the weather proved a serious handicap, the services were irregular, and in general the results were not encouraging. Nevertheless, in the Spring of 1919, the Royal Air Force began another service to carry the mails of the British Army of Occupation in Germany between Cologne and Folkestone. This time the air mails sometimes gained as much as 24 hours in delivery, but the service was not very regular.

II.—The Early Companies and the First Subsidies.

In the summer of 1919, services were established by Aircraft Transport and Travel, Ltd., and Handley Page, Ltd., between London and Paris, and by Handley Page, Ltd., between London and Brussels. The fare from London to Paris was £25 and £15 by the respective services, and the fee for carrying a letter was 2s. 6d. The companies were not able to secure much traffic at these prices and were already in difficulties when the French air transport companies reduced their fares by the aid of a subsidy from the French Government.

Mr. Churchill, when Secretary of State for Air, then appointed an Advisory Committee on Civil Aviation and instructed it "to consider the essential steps in the national interest which the Government should take to develop civil aviation, bearing in mind the need for the utmost economy." The Committee, which reported in April, 1920, considered that State financial assistance was justified as a temporary measure and recommended "that direct assistance should be given, limited to a maximum amount of £250,000 within the two financial years of 1920-21 and 1921-22," payments to be made on the basis of 25 per cent. of certified gross revenue. This recommendation was, however, not adopted, as it seemed possible for a time that the companies might be able to continue without Government assistance. But when the French companies were given increased subsidies by their Government and reduced their rates in consequence, the British companies were unable to compete and discontinued their services. Mr. Churchill then appointed a small Cross-Channel Subsidies Committee and, as a result, the so-called "temporary" scheme of subsidies was adopted in order to keep the British air transport companies working until 31st March, 1922. In April, 1922, the so-called "permanent" scheme of subsidies recommended by the Committee came into operation. The chief feature of this scheme was that the British companies (the number of which had then increased to three) were to share the comparatively large traffic which was growing up on the London-Paris line and it was hoped that operating costs would be reduced under the pressure of competition. But the traffic did not increase as had been expected, and the three British companies found themselves competing for traffic which yielded too small a revenue to support them. In October, 1922, therefore, the scheme was revised so that each company operated a separate route.

As time went on it was seen that the position was not satisfactory, either for the Government or the companies. It became apparent that if British air transport was to continue, subsidies would be necessary for several years, and if it was to develop, adequate capital would have to be attracted to the enterprise. Sir Samuel Hoare (Secretary of State for Air) therefore appointed the Civil Air Transport Subsidies Committee, under the chairmanship of Sir Herbert Hambling, "to consider the present

working of the scheme of cross-Channel subsidies and to advise on the best method of subsidising air transport in the future." This Committee was the first to formulate a comprehensive policy. It considered that although there were generally many advantages to be derived from competition in business, yet in the particular circumstances of the time British air transport could not be expected to flourish under competitive conditions. The Committee therefore recommended that on the termination of the then existing agreements with the four subsidised operating companies a new company with a capital of £1,000,000 should be established and should be guaranteed a subsidy of not less than £1,000,000, spread over 10 years. It was recommended that the Government should not exercise any special direct control over the activities of the company, other than by being represented on the Board by two directors.

III.—The Agreement with Imperial Airways, Ltd.

The new company, known as Imperial Airways, Ltd., came into existence on 1st April, 1924, and into it were merged the interests of the four companies, who thereupon ceased to operate.

The terms of the agreement with Imperial Airways, Ltd., followed closely the detailed recommendations of the "Hambling" Committee. Brief particulars of the leading points will be sufficient to indicate the system of subsidy payment :—

- (1) The company enjoys a monopoly of British subsidies for air transport in Europe.
- (2) The company undertakes to maintain services on the routes upon which development work was carried out by the four companies previously operating or on such other approved routes as the company may consider commercially desirable.
- (3) The subsidy payable to the company will be £137,000 per annum for the first four years, after which a "tapering" subsidy will be paid diminishing in amount until, in the tenth year, the company will receive £32,000 as a final payment.
- (4) In return for this subsidy the company undertakes to perform a minimum amount of flying. Under the original agreement, dated 15th May, 1924, the mileage flown on chartered routes was taken as the basis of calculation, the company being required to fly a minimum of 1,000,000 miles per annum, except that during the first four years the annual minimum in any one year might be 800,000, provided that not less than 4,000,000 miles was flown in the four years. After the first year's operation, however, it was seen that "mileage" was not the most satisfactory basis of reckoning, since the company did not benefit from the use of more modern aircraft of larger capacity, as they counted for subsidy purposes on equal terms with small machines with less accommodation. The agreement was therefore amended on 18th December, 1925, so that 425,000,000 "horse-power miles" was substituted for 1,000,000 "miles." The work done by the company's aircraft is, therefore, now reckoned proportionately to the horse-power employed and the company has a direct incentive to develop larger and more economical types of aircraft. A further modification provided that every mile flown by a marine aircraft should count as one mile and a half, in view of the smaller carrying capacity of marine aircraft at their present stage of development.
- (5) The subsidy of £1,000,000 is not a gift, but is repayable when the company has reached a definite profit-earning condition. The agreement provides for the distribution of profits on the following lines :—
 - (i) Ten per cent. on the paid-up capital of the company shall be made available for distribution amongst the shareholders.
 - (ii) The balance, if any, shall be divided into three parts :—
 - (a) One-third shall be utilised for the repayment to the Government of the annual subsidy advanced.
 - (b) One-third shall be devoted to the development and improvement of the air services provided by the company.
 - (c) The remainder shall be available for distribution amongst the shareholders of the company.

MAP SHOWING **BRITISH** AIR SERVICES IN 1926.



British services (existing) ———
" " (proposed) - - - -
Other services (existing) ———
" " (proposed) - - - -

Under this arrangement, repayment will not take place to the exclusion of development and the shareholders will not lack an inducement to see repayment begin. Up to the present, however, no profits have been made.

In addition to the subsidy, the Air Ministry assists the company indirectly by the establishment of aerodromes, wireless communications, and other services which are described more fully in Appendix B.

In general, Imperial Airways, Ltd., have security of a subsidy monopoly in Europe during a 10 years' period, until April, 1934, in which to create the operational and commercial organisation which is required to make the services self-supporting.

IV.—Routes Operated.

Since 1924, when Imperial Airways, Ltd., was established, there has been practically no change in the routes. In 1926, the Company is operating the following routes :—

(Extensions in brackets are operated by foreign companies.)

	<i>May to September.</i>	<i>October to April.</i>
1. London-Paris	Twice daily.	Daily.
2. London-Paris-Basle-Zurich	Daily.	—
3. London-Ostend-Amsterdam [Hamburg-Copenhagen-Malmo].	Twice daily.	—
4. London-Cologne [Hanover-Berlin]	Daily.	Daily.
5. Southampton - Channel Islands	Weekly.	Weekly.

There has lately been a growth of co-operation between the various air lines and railways, with the result that the following four long journeys may be made by definite connections :—

1. *London-Malmo-Stockholm and Oslo*—The route of approximately 700 miles to Malmo, *via* Ostend, Amsterdam, Bremen, Hamburg, Copenhagen, can be flown in one day between 8 a.m. and 7 p.m., with one change at Amsterdam. At Malmo, night trains can be taken to Stockholm and Oslo. British machines are used between London and Amsterdam, and Swedish machines between Amsterdam and Malmo.

2. *London-Moscow*.—Departing from London at 8.30 a.m. a machine of Imperial Airways, Ltd., reaches Cologne 12.45 p.m. A machine of the German "Lufthansa" departs from Cologne at 1.15 p.m. arriving at Berlin at 5.35 p.m. Thence, a machine of the German-Russian "Deruluft" leaves at 2 a.m. and (flying by night) arrives at Moscow at 5.30 the next afternoon, with four intermediary landings. Thus, the route of 1,760 miles is traversed by air with machines belonging to three different companies in a total time of 33 hours.

3. *London-Casablanca*.—A passenger leaves London by French machine at 9 a.m. and arrives at Marseilles at 5.45 p.m. where he spends the night. At dawn next morning an aeroplane of the French Latecoere Company leaves for the West African coast and arrives at Casablanca at 8 o'clock in the evening, having stopped at six intermediary places en route. This route of 1,737 miles is thus covered in 35 hours. If he prefers it, a passenger can leave London by British machine three hours later, arrive in Paris at 2.30 p.m. and take the night train to Toulouse, thence continuing by air next morning. Time 32 hours.

4. *London-Milan (via Basle)*.—Leaving Croydon by a British machine at 7.55 a.m. Paris is reached at 10.25 a.m. and Basle at 1.55 p.m. Connection is made with the Milan express at 2.40 p.m. On the return journey the train leaves Milan at 10.5 a.m. arriving at Zurich the next morning at 5.22 a.m. Breakfast is taken at Zurich and the British machine leaves at 8.20 a.m. arriving at Paris at 12.45 p.m. A stop of one hour is made, and Croydon is reached at 4.15 p.m.

In spite of progress in efficiency during the past seven years, no British air route is longer than 520 miles. Amsterdam, Cologne and Zurich represent the furthest points reached in Europe. This is largely due to European complications which centre around Germany. The German Government stipulated that only machines which complied with the "Nine Rules" imposed on German aircraft could be used over German territory. Thus the gateway to central Europe via Germany has in the past been closed, except to small and uneconomical machines. Again, the money allocated

as subsidies has not gone so far as was anticipated, partly owing to the fact that the British subsidy system in Europe aims at attaining commercial success as soon as possible and does not attempt to maintain uneconomical lines with a view to establishing British prestige and influence.

V.—Traffic Results.

The shortness of the British routes and the fact that Great Britain and the Continent are connected by excellent systems of surface transport, limits the saving in time that can be effected by air transport. With this handicap the naturally conservative attitude of the public towards air transport has not been overcome swiftly, but it is being overcome, as the statistics of traffic show.

1. *Passengers.*—The total number of passengers carried by air between Great Britain and the continent, by British and foreign air services combined is increasing at the rate of nearly 3,000 a year. Goods traffic has reached fair proportions and shows promise of a large expansion. Mail traffic is comparatively small.

The following table illustrates the growth of passenger traffic across the Channel :—

Year.	Passengers.		
	By British Aircraft.	By Foreign Aircraft.	Total.
1919 (5 months)	870	52	922
1920	6,799	584	6,383
1921	5,256	5,475	10,731
1922	9,490	2,869	12,359
1923	11,947	3,189	15,136
1924	10,456	7,402	17,858
1925	10,602	10,119	20,721
Grand Totals ..	54,420	29,690	84,110

It will be seen that last year over 20,000 passengers crossed the Channel by air. Over 5,000 flights were made and the average load per flight was four passengers and 400 lb. of goods.

The fares charged for air transport across the Channel are fixed according to the traffic demand. For example, on the London–Paris route where the demand is heaviest a comparatively higher charge can be made than on other routes. On an average the extra charge for air transport over first class ordinary transport is relatively small. The average extra cost for each hour saved is under 3s., excluding the appreciable saving in tips, taxis, meals and sleeping berths when travelling by air.

2. *Freight.*—Passenger traffic has the serious disadvantage to the operating companies that it is seasonal. By far the largest part of it is forthcoming during the summer months, and in the winter the companies have to face a large drop in revenue. For this reason they have a special incentive to develop goods traffic, which remains fairly constant all the year round. The carriage of goods by air has several important advantages apart from the mere speed of the aircraft. All the *en transit* customs formalities involved at every point of transshipment in surface transport are eliminated. Customs clearance at the place of destination is effected immediately, and a rapid system of collection and delivery is available at the beginning and end of the journey. Because handling is reduced to a minimum and the goods are under no risk of pilferage during most of the period of transit insurance rates for air borne goods are actually lower than for goods conveyed by surface transport. The following comparative table of insurance rates illustrates this advantage :—

Freight Insurance Premium per £100.

	Surface Transport.		Air Transport.	
	s.	d.	s.	d.
London to Paris	6	8	2	0
Amsterdam	6	8	3	0
Cologne	7	6	4	0
Zurich	7	6	5	0

These factors have led to a considerable transport of gold, precious metals, jewellery and other objects of high value. During the year ending 31st March, 1926, for example, the cross-Channel services carried bullion and specie to the value of over £11,328,829.

The carriage of ordinary merchandise apart from bullion and specie is increasing steadily and the total weight carried across the channel annually is nearing 1,000 tons. The following figures illustrate the improvement in this branch of traffic :—

Year.	Ordinary Freight. Total Value. £	Ordinary Freight. Weight.		
		By British Aircraft.	By Foreign Aircraft.	Total.
		Tons.	Tons.	Tons.
1919 (5 months) ..	90,936	†	†	†
1920	1,028,812	†	†	†
1921	571,300	†	†	†
1922	713,020	182·7	294·6	477·3
1923	776,251	326·5	498·9	825·4
1924	1,350,960	541·8	391·4	933·2
1925	1,586,936	454·8	437·9	892·7
	6,118,215	(4 years) 1505·8	(4 years) 1622·8	(4 years) 3128·6

† Totals not available.

VI.—Some Lessons of Flying Experience in Great Britain.

The operation of the cross-Channel services has always been looked upon as a full-scale experiment in air transport, from which lessons could be learnt and data collected for use in the development of the main Imperial routes. The fruits of this policy are now ready to be gathered. The weak points of air transport and the directions in which improvements must be made before it can become financially self-supporting are now apparent.

1. *Safety and Reliability.*—In regard to safety, the record of the British air lines proves that air transport when properly administered and efficiently operated is reasonably safe. Imperial Airways, Ltd., and its predecessors have in seven years carried over 75,000 passengers in the course of flying approximately 5,000,000 miles, equal to 200 times round the world at the equator. In all this flying only four accidents have occurred causing the death of passengers. Thirteen passengers have been killed and five injured.

The reliability of the services is most easily expressed by the percentage of flights commenced which were completed without interruption, although this basis admittedly gives a more favourable impression than is justified, since it disregards scheduled services not begun. On this basis, then, in the year ending 31st March, 1926, the reliability was 93 per cent. Of the remaining 7 per cent. of flights, about one-half were completed on the same day after interruption and the remainder completed later or abandoned. This represents the average reliability all the year round, including the periods of winter fogs and gales when reliability is at its lowest point. In the summer months the reliability rose to 99·2 per cent.

The main causes of interrupted flights in the year in question were the following :—

Weather	52 per cent.
Mechanical defects	33 ..
Miscellaneous	15 ..

Weather, therefore, accounted for more than half of the interruptions. From a meteorological point of view Great Britain is in a very unfavourable situation. Fog, very low cloud, and snow (in other words bad visibility) are frequent, and this is the principal obstacle to greater reliability. In bad visibility the pilot of an aircraft has cause to fear three things : failure of his power plant when he is unable to see the ground prior to choosing a suitable landing place ; inability to fix his position ; and loss of control when flying through cloud. Solutions to these difficulties are in preparation which will by degrees overcome them.

(i) Failure of power plant is being met by the provision of three-engined aircraft which can fly safely with one engine stopped. Such a machine has two advantages : the fact that all three engines are functioning simultaneously enables them to be run at low revolutions and so reduce wear and tear ; and if one engine stops, the other two can be opened up to their full power and the journey completed, or at the worst a recognised landing place reached in safety. Some machines of this type are already being used by Imperial Airways, Ltd., and should eliminate any chance of a forced landing on account of power plant failure.

(ii) Inability of the pilot to fix his position is being met by an application of wireless telephony. Wireless navigation for aircraft has only been seriously developed during the last four years. Great progress has been made, and to-day all aircraft belonging to Imperial Airways, Ltd., are equipped with wireless which provides the pilot with the means of ascertaining his exact position, and keeping in touch with local weather conditions prevailing in the vicinity of the aerodromes in front of him. This system has proved so successful that pilots are flying more and more through weather which would have been considered impossible a short time ago.

(iii) Lastly, loss of control while flying through clouds is being met by several methods. Gyroscopic rudder control has been tried, and further devices to give lateral and longitudinal stability are being developed.

These and other aids to navigation which are under investigation are explained in detail in Appendix B. Of outstanding interest is a very promising combination of devices which it is hoped will render flying and landing in fog a matter of reasonable safety. The following brief particulars will serve to indicate the general lines of this system.

Firstly, a method of directional wireless reception, depending upon fixed loop aerials in the aircraft, is being developed. A wireless signal is transmitted from the aerodrome and affects the receiver in the aircraft in such a manner that it enables the pilot to steer directly on to the transmitting station. Relying upon this device, the pilot will be able to leave his route in order to avoid storm, local low cloud, etc., and, as soon as he desires to do so, to fly straight to the aerodrome which is emitting the wireless signals, without having any knowledge of his actual position relative to the ground, which may be completely obscured by clouds or fog.

Next, it is hoped that by means of the Leader cable system, the pilot, on nearing the aerodrome, will be guided to a point directly over the landing ground in any degree of bad visibility.

Sunk in the landing ground, flush with the surface, will be a system of Neon lights which will indicate the best position and direction for landing. Tests of these lights have proved them to possess remarkable fog-penetrating properties. In the third stage, therefore, the pilot having been brought over the landing ground, will come into the range of these lights and with their guidance will be able to land in safety even though the surface of the aerodrome is invisible.

It needs no imagination to realise that with the perfection of such a system aircraft will be able to operate in really bad weather, and air transport will be able to run with a degree of safety and reliability equal, if not superior, to that achieved by trains and steamers.

2. Night Flying.—A parallel problem to flying in bad visibility is flying by night, the solution of which is equally essential to the full development of air transport.

The problem is largely one of navigation. By a rigorous use of an efficient compass, in fine weather, night flying presents no difficulties, but in bad weather the difficulties are considerably greater than in day flying. One feature which makes night navigation easy in fine weather is the fact that the lights of towns at a distance take on the nature of beacons. Considerable experimental work has been carried out in this country to evolve an efficient system of air lights which will serve the same purpose, while also solving the problem of locating the aerodrome and facilitating landing. An account of the work done and experience gained in this subject is given in Section 3 of Appendix B.

Lest the attention devoted to night flying should be obscured, however, it is desirable to outline briefly in this chapter the subsidiary problems introduced by bad weather at night. First among these is control of the aeroplane. This problem is precisely similar to that of control in cloud or fog by day, but it is accentuated by the fact that when there is no moon and a general lack of illumination, fog or cloud

banks are not easily visible, and the pilot enters them without warning. The importance of turning indicators and automatic controls such as the gyro rudder control and pendulum aileron control is therefore emphasised.

The second problem is that of landing both at a prepared aerodrome and in emergency. No difficulty is experienced in landing on a night with good visibility at an aerodrome equipped with efficient lights, while the problem of landing in fog at a prepared aerodrome will probably be overcome by the methods which have already been described in connection with day flying. An emergency landing in fog at night is the most serious problem, and no solution to this is in sight. The use of pyrotechnic flares on the wing tips is a satisfactory aid to landing in clear weather and in normal country, but the existence of fog at night makes it necessary entirely to eliminate forced landings—in other words, multi-engined aircraft are a necessity for regular night flying.

Night flying calls for the use of similar aids in the form of wireless communication and direction-finding to those described for day flying. In this connection, it is only necessary to say that certain directional errors are apparent in wireless bearings taken at night, and that further investigation of these errors is required.

It is fortunate that fog, the enemy of safety and reliability in air transport, is unknown in many parts of the world, and that the British Dominions and Colonies are practically free from the difficulties caused by bad visibility which have to be faced in Europe.

VII.—Development of Experimental Aircraft.

The Air Ministry has devoted considerable attention to the production of improved types of commercial aircraft as a part of its programme of experiment and research. Several machines of experimental commercial types have been built to the order of the Ministry and put into service with Imperial Airways, Ltd., in order to test them under conditions of commercial operation. In this way it is hoped that the company, in common with civil aviation enterprises throughout the Empire, will be enabled to secure the improved types of aircraft that are necessary without having to bear the heavy cost of experiment that is involved in their development.

CANADA.

In Canada, aviation has had to face requirements of a totally different order from those in other countries and air transport on fixed routes has not been one of the most important uses of aircraft. Forest fire protection and air survey, to name but two of these requirements, have demanded the first and principal attention.

Even so, there are occasionally opportunities for a regular service of aircraft to be operated with advantage. For example, on the opening up of the Rouyn mining district in north-west Quebec, a service of flying boats was run which covered in 30 minutes a stretch of country that could not be crossed in less than three days on the ground. The air service not only carried the prospectors and their kit to the field, but kept up a supply of fresh provisions.

Conditions of a similar type are found from time to time in different parts of Canada and it cannot be doubted that with more experience and increased public interest there will be many opportunities for commercial air transport both on fixed routes and in taxi service. As in the United States, the great distances separating the principal centres of Canada favour air transport, and the advantages of connecting these centres by air are immediately apparent. But for the time being, other work takes precedence.

AUSTRALIA.

1. Rapid Development of Civil Aviation.

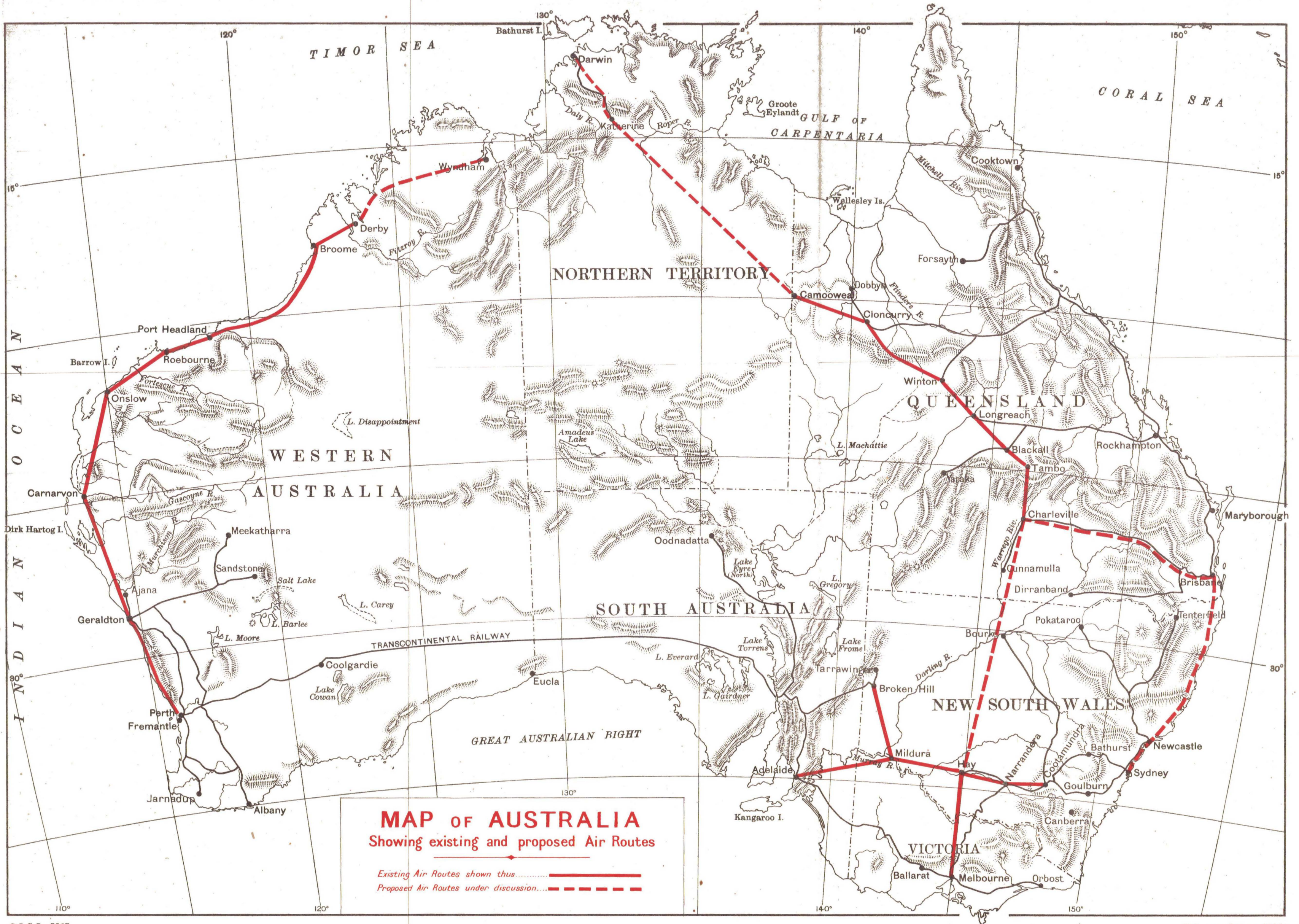
Civil aviation in Australia has been developed with remarkable rapidity and success. It was not until the end of 1920 that the Civil Aviation Branch of the Australian Ministry of Defence came into existence and began to draw up plans for the utilisation of £100,000 which had been granted for the development of civil aviation during the financial year 1920–21. The task was taken up with great enthusiasm however, and the co-operation of the Shire and Municipal authorities was enlisted. Routes were surveyed by the Air Force; aerodromes were acquired; invitations to commercial firms to tender for the operation of the services were issued; and by the end of 1921 the first Australian commercial air service—that between Geraldton and Derby—had been inaugurated. The people of Australia, particularly

those in some of the outlying parts which were to be served by the air routes, had still to be convinced that aeroplanes had uses other than those connected with warfare and that flying was not inherently dangerous and uncertain, but the successful operation of the earlier routes produced a great effect on the public mind. To-day, more so perhaps than is the case in any other country in the world, the air services in Australia are a useful and important feature of the regular transport system. By their means the delivery of mails and newspapers is accomplished in hours instead of days or days instead of weeks; and business men and others, either by utilising the regular services, by chartering a special "taxi" machine or by a combination of both methods, are able to embark on long journeys which would previously have been impossible or would have meant a great loss of valuable time.

2. Air Transport Companies and Routes Operated.

(i) *Western Australian Airways, Ltd.*—This company was formed during 1921 by Major Brearley as a result of his having been granted the contract for the operation of the Geraldton–Derby service. The service was actually inaugurated in December, 1921, but an accident caused a temporary suspension and it was not re-opened in full until April, 1922. From that date, however, the service proceeded without interruption and soon began to attract increasing patronage, with the result that an extension from Geraldton to Perth was opened in January, 1924. The extended route from Derby to Perth which is 1,442 miles long and is covered in 2½ days, as compared with the average of 13 days by the irregular service of coastal steamers, provides a rapid and comfortable means of access to the rich pastoral and metalliferous regions of the North-West and will, no doubt, play an important part in the further development of those districts. Up to the end of 1925 the company's machines had carried a total of 631,632 letters, 2,731 paying passengers and 27,027 lb. of freight and had covered a distance of 542,741 miles. The progress made by the company may be judged from the fact that 1,056 passengers were carried in 1925 as compared with 774 in 1924 while the amount of freight carried showed an increase of almost exactly 100 per cent. A further extension of the route, from Derby to Wyndham, 300 miles, has been decided upon.

(ii) *The Queensland and Northern Territory Aerial Services, Ltd. (Q.A.N.T.A.S.).*—In February, 1922, this company was granted the contract for the operation of the Charleville–Cloncurry service. During the previous 18 months the company had been operating in the districts concerned, and having flown upwards of 40,000 miles without serious accident had already partly prepared the public for the opening of a regular air service. The Charleville–Cloncurry service which was successfully inaugurated in November, 1922, was the means of linking the inland terminals of three railways running inland from ports on the Queensland coast, and after over two years of successful operation the service was extended from Cloncurry to Camooweal. This new extension not only served to connect Camooweal with the railways but also passed through the new mining district of Mount Isa, in this case reducing a journey of two to three days by car through difficult country to a three to four hours' journey by air. The total distance of 825 miles from Charleville to Camooweal is covered in 2½ days as against seven days by rail and road. Taxi work has been a special feature of the activities of "Q.A.N.T.A.S." and it was reported in May, 1925, that during the previous two and a half years 240 taxi passengers had been carried on urgent errands both to places on the main route and to many remote districts and that not once had the company failed to carry out a flight. In many cases patients have been conveyed to hospital when road travel might have proved fatal and doctors have been carried on many urgent missions as, for example, when an epidemic of typhoid fever had broken out at Mount Isa, and the Cloncurry Shire doctor was sent with his matron on three occasions to inoculate the residents. Each trip entailed an absence of only eight hours from the doctor's headquarters instead of the two or three days which would have been occupied if ordinary means of transport had been used. Similarly when owners of cattle and sheep have been threatened by heavy losses through drought they have utilised aircraft in the search for new grazing land and watering places, travelling in a few days by air journeys that would otherwise have occupied weeks. As an example of the value of aeroplane transport to isolated districts may be cited the special trip carried out primarily to convey a business man, who had already travelled from Charleville to Cloncurry by the regular service, to Brunette Downs, 451 miles west of Cloncurry by road. Brunette Downs, although situated in the centre of a large



area of good grazing country, is not even connected by telephone with any of the large towns, and was at the time entirely isolated by flooded roads. By aeroplane the whole journey from Charleville was accomplished in three days, and amongst the freight conveyed to Brunette Downs was the first mail received for over a month and a batch of Brisbane papers which were only three days old instead of the usual five to six weeks. Up to the end of 1925 the company's machines had flown 215,990 miles and had carried 45,826 letters, 2,333 paying passengers, and 22,010 lb. of freight. Nearly twice as many letters and passengers and nearly three times as much freight were carried during 1925 as in 1924.

(iii) *The Larkin Aircraft Supply Company*.—The company opened a contract service between Adelaide and Sydney, in June, 1924, but owing to the particularly good express night train service between the two capitals the traffic attracted was not considerable, and it was eventually decided to alter the route to Adelaide—Cootamundra, leaving passengers to utilise the existing railway facilities between the latter town and Sydney, and to open branch services between Broken Hill and Mildura, and between Melbourne and Hay. This new programme was brought into operation in July, 1925, the services serving to connect several important centres which previously had very poor communications with the capital cities. Broken Hill, for instance, a town of 30,000 inhabitants, was separated from Sydney by a train journey of 69 hours, whereas, by using the air service via Cootamundra and Mildura, it can be reached from Sydney in 19 hours. The total length of the system is 1,000 miles, while up to the end of 1925 the company's machines had carried 8,752 letters, 309 passengers, and 95 lb. of freight, and had flown 163,647 miles. Traffic over this company's routes has shown a considerable increase during the first part of the current year.

3. Subsidies.

The Australian Government has recognised from the beginning the necessity of assisting the development of civil aviation, and all three companies have received regular and adequate subsidies on the basis of a mileage rate for a fixed number of contract flights a year. At present the companies are working under agreements of three years' duration and the subsidy rates are the same for each company, namely, 4s. per mile in the first year, with possible reductions to 3s. 6d. and 3s. per mile in the second and third years respectively. The dates upon which these agreements came into force and the maximum annual subsidy for the individual services are as follows :—

<i>Perth—Derby</i>	.. ..	Commencing December, 1923, maximum annual subsidy, £30,000.
<i>Charleville—Camooweal</i>	..	Commencing November, 1925, maximum annual subsidy, £17,160.
<i>Adelaide—Cootamundra</i>	..	Commencing July, 1925, maximum annual subsidy, £12,022.
<i>Mildura—Broken Hill</i>	..	Commencing July, 1925, maximum annual subsidy, £7,862.
<i>Melbourne—Hay</i>	.. ..	Commencing July, 1925, maximum annual subsidy, £9,692.

4. Conclusion.

It would appear that there is a great future for civil aviation in Australia. The standard of reliability is very high, a total distance of over 1,000,000 miles has been flown in regular transport and taxi-work with only one fatal accident (that which occurred at the opening of the Geraldton—Derby service), and public confidence in the services is firmly established. Traffic is increasing steadily as the services become better known, and although the day when Australian civil aviation will be self-supporting is not yet definitely within sight, the fact that at least one company has been able to pay a dividend is encouraging. With regard to extensions of the air transport system in the near future a service between Melbourne and Launceston is now receiving consideration and a number of other services are in prospect, notably one between Brisbane and Charleville. Further steps in the expansion of Australian air transport are likely to follow as a natural outcome of the proved utility of the existing services.

SOUTH AFRICA.

1. Subsidy Offered.

Up to the present there have been no air transport services in South Africa except an experimental service operated for a short period during 1925 by the Union Air Force between Cape Town and Durban. The Government, however, have decided to subsidise air transport in its early stages and £8,000 a year has been offered for this purpose. There are several important routes over which an air transport service could operate without difficulty, but at present acceptable proposals have not been made.

2. Connection with Imperial Aeroplane Routes.

The recent flights by a Royal Air Force unit and Mr. A. J. Cobham from Cairo to the Cape have again demonstrated the fact that this route presents no insuperable obstacles to aircraft, and the establishment of a regular air service over this main highway is therefore an important factor in questions of African air transport. As a beginning of this development the experimental service being organised between Khartoum and Kisumu has special interest.

3. Route under Investigation.

The establishment of an air service in the Union upon which a foundation of experience can be built up is being closely studied. The route from Walvis Bay (S.W. Africa) to Johannesburg and Durban has been suggested as one offering very favourable possibilities for this purpose. As the European mails are at present taken by liner to Cape Town and are from there distributed by rail, there would obviously be a valuable saving of time in stopping the liner at an earlier point and distributing by air. If, therefore, the mails were landed at Walvis Bay and an air service ran from the west coast to the east coast, touching at all the principal intervening centres and reaching Johannesburg in one day's flying, a large part of this saving would be realised at comparatively small cost. The route is shown on the map on the opposite page.

At present the proposal has not attained a concrete form, but it is being carefully investigated, since it certainly appears to promise immediate and useful benefits to the Union. The following time-table has been prepared :—

	<i>Miles.</i>	<i>Arrive.</i>	<i>Depart.</i>
Walvis Bay	—	—	6.00 a.m.
Rehoboth	165	7.50 a.m.	8.20 a.m.
Matsa	310	11.45 a.m.	12.15 p.m.
Munguaban	260	3.10 p.m.	3.40 p.m.
Johannesburg	165	5.50 p.m.	6.00 p.m.
Durban	330	9.40 a.m.	—

WEST INDIES.

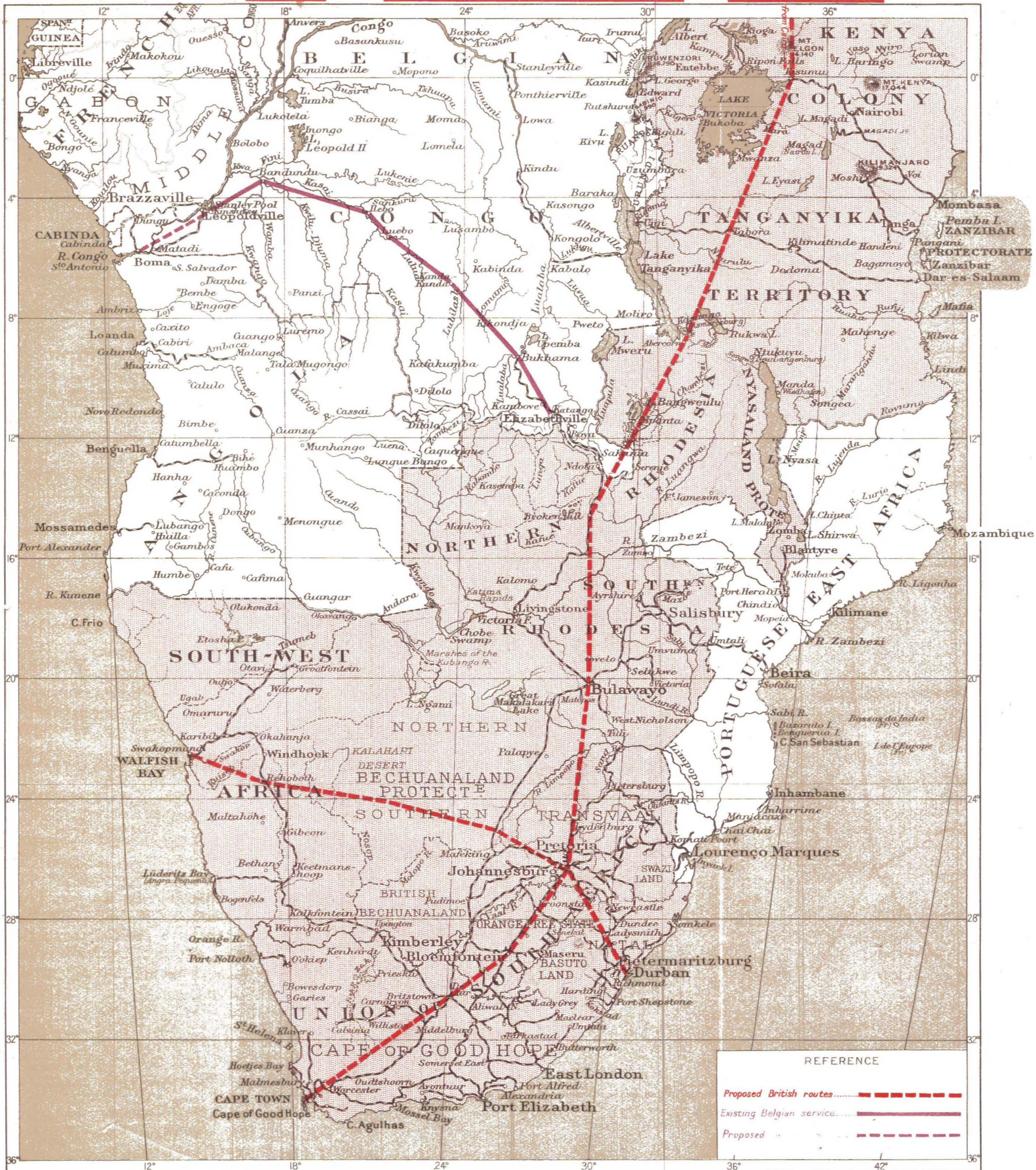
1. Favourable Conditions for Operation.

The West Indies form geographically a very favourable field for air transport. Consisting as they do of a group of islands extending over roughly 1,800 miles and separated by considerable distances, the West Indies are in a position to derive the maximum benefit from the rapid transport facilities afforded by air services, while from a technical point of view the operation of seagoing aircraft would present small difficulty.

2. Investigation by Air Ministry Committee.

In order to investigate the question a committee has been set up in the Air Ministry "to consider what opportunities exist for the operation of civil air transport in the neighbourhood of the West Indies." At the moment the report of the Committee has not reached final form. A service throughout the West Indies is recognised to be impracticable at the present stage owing to the comparatively small volume of traffic likely to be forthcoming and the necessity of a large subsidy. The Committee, therefore, considers that local services should first be established on those sections which offer the best chance of early commercial success, and when their value has been demonstrated the scope of operations should be gradually extended until they embrace the whole area.

MAP SHOWING EXISTING AND PROPOSED AEROPLANE SERVICES IN SOUTHERN AFRICA



G.S., G.S. 3814

War Office, 1926

Scale 1:16,000,000 or 1 Inch to 252.52 Miles

Miles 100 50 0 1 2 3 4 5 6 7 8 900 Miles

Kilometres 100 0 1 2 3 4 5 6 7 8 900 Kilometres

3. Routes Suggested.

The Committee considers that the following services would offer the best prospects at the present time :—

- (a) *A service in British Guiana.*
- (b) *A service from British Guiana to Trinidad.*
- (c) *A coastal service from Trinidad to Curacao and Maracaibo.*
- (d) *A service from Trinidad to Barbados.*

(a) The conditions prevailing in British Guiana suggest distinct possibilities for air transport from Georgetown into the interior, where there is a floating population of 18,000 persons employed in connection with the diamond and gold mining industries. Communications along the rivers are slow and precarious, accidents involving loss of life and freight are frequent in the rapids and whirlpools, and damage to freight through exposure is a serious risk, while during times of flood there is the possibility of disaster through an interruption of the river traffic causing a stoppage of food supplies to the men at the workings. The river journey, which at present occupies from two to three weeks, could be accomplished by air in $1\frac{1}{2}$ hours.

(b) Mails from the United Kingdom to British Guiana are forwarded to Trinidad, where they await local sailings, and are delayed for a period varying from a few hours to as much as a week. Return mails for England are similarly delayed, and crossing letters may thus lie together in Trinidad for several days. These disabilities apply also to the passenger service. The route of 350 miles from Trinidad to Georgetown could be flown in $3\frac{3}{4}$ hours and the cost of establishing an air service should be considerably less than that of improving the steamship facilities.

(c) Owing to the oil boom in Venezuela there has been a considerable increase in traffic on the route between the oil districts at Maracaibo and Curacao and Trinidad, and a service on this route would form a natural extension of the route from Georgetown to Trinidad.

(d) There is a considerable traffic between Trinidad and Barbados, and a fast air service to supplement the existing steamship service on this route should attract good loads provided the rates were reasonable. The journey could be flown in two hours. Such a service could readily be made to fit in as an extension of service (b) and might form a stepping stone to further extensions to the islands of the Windward and Leeward Groups.

II.—FRANCE.

I.—Policy.

The policy of the French Government in regard to civil aviation has seemed to be inspired by political rather than commercial aims. In the first few years of its existence commercial aviation was regarded mainly as a reserve for the military Air Service and the Government subsidies were given for machines adaptable to war uses. This resulted in the French companies maintaining fleets larger than were needed for the routes they were operating, and the machines themselves were uneconomic and uncomfortable. The French Government, however, gradually modified the subsidy conditions in order to encourage development on a more commercial basis, but the subsidy system remains a generous one, and the French air lines now serve the political purpose of providing rapid transport from France to the chief cities of her colonies and allies.

The following table shows the subsidies voted and miles flown since 1919 :—

						<i>Total Mileage Flown.</i>	<i>Subsidies Voted Frs.</i>
1919	..	..	..	..	..	166,115	2,437,250
1920	..	..	..	..	..	533,725	8,000,000
1921	..	..	..	..	..	1,470,910	31,700,000
1922	..	..	..	..	..	1,748,980	45,382,000
1923	..	..	..	..	..	2,116,997	46,922,000
1924	..	..	..	..	..	2,279,891	46,922,000
1925	..	..	..	..	..	2,945,555	57,210,000

II.—The French Aeroplane Transport System.

There are four main French air lines :—

- (1) *Paris—London.*
- (2) *Paris—Amsterdam.*
- (3) *Paris—Prague—Bucharest—Constantinople* (with a branch from Prague to Warsaw).
- (4) *Toulouse—Casablanca—Dakar* (with branches from Alicante to Oran and Algiers ; and from Perpignan to Marseilles).

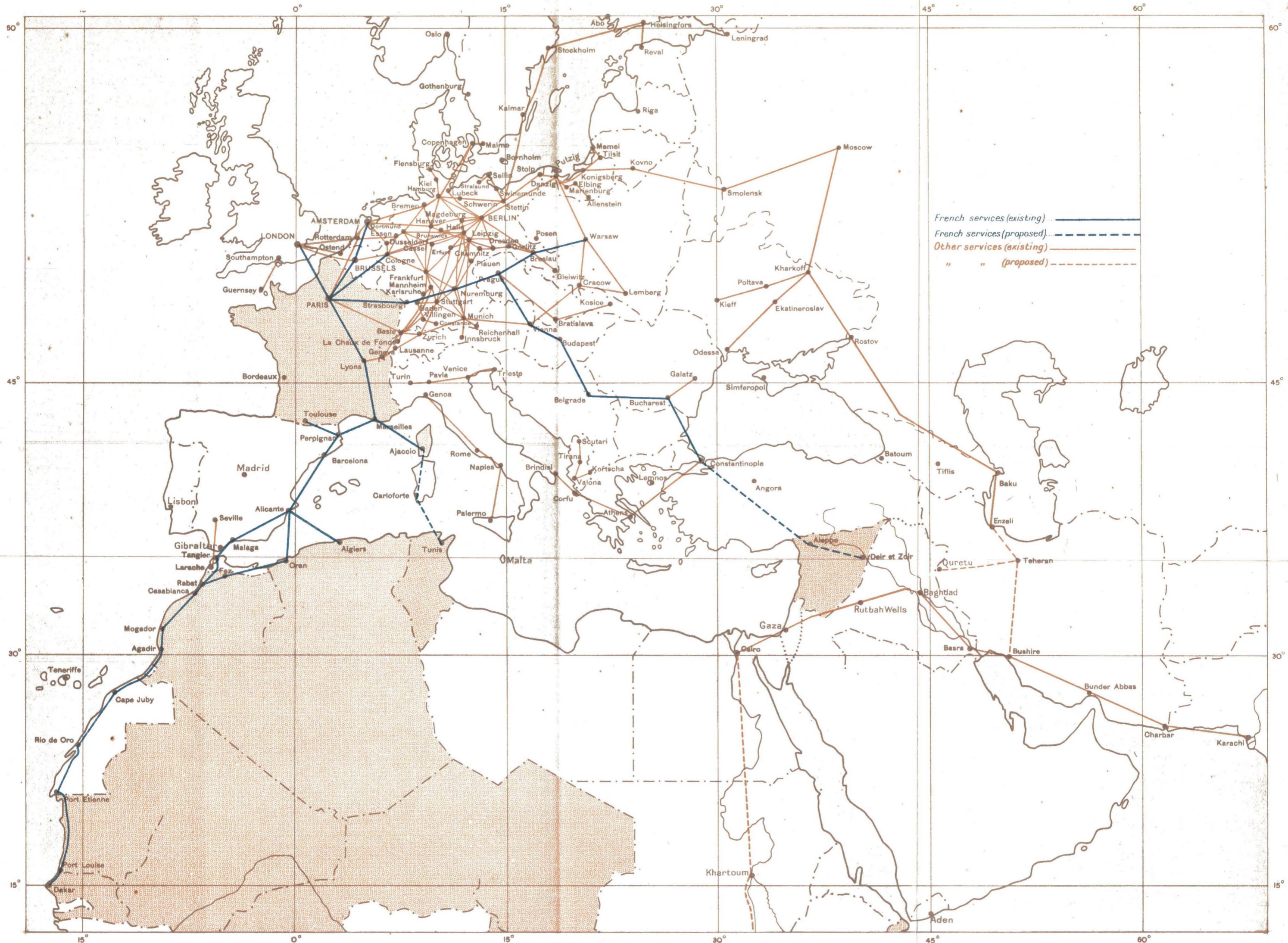
Line (3) connects Paris with the capitals of Czecho-Slovakia, Poland, Austria, Hungary, Roumania, Jugo-Slavia, and the ancient capital of Turkey. Development has been hindered until recently by the lack of agreements allowing flight over Germany and Turkey, but this difficulty no longer exists and development work will certainly be pressed forward energetically. At present it is possible to travel by this service from Paris to Constantinople in 36 hours, thus saving 2½ days on railway time, and this saving will be much greater after the adoption of night flying (which has already been tried experimentally between Belgrade and Bucharest). It is planned to extend the service from Constantinople into Syria, and perhaps on to Baghdad.

Line (4) is perhaps the most interesting and important of the French air transport systems and is the practical result of a comprehensive policy laid down in 1919. This policy aimed at the establishment of commercial air transport services—

- (a) Between France and her North African Empire.
- (b) Between the units of the North African Empire (Morocco, Algeria, and Tunisia).
- (c) Between North Africa and French Equatorial Africa.

The Latecoere Company has free use of the aerodromes established at strategic points by the Army and Navy, and received 23,210,000 francs as subsidy in 1925.

MAP SHOWING FRENCH AIR SERVICES IN 1926.



French services (existing) ————
 French services (proposed) - - - -
 Other services (existing) ————
 " " (proposed) - - - -

How great has been the increase in the load of mails carried between France and Morocco will be seen from the following table :—

1919.	Total number of letters carried	..	9,124
1920.	"	"	182,061
1921.	"	"	327,805
1922.	"	"	1,407,352
1923.	"	"	2,958,863
1924.	"	"	4,026,593
1925.	"	"	7,502,191

The system is at present composed of the following services :—

- (i) Toulouse-Casablanca (Morocco). Landplanes leave Toulouse daily at 5.30 a.m. and arrive at Casablanca, in summer, at 7 o'clock the same evening, and in winter at 10 o'clock the next morning.
- (ii) Oran-Casablanca (connecting Algeria and Morocco). This service has been regularly operated twice weekly since 1922.
- (iii) Oran-Alicante (completing the connection Toulouse-Oran). There are four seaplane services a week and at present only mails are carried.
- (iv) Algiers-Alicante seaplane service (completing the connection Toulouse-Algiers). This service is temporarily suspended.
- (v) Casablanca-Dakar (connecting Morocco and Senegal in French West Africa). Services twice a week.
- (vi) Antibes-Ajaccio seaplane service (with proposed extension to Tunis). This line is operated by the Air Union.

The French capital, through this Mediterranean system and the line Paris-Lyons-Marseilles, is therefore connected by air with Algiers, Morocco, and French West Africa. A scheme has been proposed for extending the line from Dakar to South America, using fast steamers for the crossing of the Atlantic from Dakar to the coast of Brazil, until seaplanes have been developed capable of flying over this stage.

III.—Air Services in the French Colonies.

Indo-China.—On 3rd April, 1926, a regular weekly air mail service was begun between Saigon-Kratie-Savannakhet. It is proposed to extend this service to Hanoi, when it is hoped to complete the journey from Saigon to Hanoi in 12 hours. This service has lately been suspended during the period of the monsoon.

The attempts to establish an air service in Madagascar have not yet proved successful.

Experimental air mail services have been operated in Syria with good results.

III.—GERMANY.

1. One Large Company.

German air transport, following the lead given in Great Britain, has been combined and placed in the hands of one large well-capitalised company, which is known as the Deutsche Lufthansa. This step was taken at the end of last year and was primarily the result of destructive competition between the earlier companies and the need for financial re-organisation. The subsidies paid may be divided roughly into two classes: subsidies granted by the Reich Government for main lines and subsidies found by local authorities for subsidiary lines, of which there are a great number. Reich subsidies take the form of a flat mileage rate and the local subsidies consist of a lump sum grant. The Municipalities have been generous in helping to establish aerodromes, and this system of local subsidies is a particular and important feature of German Civil Aviation.

2. Constricted Development.

The Deutsche Lufthansa has commenced its life in promising circumstances. The restrictions on German civil aviation have been raised, a keen air spirit permeates the German public, and adequate subsidies are available. In the past Germany has been handicapped by the political situation in organising long international routes, and, as the map shows, her principal route mileage at present is within Germany. The admission of Germany to the League of Nations affords a still smoother path for the advance of her air transport, and it is probable that the German lines will in a very few years assume an entirely different appearance and many local lines disappear in favour of extensions outside Germany.

3. Russia.

A plan is already being discussed for an extension of the Berlin–Moscow route eastward across Russia to the Pacific coast. Russia provides a natural outlet for German aviation enterprise, and a foundation has been laid in that country for German participation in future aeronautical developments. Russia, with her immense area, scattered population, and rich untapped resources, is in a somewhat similar position to the British Empire as regards the advantages she can gain from improved communications, but she must go outside for help.

4. German Manufacturers Abroad.

German aircraft manufacturers have for some years been very active outside Germany and have established several factories in foreign countries. Their propaganda has, in fact, at one time or another, been carried into almost every part of the world, resulting in some cases in the organisation of a semi-German air transport company or in the direct operation of air transport services.

5. Statistics.

The following tables show the money spent on Civil Aviation and the progress of German Air Transport in recent years:—

German Civil Aviation Votes.

<i>Year.</i>	<i>Gold Marks.</i>	<i>£ (approx).</i>
1924–25	10,457,500	522,875
1925–26	24,157,500	1,207,875
1926–27	26,511,500	1,297,040

MAP SHOWING GERMAN AIR SERVICES IN 1926.



- German services (existing) —————
- German services (proposed) - - - - -
- German-Russian services (existing) - · - · -
- German-Albanian services (existing) - · · - · -
- Other services (existing) ————
- " " (proposed) - - - - -

German Air Transport Statistics.

	1923.	1924.	1925.
Total number of aeroplanes ..	145	249	324
Distance covered daily in miles	6,009	9,339	21,856
No. of miles flown during the year	446,046	983,940	3,075,209
Regularity per cent. ..	84.0	84.4	89.7
<i>Passengers carried :—</i>			
Total number	8,507	13,422	55,185
Passenger miles	1,283,322	2,029,608	6,588,409
<i>Freight carried :—</i>			
Goods	39 tons	71 tons	521 tons
Mails	5 "	22 "	287 "
Total	44 "	93 "	808 "
Ton miles	5,904*	25,795	110,808

Not including mails.

The statistics of air transport are perhaps based on a less rigid system of reckoning than in other countries, and may give an exaggerated idea of the amount of air traffic in Germany, but they show fairly correctly the rapid rate of expansion during the past few years.

IV.—THE UNITED STATES.

1. A Special Policy.

Conditions in the United States are probably more favourable to the development of air transport than those in any other part of the world. The country has a good climate and is of vast area ; a great population is obtaining constant employment and a high standard of life from an active and prosperous industry ; and the minds of the people have long been accustomed to the habit of travel and the necessity of speed. The United States, in its special circumstances, did not adopt the European practice of subsidising air transport services. Instead, the Government left general commercial flying unregulated and unassisted, but decided that the Post Office should itself thoroughly test the possibilities of air transport for the rapid carriage of the mails.

2. The Development of the Air Mail.

The first experimental air mail route was begun in May, 1918, between Washington, Philadelphia and New York, a distance of about 200 miles. It soon became apparent, however, that the air mail had no great advantages for short distances, and by September, 1920, the full trans-continental route of 2,665 miles was in operation. Following some years of experiment, the practicability of night flying was regarded as proved, and in July, 1924, the through trans-continental air mail service was established, covering the route in about 32 hours as against 3 days by the fastest train. The lighted route for night flying now extends from New York City, over the Allegheny Mountains, through Chicago to Salt Lake City ; it is just over 2,000 miles long and has cost \$270 a mile to establish, while the annual maintenance expenditure is \$147 per mile.

3. The Success of the Air Mail.

Since 1918 over \$12,000,000 has been spent on this official experiment and it has been a complete success. In the year ending 30th June, 1925, a distance of 2,501,555 miles was flown (of which 696,126 miles were flown at night) ; 96 per cent. of scheduled flights were carried out ; and the revenue derived from the air mail surcharge was \$600,000. The revenue from the surcharge has now reached a rate which is expected to produce \$1,000,000 in the current year.

4. A New Policy.

The Government have now decided on a new policy which is designed to follow up the success of the Post Office experiment and which is based on the belief that further developments will be made more cheaply and more quickly by commercial enterprise. The carriage of the air mails is to be transferred to contractors, who will combine the transport of passengers and goods with the mail services. Already contracts for 12 new routes have been awarded, and others are under consideration ; while the original trans-continental route itself will be entrusted to contractors when they are considered to have gained sufficient experience. Surcharges will be levied on letters carried by air mail, but no subsidies will be paid to the companies operating the routes. The experience of the Post Office gives ground for the belief that the revenue derived from the air mails, together with that from passengers and goods, will be large enough to make the services a commercial proposition. In any case, there is at present no lack of bidders for the contracts.

5. Routes Operated.

The following routes are in actual operation :—

<i>Post Office Routes.</i>	<i>Miles.</i>
New York—San Francisco	2,680
New York—Chicago	780

MAP OF THE UNITED STATES OF AMERICA

Air Routes in the U.S.A. shown in Blue.



Post Office Air Mail Route.....
Contract Routes in operation.....
Proposed Contract Routes.....

<i>Contract Routes.</i>	<i>Miles.</i>
Boston-New York	192
Chicago-St. Louis	278
Chicago-Dallas-Fort Worth	1,000
Salt Lake City-Los Angeles	660
Elko-Pasco	437
Chicago-St. Paul-Minneapolis	377
Atlanta-Miami	550
Chicago-Detroit-Cleveland	328
Cheyenne-Pueblo	205
Washington-Philadelphia	124
Detroit-Grand Rapids	135
Juneau-Petersburg (Alaska)	115
Seattle-Victoria	84
New Orleans-Pilottown	80
	8,025

V.—SOVIET RUSSIA.

1. German Companies in Russia, 1921–1923.

The history of civil aviation in Russia really commences with the formation at the end of 1921 of the Russo-German air transport company known as the "Deruluft," part of the capital of which was provided by the Soviet Government and part by the group of German air transport companies which soon afterwards became the "Deutsche Aero-Lloyd." In 1922 the "Deruluft" opened a service between Königsberg and Moscow, which having been operated with increasing frequency and success during the past four summers, has outlived several more ambitious schemes and experiments and remains the most definite achievement as regards regular air transport in Russia.

It was the year 1923, however, which saw the commencement in Russia of a great effort to establish air transport services on a large scale. The Russians, finding that the railway services, which had never been very good, were becoming more and more inadequate as a means of traversing the enormous distances between their scattered towns, had begun to look towards aerial transport not only as a solution of the problem of ordinary transport but also as a means of extending and consolidating the influence and power of the Soviet Government, both in Russia and in neighbouring foreign countries. The Germans appeared already to have achieved considerable success in the organisation of air transport services—the Königsberg–Moscow service was, as mentioned above, actually being operated in Russian territory—and it was to Germany that the Russians turned for assistance in carrying out their own schemes.

During this year, 1923, the German Junker company, as the result of an agreement entered into with the Soviet Government, opened an aircraft factory in Moscow, founded a Russian branch of their air transport section, and commenced to carry out preliminary work with the idea of organising a large air route linking Sweden and Persia via Leningrad and Moscow, to include eventually a connection with Berlin. A service was operated for a short period over the section Moscow–Tiflis, and experimental flights were also carried out over other portions of the route.

2. The Formation of Russian Companies, 1923.

At the same time the Russians themselves did not remain idle. A body known as the "Society of the Friends of the Air Fleet," which had recently been organised, embarked on a widespread propaganda campaign with the object of arousing public interest and obtaining funds for the organisation of both a military air fleet and civil air transport companies. This society appears to have been practically a Government organisation and funds were obtained not only by more or less voluntary subscriptions from workers' and peasants' unions, and the proceeds from competitions and exhibitions, but also, it was reported, by compulsory deductions from salaries and wages. As a result of the activities of the society and partly with the assistance of the Junkers Company, three Russian air transport companies came into existence. The first and most important of these was the "Dobrolet," which was organised on the lines of the Russian Volunteer Mercantile Fleet and received considerable financial support from the Soviet Government. The other companies formed were the "Ukrvozdrukput" (Ukrainian–Crimean Air Traffic Company) and the "Zakavia" (Trans-Caucasian Air Company). None of these companies did much more than preliminary experimental and organisation work during 1923, the only attempt at a definite service being the Moscow–Nijni-Novgorod service, which was operated by the "Dobrolet" during the fair at the latter town.

Considering the efforts put forward in 1923, the progress made in 1924 was disappointing. The Königsberg–Moscow service was, of course, again operated, but the Junkers company were unable to re-open their service between Moscow–Tiflis owing to lack of passengers, and practically confined themselves to carrying out preliminary work in connection with a proposed service Baku–Enzeli–Tehran–Bushire. The following services were operated with fair regularity by the three Russian companies during the year :—

Moscow–Nijni-Novgorod–Kazan (Dobrolet).
 Tashkent–Alma Ata (Dobrolet).
 Kharkoff–Kiev, Kharkoff–Odessa (Ukrvozdrukput).
 Tiflis–Baku (Zakavia).

The Society of the Friends of the Air Fleet, however, continued its intensive propaganda during 1924, and at the beginning of November it was reported to have 15,000 branches throughout the Union with a total membership of approximately 1½ millions and to have collected 4,500,000 roubles ; while a grant of 1,000,000 roubles was made during the year by the Soviet Government for the purpose of developing the aviation industry.

3. The Development of the Russian Companies, 1925.

By 1925 the German influence in Russian aviation had dwindled considerably, especially as regards the activities of the Junkers company, whose agreement with the Soviet Government had proved unworkable for various reasons, and the Moscow-Tiflis service was, after another brief attempt to operate, forced to close down. Attempts have since been made, so far without success, to negotiate a second agreement on more satisfactory lines. The Königsberg-Moscow line was still, it is true, practically a German operated line. The use of German machines on most of the Russian air lines was continued, but numbers of German pilots were replaced by Russians, and increasing support was given to the manufacture of Russian machines and engines. During this year the "Society of the Friends of the Air Fleet" amalgamated with the "Dobrokhim" (Volunteer Chemical Society) under the title of the "Aviokhim," the membership of the combined society being reported as approximately 3,000,000, but the nominal abolition by law of the compulsory subscriptions to the society caused a check in the flow of funds. Nevertheless, the society continued to extend its influence and foreign branches were opened at Berlin, Hamburg, and Kabul, while in conjunction with the "Dobrolet" a propaganda flight to Peking by six machines was organised and was carried out during June and July, 1925. Five of the machines succeeded in reaching Peking, two subsequently going on to Shanghai and one to Tokyo. Demonstration flights within Russia were also carried out by machines belonging to the "Aviokhim."

Numerous experimental services were organised by the Russian companies during 1925, but it would appear that, apart from the Königsberg-Moscow service, the following were the only routes operated with any degree of regularity :—

- | | |
|---|----------------------|
| (1) Moscow-Kharkoff-Rostoff | } ("Ukrvozdukhput"). |
| (2) Kiev-Kharkoff | |
| (3) Kharkoff-Odessa | |
| (4) Pishpek-Alma Ata (irregular service) | } ("Dobrolet"). |
| (5) Bokhara-Khiva, later extended to Teschaus | |
| (6) Bokhara-Dushambe. | |

None of these services was scheduled to operate more than three times weekly, and it is probable that in many cases the actual frequency was very much less ; but it must not be overlooked that owing to the comparatively infrequent railway services in Russia, and the general difficulties of inter-communication between the towns, a weekly connection might in many cases be regarded as an adequate and frequent service.

4. The Present Position.

Of the extensive and ambitious programme drawn up for 1926, the first three routes mentioned below are reported as the regular air mail services at present in operation (in addition to the Königsberg-Moscow service) and it is probable that services are also being operated over the other two routes shown :—

- | | |
|---|----------------------|
| (1) Moscow - Orel - Kharkoff - Artemovsk - Rostoff - Mineralnia Vody - Enzeli | } ("Dobrolet"). |
| ("Ukrvozdukhput.") | |
| (2) Kagan (New Bokhara)-Khiva-Teschaus | |
| (3) Kagan (New Bokhara)-Termes-Dushambe | } ("Ukrvozdukhput"). |
| (4) Tzaritsin-Astrakhan-Gurier. | |
| (5) Kharkoff-Odessa | |
| (6) Kharkoff-Kiev | |

In addition to the above the "Dobrolet" has under consideration an important route, Irkutsk-Urga (Mongolia)-Peking, in connection with which a certain amount of preliminary survey work has already been carried out, and proposals to organise

services between the Aldan gold fields and the Amur railway, between Irkutsk and Yakutsk, and to the northerly fur depots. The company also proposes to undertake air photography and survey. The "Zakavia" company intended to operate a service Tiflis-Tabriz this summer, but it has not yet been reported as running.

Another important scheme which has been under consideration since the latter part of 1925 is for an extension of the Berlin-Konigsberg-Moscow route through Omsk, Irkutsk, and Vladivostock to Tokyo. The introduction of night flying on the Berlin-Konigsberg-Moscow service, which has taken place this year and which enables the journey to be completed in one day, may be regarded as a preliminary step towards the realisation of this scheme.

It will be realised that the organisation of civil aviation in Russia is intimately bound up with the needs and aspirations of the Soviet Government. When the Konigsberg-Moscow service was first opened all the seating accommodation was reserved for the use of the Government and one seat in each machine is still thus reserved. In a similar way considerable use has been made of practically all the services so far operated for the conveyance of Soviet officials and Government mail, and there is no doubt that all the companies are largely financed by the Government. Too much importance, however, should not be attached to the Soviet air services as a serious contribution towards the technical and operational development of air transport.

VI.—HOLLAND.

Holland ranks as one of the pioneers of air transport in Europe, and has in the K.L.M. (Royal Dutch Air Service Company) an organisation of outstanding efficiency and enterprise which has an excellent record of reliability and safety. Having started in May, 1920, with a service between Amsterdam and London, this company now runs an independent service from London through Rotterdam, Amsterdam, and Hamburg to Malmo and Copenhagen, with a connecting service between Amsterdam and Paris.

The K.L.M. has been subsidised from its commencement by the Netherlands Government, and has this year entered into negotiations with the Government for an extension of the subsidy period until 1934, after which the company hopes to be in a position to operate on a self-supporting basis. Holland is anxious to participate in the organisation of an air service to the East, which would provide her with a rapid connection to the Netherlands East Indies, and the K.L.M. is anxious to expand in this direction. Attempts to start operations in the East Indies have hitherto been checked by financial difficulties, but there are signs that these difficulties are becoming less formidable.

VII.—MISCELLANEOUS SERVICES.

1. European Nations.

Sweden is the most forward of the smaller European countries, and has a company known as the Aerotransport A.B., which runs in conjunction with other companies to Berlin, Paris and London. Italy has started three services this year, one from Turin to Trieste, another from Genoa to Palermo, and a third from Brindisi to Athens and Constantinople. Belgium, Poland, Denmark, Switzerland, Spain, Czechoslovakia, Hungary and Finland all have services in operation. There is a scheme for a service from Athens to Egypt, with a northerly branch to Bucharest. This has been formulated by a Greek company, and, it is understood, has been given the support of the Greek Government.

2. Belgian Congo.

The Belgian company, S.A.B.E.N.A. (Société Anonyme Belge d'Exploitation de la Navigation Aérienne), maintains a very successful aeroplane service, using machines of British type, from Kinshasa (Leopoldville) to the Katanga, in the Belgian Congo. The Katanga is brought within 3 days (instead of 45 days) of the capital, Leopoldville, and Elizabethville (Katanga) can now be reached in 23 days from Brussels, entirely by Belgian means of transport. An extension of the service to Boma, the coastal port, is in course of organisation. The Katanga was formerly served for passengers and mails mainly by the railway from Cape Town to Elizabethville, a route necessitating a wide detour to the south on the journey to and from Europe.

3. Colombia—An Unsubsidised Service.

Colombia has a population of about 6,000,000 and is the second largest coffee producing country in the world. The centres of population and production are located on high plateaux, several hundred miles from the coast. The country is divided by three long parallel mountain ranges and traffic between the plateaux is forced to follow the lines of the valleys, principally the main valley of the Magdalena River, which is the only navigable waterway in the country and the only practical traffic route for exports and imports.

The air service has been running entirely without artificial assistance since 1921. It connects the port of Barranquilla with Bogota, the capital, following the course of the Magdalena River as far as Girardot. With its branch lines this service covers 790 miles. The only other means of communication are the river itself or mulepack; and the river boats are very slow, being delayed for long periods in times of low water. Normally, the service saves from 9 to 11 days between Barranquilla and Bogota.

Encouraged by its success in Colombia, the German-Colombian company responsible for this service is endeavouring to obtain support for a service linking up the central and adjoining South American Republics with the United States. An associated company has been formed in the United States and is now engaged in interesting the other countries concerned.

This service is an example of regular air transport running under typical colonial conditions and filling a need for improved communications which could not otherwise be satisfied except at great expense. It demonstrates the fact that difficult country from a flying standpoint is, on the whole, a less serious drawback than such difficult weather as is experienced in Europe.

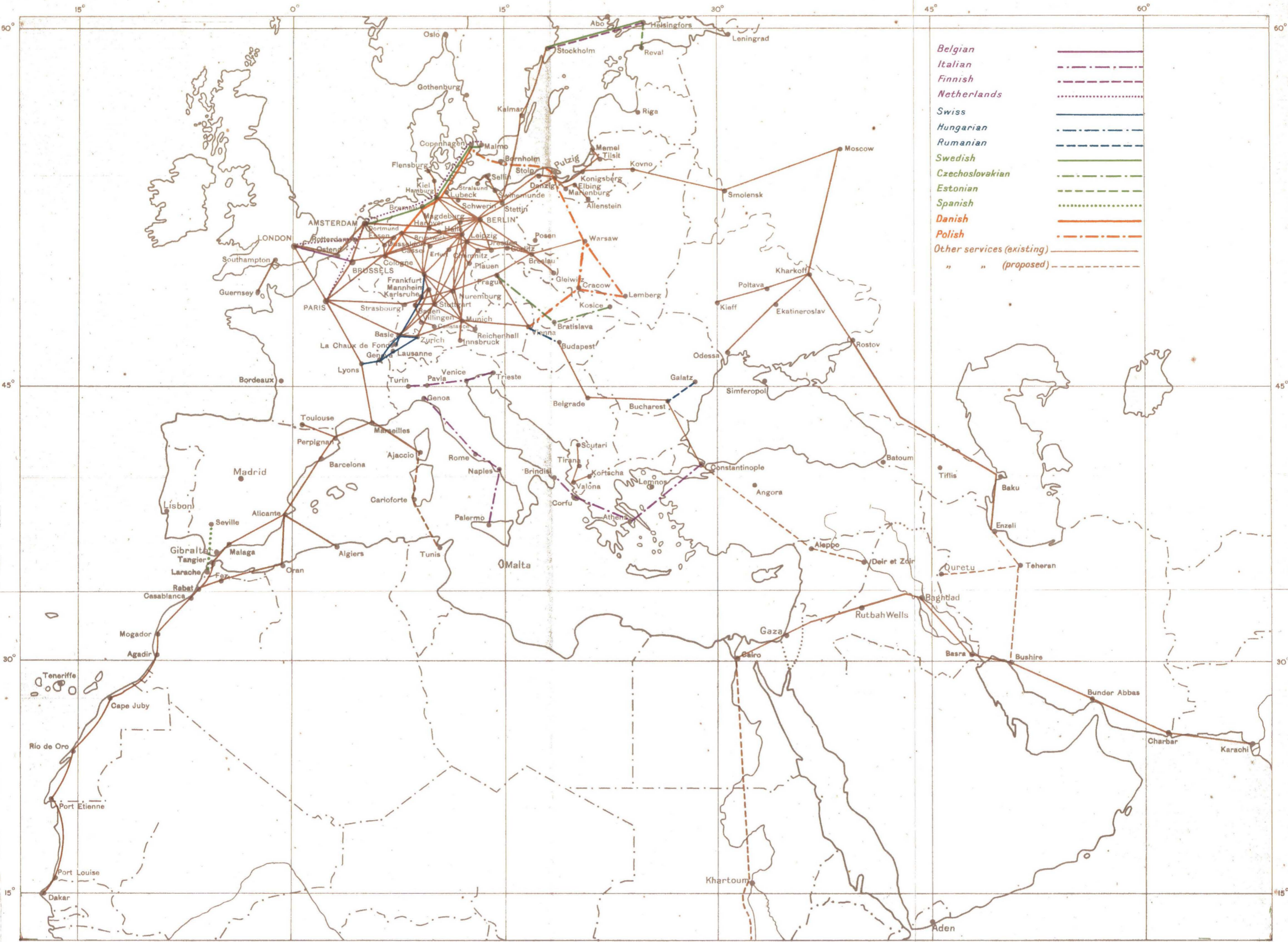
4. Bolivia.

An air transport company known as the Lloyd Aero Boliviano was formed in Bolivia towards the end of 1925 by agents of the German Junkers Company, which has supplied the machines and operating personnel for the enterprise. The company is reported to have been granted a subsidy by the Government and hopes to link all the important centres of the Republic by aeroplane routes, but the only service operated so far is one between Cochabamba and Santa Cruz.

5. Argentina.

The River Plate Aviation Company, an English firm, which commenced a daily service between Buenos Aires and Montevideo in January, 1924, and operated successfully for three months, was compelled to cease operations owing to the inadequacy of the subsidy provided by the Argentine Government.

MAP SHOWING MISCELLANEOUS AIR SERVICES IN 1926.



On the 7th January, 1925, however, a mission sent out by the German Junkers Company commenced the operation of a service between Cordoba and Villa Dolores, the journey being made three times weekly in each direction and taking 45 minutes as compared with seven hours by automobile, and this was so successful that a company known as the "Aero Lloyd Cordoba" was formed and an additional service between Cordoba and Rio Cuarto opened during May, 1925. The company, which receives a subsidy of \$7,000 per month from the Provincial Government of Cordoba, has opened a flying school and proposes to operate additional services in the near future between Cordoba and Rosario and between Cordoba and Mar Chiquita.

The Junkers Company has also operated an air mail and passenger service between Buenos Aires and Montevideo since 4th March, 1926, receiving a subsidy of \$4,000 per month from the Argentine Government and undertaking in return to carry 300 kg. of mails thrice weekly.

6. Siam.

Air transport services in Siam are carried out by units belonging to the Royal Aeronautical Service. There are at present two lines in operation :—

- (1) Korat-Roi Ech-Ubon (opened June, 1922), extended to Nong-Kai during 1924.
- (2) Korat-Roi Ech-Udorn (opened in 1924).

Goods of all descriptions, passengers and mails are carried and both routes are operated weekly in each direction, the time saved over ordinary means of transport being two to three weeks. The machines engaged in these services have covered about 150,000 miles without serious accident, and during the year 1924-25 carried 255 passengers and approximately 50 tons of mail. The machines used are of French types and the pilots are Siamese trained by French instructors.

In addition to the machines employed on the regular services six ambulance machines are kept available for conveying invalids and doctors. Doctors and vaccines are carried free and patients requiring urgent medical attention are also carried free if they cannot afford the fare.

7. Japan.

Up to the present time the development of air transport in Japan has not been very substantial, but an elaborate policy of expansion has been under consideration. The programme would take 20 years to complete, and by the end of that time Japan would possess a comprehensive system of airways, covering 15,692 kilometres.

In the financial year 1926-27 a sum of yen 371,800 has been allotted for bounties to encourage civil aviation, this being an increase of yen 100,000 over the previous year. Bounties are provided in the current year for the operation of the following services :—

<i>Company.</i>	<i>Service.</i>
Tosai Teiki Koku Kai . .	Tokyo-Osaka, about three return flights per week. Tokyo-Sendai, about one return flight per week.
Nippon Koku Kabushiki Kaisha.	Osaka-Fukuoka, about three return flights per week. Osaka-Dairen, about six trial flights during the year.
Nippon Koku Yuso Ken- kyujo.	Sakai-Oita, about three return flights per week.

APPENDIX B.

THE REGULATION AND ADMINISTRATION OF CIVIL AVIATION.

Historical and International.

1. Before the war, civil aviation, in an organised form, did not exist. From time to time attempts were made to draw up regulations for the control of air traffic on an internationally acceptable basis, as, for instance, by the abortive Conference held in Paris in 1910 and by the Institute of International Law in 1911, which adopted rules for the marking and registration of aircraft. As regards British legislation, the Orders made under the Aerial Navigation Acts of 1911 and 1913 limited the landing areas for aircraft from abroad to eight small areas on the coast. The Home Office required notice of the proposed place of landing of aeroplanes, the approximate time of arrival, and the name and nationality of the person in charge. The carriage of dutiable goods or mails by aircraft was forbidden. Responsibility for safety measures and the certification of air pilots devolved upon the Royal Aero Club.

2. As a result of the impetus given to aviation by the war, the potential value of aircraft for commercial transport was appreciated, and in 1917 a Civil Aerial Transport Committee was appointed to consider the subject from its international and national aspects. This paved the way for the Committee which came into being immediately after the Armistice and whose labours resulted in the Act of 1919 and the Air Navigation Regulations, 1919, issued on the 30th April, provisionally regulating civil flying in the British Islands. Post-war civil aviation commenced officially on 1st May, 1919.

International Air Convention.

3. Meanwhile, the Convention for the Regulation of Aerial Navigation was drafted at the Peace Conference and signed on 13th October, 1919. This Convention recognises the exclusive sovereignty of each State over the air space above its own territory, and provides, *inter alia*, for freedom of innocent passage, except over prohibited areas, by the civil aircraft of other contracting States; the registration of aircraft; the reciprocal recognition of certificates of airworthiness and competency, and of licences; the establishment of "customs aerodromes," and the setting up of a permanent International Commission for Air Navigation. It contains Annexes dealing with the marking of aircraft, certificates of airworthiness, log books, lights and signals, rules of the air, pilots' and navigators' certificates, maps and ground markings, meteorology, and customs.

4. The Convention came into force on 11th July, 1922, and the following States are at present parties to it:—

Belgium.	Greece.
Great Britain and Northern Ireland.	Italy.
Canada.	Japan.
Australia.	Persia.
Union of South Africa.	Poland.
New Zealand.	Portugal.
Irish Free State.	Roumania.
India.	Kingdom of the Serbs, Croats and Slovenes.
Bulgaria.	Siam.
Chile.	Uruguay.
Czechoslovakia.	
France.	

5. Under the terms of the Convention the International Commission for Air Navigation, comprising representatives of each contracting State, was set up as from the same date, 11th July, 1922, to consider technical questions arising in the application of the Convention, generally to co-ordinate the operation of its provisions, including the amendment of its technical Annexes as necessity arises, and the collection and dissemination of aeronautical information. This Commission now meets regularly twice a year and has appointed six Sub-Commissions to deal with the various phases of the subject. The offices of the Commission are at 20, Avenue Kléber, Paris (XVI^e).

Agreements with Foreign Governments.

6. Provisional Agreements, the terms of which are in harmony with the Convention, have been negotiated by Great Britain and Northern Ireland with the following countries which are not yet parties to the Convention :—

Denmark.	Norway.	Switzerland.
Holland.	Sweden.	

7. Flights by British aircraft to or over the territory of States other than those mentioned in paragraphs 4 and 6 above are in general subject to special arrangements being made beforehand.

In the case of Germany, negotiations for a mutual air traffic agreement have been in active progress for some time and will, it is hoped, soon be concluded. In the meantime, British air services to Berlin and Cologne, and German services to London, are operated under special and temporary authorisations. Other flights to either State require to be individually authorised.

Air Navigation Act, 1920.

8. Civil aviation in Great Britain and Northern Ireland is to-day regulated by the provisions of the Air Navigation Act, 1920, and Orders in Council made thereunder. This Act replaced the Acts of 1911 to 1919, and its purpose is to bring British air legislation into conformity with the requirements of the Convention and the development of civil air traffic. It provides, *inter alia*, for additional safety regulations, the prevention of flying over prohibited areas, the compulsory investigation of accidents, penalties for dangerous flying, the application to aircraft of the law of wreck and salvage, etc., and delimits trespass, nuisance, and responsibility for damage caused by aircraft.

Air Navigation Orders.

9. The detailed regulations governing civil aviation in Great Britain and Northern Ireland are contained in the Air Navigation (Consolidation) Order, 1923, as amended by the Air Navigation (Amendment) Order, 1925. These Orders are applicable to British aircraft registered in Great Britain and Northern Ireland wherever such aircraft may be, as well as to aircraft, British and foreign, when in or over Great Britain and Northern Ireland. The discussions which are now proceeding with regard to the relaxation in certain respects of the existing regulations governing private flying in so far as certificates of airworthiness, licences of pilots, and carriage of log books are concerned, will necessitate consequential amendments of these Orders.

Air Navigation Directions.

10. For the purpose of supplementing or giving full effect to the provisions of the Air Navigation Orders or for other specific purposes, the Secretary of State has issued certain directions under the powers conferred on him by the Orders. The following directions are at present in force :—

- (a) The Air Navigation Directions, 1922 (A.N.D.3), as amended subsequently by the Air Navigation Directions, 1923, 1924 and 1925 (A.N.D.3A–3F). These deal with a variety of requirements of too detailed a character for inclusion in the Orders, such as the conditions for the issue of licences and certificates, the rules as to instruments, and the use of log books.
- (b) The Air Navigation Directions, 1922 (A.N.D.4), 1923 (A.N.D.4A) and 1924 (A.N.D.4B), regarding the aerodromes approved as customs aerodromes.
- (c) The Air Navigation Directions, 1923 (A.N.D.5), containing the special rules to be observed by aircraft in landing and taking-off at Croydon and Lympe Aerodromes.

The foregoing directions will shortly be amended in consequence of impending amendments of the Order and will be replaced in a consolidated form by the Air Navigation Directions, 1926 (A.N.D.6), which are now in draft.

Miscellaneous Orders, etc.

11. An Order in Council dealing with the application to aircraft of the law relating to wreck and salvage and to the duty of rendering assistance to vessels in distress, was made under the 1920 Act on the 10th August, 1921 (S.R. and O., 1921, No. 1286).

12. The Air Navigation (Investigation of Accidents) Regulations, 1922 and 1925 (S.R. and O., 1922, No. 650, and 1925, No. 1099), have been made under Section 12 of the Act.

13. Certain provisions of the Air Navigation Act, 1920, were under Section 4 of the Act extended to British Colonies and Protectorates by the Air Navigation (Colonies and Protectorates) Order in Council, 1922 (S.R. and O., 1922, No. 121).

The draft of a further Order is now under consideration to provide for the detailed regulation of civil aviation in the Colonies in conformity with the International Air Convention.

Administration.

14. The following paragraphs explain briefly the administration of civil aviation by the Air Ministry, with particular reference to the method of administering the regulations governing the registration and certification of aircraft and the licensing of personnel and aerodromes.

Responsible Authority.

15. The Air Council, established in 1918, under Section 8 of the Air Force (Constitution) Act, 1917, is the responsible authority for aviation in Great Britain and Northern Ireland. At the head of the Air Council is the Secretary of State for Air. The purposes of the Air Council, which in the first place were confined to the administration of matters relating to the Royal Air Force and to the defence of the realm by air, were by Section 2 of the Air Navigation Act, 1919 (afterwards replaced by Section 6 of the Air Navigation Act, 1920), extended to include all matters connected with air navigation. The Under Secretary of State for Air is the member of the Air Council responsible to the Secretary of State for civil aviation matters.

Department of Civil Aviation.

16. In February, 1919, a Department of Civil Aviation was formed, the head of which, now called the Director of Civil Aviation, is charged with the administration of civil flying and the consideration of all questions relating to civil aviation development.

17. The functions of the Directorate include the administration of the provisions of the Air Navigation Act, 1920, and of the Orders and Directions issued thereunder; representation on the International Commission for Air Navigation and consideration of all matters connected with the Convention and international civil aviation; organisation of civil air routes and administration of schemes of Government assistance for their operation; administration of the scheme of Government assistance to Light Aeroplane Clubs; the licensing of air stations; the registration and certification of civil aircraft; the licensing of pilots and technical personnel employed in civil aviation; the collection and dissemination of aeronautical information; the investigation of aircraft accidents; and the promotion of both the transport and constructional sides of civil aviation.

18. The Directorate is not entirely self-contained, and its services are supplemented by those of the other branches of the Air Ministry when their particular functions are concerned. In particular, it is assisted by the Directorates of Technical Development, Research, and Aeronautical Inspection in regard to the certification and inspection of aircraft and technical personnel, by the Signals Branch in regard to wireless and other forms of communication, and by the Meteorological Office in regard to weather reports and forecasts for the air routes. In matters of technical research, the Directorate is represented on the Air Transport Sub-Committee of the Aeronautical Research Committee; the latter carries out scientific investigations at the National Physical Laboratory, Teddington, Middlesex, and at the Royal Aircraft Establishment, South Farnborough.

Registration of Aircraft.

19. An aircraft may not fly (except under certain definite restrictions for the purpose of experiment or test, or except in accordance with directions or special permission of the Secretary of State in writing) unless it possesses a certificate of registration. Only British-owned aircraft can be registered in Great Britain and Northern Ireland, and an aircraft which has been registered in another State cannot receive British registration, until the foreign registration has been annulled.

20. Upon registration, an aircraft is allotted a registration mark, as laid down in the International Air Convention. Any change in ownership, or the destruction or permanent withdrawal from use of a registered aircraft must be notified to the Air Ministry. A certificate lapses on change of ownership, but the new certificate shows the aircraft under the original registration mark.

Certificates of Airworthiness.

21. No aircraft (with the exceptions mentioned in paragraph 19 above) may fly unless it has received a certificate of airworthiness. In order to obtain this certificate, which is normally valid for 12 months, the aircraft must comply with the following requirements :—

- (a) Its design, including the design of its components, must be approved as satisfying the requirements of safety as regards strength, stability, etc. ; in regard to strength it must comply with the standards laid down by the Load Factors Sub-Committee and published in the " Reports and Memoranda of the Aeronautical Research Committee, No. 776." (H.M. Stationery Office, price 3d. net.) An engine of new type or new construction is tested in accordance with the " Schedule of Standard Type and Production Tests for Aircraft Engines, Appendix B," which is obtainable, price 3d., from H.M. Stationery Office.
- (b) It must be constructed of approved materials and by workmanship of approved quality. An index to standard specifications of materials is obtainable from the British Engineering Standards Association, 28, Victoria Street, London, S.W.1.
- (c) It must have provision for its equipment with such instruments as may be prescribed by the Air Ministry.

22. If an application for a certificate is in respect of a " type " aircraft (*i.e.*, a new design), drawings and other particulars must be furnished to the Director of Technical Development for checking in detail the safety of the aircraft. Inspection of the workmanship and materials of the aircraft is carried out by the representatives of the Aeronautical Inspection Directorate, but the inspection of all details and components is usually effected by the constructor, subject, however, to final official inspection and approval of each component. Upon completion of construction, flying trials are made, first by the constructor's pilot in the presence of official witnesses, and, secondly, by a pilot representing the Director of Technical Development. When these trials have been satisfactorily completed and any modifications considered necessary for safety have been carried out, the certificate of airworthiness is issued.

23. In the case of a " subsequent " aircraft, the conditions to be fulfilled are that the aircraft conforms in all essential respects with a " type " aircraft, for which a certificate of airworthiness has been issued, that the requirements as to inspection are complied with, and that the aircraft is fitted with the prescribed instruments. Provided that the constructor has set up a competent inspecting staff, he may carry out the entire inspection of a " subsequent " aircraft, but an official test of his inspection may be made.

24. A modification of this procedure in so far as small aircraft are concerned is contemplated. It is proposed that the Air Ministry should issue in respect of both type and subsequent aircraft a Certificate of Airworthiness valid both in this country and abroad, on receipt of a certificate from an approved constructor stating that the aircraft has been built by him in accordance with the inspection requirements set forth in the Air Navigation Directions and conforms in all particulars with the minimum requirements as regards design and performance.

Periodical Inspection and Overhaul of Aircraft.

25. It is provided that—

All Aircraft :—

- (i) Before commencing any flight the pilot must satisfy himself that the aircraft and the instruments and equipment are fit for flight in accordance with the conditions laid down.
- (ii) Periodical inspection and overhaul of the aircraft must be carried out and certified by a licensed ground engineer. This requirement will not apply under the modified procedure referred to above to aircraft used for private purposes only.

Flying Machines Carrying Passengers or Goods for Hire or Reward :—

Before commencing any flight the pilot must sign a certificate that he is satisfied that the aircraft and the instruments and equipment are fit for flight in accordance with the conditions laid down.

- (ii) A flying machine employed on a regular air service or plying for hire other than under private charter may not fly unless it has within 24 hours of its last inspection been inspected and certified as safe for flight by a ground engineer, nor, if in the course of a flight it should land owing to a serious defect, until it has again been similarly inspected and certified. A privately chartered machine may not fly unless within the 24 hours next before it has left its ordinary station of operations it has been similarly inspected and certified as safe for flight.

Licensing of Pilots (Flying Machines).

26. All pilots of flying machines must be licensed in either one of two categories :—

Class A.—Private Pilot's Licence (valid for 12 months).

Class B.—Pilot's Licence for flying machines carrying passengers or goods for hire or reward (valid for 6 months or up to 250 hours' flying, whichever is the shorter).

27. The tests and examination for the Class A licence include practical tests in flying and a technical examination in knowledge of the rules of the air, rules as to lights and signals, international air legislation, etc. A certificate of medical fitness is also required. The practical tests may be dispensed with in the case of those qualified as Royal Air Force pilots, and both the practical tests and the examination may be waived for those holding the Royal Aero Club's certificate, issued on or after the 1st February, 1920.

28. To obtain a Class B licence, applicants must (i) pass a preliminary and a special medical examination ; (ii) undergo practical tests in flying unless qualified as a R.A.F. pilot ; (iii) submit proof of recent reasonable flying experience (*i.e.*, within not more than six months) on the class of machine for which a licence is required, or failing such proof, undergo practical tests on that machine ; (iv) pass a technical examination (*a*) in aircraft, aero-engines and instruments, unless qualified as a R.A.F. pilot, (*b*) in navigation, rules of the air, rules as to lights and signals, international air legislation, etc., and (*c*) in elementary meteorology.*

29. Medical re-examination is necessary before the renewal of a licence. It is proposed to waive this in the case of Class A pilots.

Licensing of Aircraft Navigators.

30. A licensed navigator must be carried on board passenger aircraft when carrying more than 10 passengers on a continuous flight between places more than 310 miles apart over land, or a night flight, or a flight between places more than 124 miles apart over sea.

31. There are two classes of navigators. Candidates will be required to produce proofs of competency by examination or otherwise in the subjects specified for the respective classes. In addition, in the case of an applicant for a second class licence, proof will be required of at least 50 hours' flight as a member of the operating crew of an aircraft ; and, in the case of an applicant for a first class licence, proof of at least 200 hours' flight as a member of the operating crew of an aircraft, including at least 100 hours' experience as a navigator and 15 hours' experience in night flying.

32. The requirements regarding the carriage of a navigator will, as from 1st January, 1928, be amended to conform with a recent decision of the International Commission for Air Navigation, which requires (i) a second class navigator to be on board every flying machine used for public transport and having to make a continuous flight of more than 100 miles over inhabited regions, or of more than 100 miles, but not more than 300 miles entirely over the high seas or uninhabited regions, or of more than 15 miles, but not more than 300 miles by night ; and on every airship of less than 700,000 cubic feet capacity, for every journey or flight ; (ii) a first class navigator to

* The syllabus of the examination in navigation, etc., is given in Notice to Airmen, No. 13, of 1921, and of the examination in elementary meteorology in Notice to Airmen, No. 55, of 1921.

be on board every flying machine used for public transport and having to make a continuous flight of more than 300 miles either entirely over the high seas or uninhabited regions or by night ; and on every airship of 700,000 cubic feet capacity or more, for every journey or flight.

Licensing of Ground Engineers.

33. A ground engineer may be licensed for a period of 12 months in one or more of the following classes : (A) inspection of aircraft before flight ; (B) inspection of aircraft after overhaul ; (C) inspection of aero-engines before flight ; (D) inspection of aero-engines after overhaul. In each case his licence may be restricted to one or more types of aircraft or engines. Examinations of applicants for licences are held periodically at the Air Ministry, London, and at the large provincial towns. Candidates can obtain a syllabus of the examination for each category on application to the Secretary, Air Ministry. For renewal of a licence the holder must submit proof that he has been engaged on aircraft work during the year, and also that he has received a complete set of Air Ministry Notices to Ground Engineers. He may be required to undergo re-examination.

Licensing of Aerodromes.

34. A place used regularly for landing or departure of aircraft carrying passengers for hire or reward must be licensed for this purpose. Aerodromes may be licensed for a period not exceeding 12 months, either (a) for use only by the licensee and by individuals specifically authorised by him, or (b) for public use. The licence may cover all types of aircraft or certain specified types. Applications for aerodrome licences must be accompanied by a 6-inch ordnance survey map showing the proposed site. Applications should be made at least 14 days in advance of the date upon which the licence is required.

35. In every aerodrome licensed in category (b) there must be a single tariff of charges on a scale approved by the Air Ministry, which must be applicable alike to British and foreign aircraft.

Fees for Certificates, Licences, etc.

36. The fee payable for the issue or renewal of a certificate or licence must be forwarded when application is made. Should the services represented by the fee not be carried out, the sum, or an appropriate proportion of it, will be refunded. The schedule of fees is contained in Schedule VI of the Air Navigation (Consolidation) Order, 1923.

Log Books.

37. Log books must be kept for all aircraft registered in Great Britain and Northern Ireland, and by all licensed pilots. The journey log book, to be kept for every aircraft, is issued by the Air Ministry at the price of 4s. Other log books must conform in all essentials with the authorised patterns, which are obtainable from H.M. Stationery Office, or through any bookseller. It is proposed to waive the requirement to carry a journey log book in the case of aircraft only used for private flying purposes within the limits of Great Britain and Northern Ireland.

Accidents.

38. The accident regulations apply to accidents arising out of or in the course of air navigation which occur in or over Great Britain and Northern Ireland, or which occur elsewhere to British aircraft registered in Great Britain and Northern Ireland ; they confer powers on the Air Ministry to investigate such accidents and provide for the compulsory notification of certain classes of accidents. The responsibility for such notification rests on the pilot, or, if the pilot is incapacitated by injury, on the owner or hirer of the aircraft.

39. If the accident occurs in or over Great Britain and Northern Ireland, notice must be given—

- (a) To the Air Ministry, by telegram, within 24 hours.
- (b) To the local police.

If the accident occurs elsewhere than in or over Great Britain and Northern Ireland, notice must be sent in writing to the Air Ministry.

APPENDIX C.

Aeroplane Transport Operating Costs.

It is naturally most important that some fairly close estimate regarding the cost of traffic by air should be arrived at as soon as possible. At the present state of development, however, it is difficult to give reliable figures. In England in the years following the war four small companies were operating in competition, each with different methods and different equipment; and during this period reliable financial data could not be obtained. Imperial Airways, Ltd., have now been operating for 2½ years and they are now reaching a position when reliable estimates can be made.

The annual charges of an air transport company fall into two classes: (1) Standing charges, and (2) Running charges. All charges and costs which are independent of the number of hours flown and remain the same whether a large or a small amount of flying takes place are treated as standing charges; and those costs which directly depend on the amount of flying done are treated as running costs. The main expenses of air transport can conveniently be shown by the following items under the two headings.

ANNUAL EXPENDITURE.

(1) Standing Charges.

- (a) Insurance of—
 - (i) aircraft and engines complete,
 - (ii) spare engines,
 - (iii) equipment,
 - (iv) buildings, plant, etc.,
 - (v) motor transport,
 - (vi) personnel.
- (b) Depreciation of—
 - (i) equipment,
 - (ii) buildings, plant, etc.,
 - (iii) motor transport.
- (c) Obsolescence of aircraft and engines.
- (d) Rents, rates and taxes.
- (e) Housing fees.
- (f) Office expenses, postage, telegram and telephone charges.
- (g) Lighting and power.
- (h) Cartage, travelling and salvage charges.
- (i) Advertisement.
- (j) Directors' fees and legal expenses.
- (k) Salaries and wages.
- (l) Sundry trading expenses.
- (m) Interest on capital.

(2) Running Charges.

- (a) Petrol and oil.
- (b) Maintenance of aircraft and engines.
- (c) Maintenance and running of motor transport.
- (d) Pilots' and mechanics' flying pay.
- (e) Wireless charges.
- (f) Landing fees.

In any air transport service, in order to approach commercial success, the revenue earned from the carriage of passengers and goods should substantially cover the running charges. It is obvious that, having earned a gross profit on these running charges, provided that a sufficiently large number of flights can be made, the accumulation of these gross profits will eventually cover the standing charges. Already it has proved possible for modern multi-engined aircraft to cover their running costs on certain routes where a high rate of revenue is earned.

With the defective data available, a very rough estimate has been made that in the past air transport has operated at 85 m.p.h. over stages of 300 miles at a running cost of 3s. a ton-mile, plus standing charges of 2s. a ton-mile. Every effort has been made by the Air Ministry and by Imperial Airways, Ltd., to reduce these figures by the development of new aircraft specially suited for commercial work, and by increased efficiency of organisation.

The following statement shows the extent to which success has rewarded these efforts:—

	Running cost per ton mile.	
	s.	d.
Single-engined type of machine, built and put into service 1922	4	2
Twin-engined machine, constructed and put into service 1922	3	2½
Twin-engined machine, constructed and put into service 1926	2	10
Three-engined machine, constructed and put into service 1926	1	10

Steady progress towards economical operation has been made along several lines.

Under the head of standing charges, one of the most important items is that of insurance. In the early days of air transport premiums as high as 30 per cent. per annum were charged; to-day, with the latest type of 3-engined aircraft, a rate of 7½ per cent. may be obtained.

Obsolescence, on the other hand, is a very serious item and cannot be reduced in the near future. Technical progress is so rapid that constant improvements in design and construction will demand the rapid replacement of any existing fleet. The ideal for an air transport company to follow is so to expand its activities that it can use its obsolescent aircraft on new routes and replace them by the latest modern types on the more well-established services.

Under running charges, past experience has given the following percentages of distribution:—

Fuel and oil	30 per cent.
Maintenance and overhaul of engines	44 per cent.
Maintenance and overhaul of aircraft	20 per cent.
Miscellaneous	6 per cent.
	—
	100 per cent.

Here, the three large items are susceptible of considerable improvement. In certain experimental engines greater horse-power is being obtained for the same rate of consumption of fuel. Beyond this, there is practically no doubt that in the next few years satisfactory aviation engines burning heavy oil will be produced. These will be used first for airships, and eventually will reach a weight suitable for their use in aeroplanes. The saving in expenditure on fuel will then be very large.

The maintenance and overhaul of engines have been the biggest item in the past, but considerable progress has already been made towards eliminating a large proportion of these costs. The introduction of the air-cooled engine has lowered the capital costs, and eliminated all water troubles, which are always an expensive item. Improved design and material are reducing the cost of small repairs and replacements enormously; and hours of running before overhaul have on the average risen from about 150 to nearly 300.

Progress is also being made in the maintenance of aircraft. Metal aircraft are coming into production and, although at present their capital cost is high, it is anticipated that the cost of their maintenance will be very much lower.

Another line of progress towards economy is the increase of revenue for a fixed rate of running cost. Obviously, the volume of traffic is the first factor on this side of the problem, but improvements in design will also make it possible to carry a greater proportion of paying load in an aircraft of given weight and cost. The introduction of the air-cooled engine has resulted in a marked saving in total weight.

It seems clear that a considerable reduction in cost per ton-mile is possible in the near future, and it has been estimated that during the next ten years it should be possible to achieve a total cost of less than half-a-crown a ton-mile flying at 100 m.p.h.

The development of larger aircraft promises a still greater saving in the more distant future, when it seems possible that really big flying boats of several thousand horse-power may prove to be cheaper than large land-planes.

APPENDIX D.

SECTION 1.

AIR NAVIGATION AND ITS AUXILIARIES.

The safe navigation of aircraft is a task which needs the co-operation of a number of auxiliary services.

The foundations of any system of navigation are the map and the compass. The map decides the direction, the compass maintains it. A word with regard to the development of these two is therefore necessary.

Though attempts have been made to produce special aeronautical maps, they have not been attended with a great measure of success, and in European air transport the ordinary topographical maps of the various countries are still in use. The International Convention lays down the outline of a system of large and small scale international aeronautical maps. The only serious contribution to this scheme has been provided by Great Britain, who has produced seven general sheets—Britain, Balkans, Iraq, Egypt, Kordofan, Yemen and Oman—as well as a number of experimental large scale sheets. Experience has shown that the scale laid down in the Convention for the general maps is too small for use in aeroplanes, but for the longer journeys undertaken by airships, these maps will have considerable value. Work has now been suspended pending the agreement of other countries to produce their share.

A great deal of development work in aircraft compasses has taken place in Great Britain since the later days of the war. The production of the aperiodic magnetic system has vastly improved the performance of compasses in aeroplanes and led to the abandonment of all other types. In air transport, the type 6/18, or its successor the P2, is almost universally used, with complete satisfaction.

If the aeroplane were subject to no disturbing forces other than its own motive power, the problem of navigation would be solved by the map and compass. The mariner, however, has currents to contend with and the airman has wind. While he remains in sight of the ground he can still solve the problem with practically no other instruments or aids than compass and map. When, however, fog or low cloud intervenes and obscures the ground, the real problem of air navigation begins, and the necessity arises for some auxiliary means of fixing position, for liaison with the ground and generally for the use of auxiliary services.

A point of some importance in connection with the flying of the aeroplane deserves notice before passing to wireless and other ground organisation. The magnetic compass is only true so long as the magnet system remains in a horizontal plane. When flying in a cloud the pilot finds difficulty in maintaining his machine on a level keel, since he lacks the reference marks usually provided by the horizon. In consequence, his compass begins to turn and he is totally unable to maintain the machine on its course—in fact the movement sometimes reaches the point where the machine becomes out of control. This danger has restricted flying both through cloud and fog. The development of turn indicators, however, has completely altered the position, and it is now perfectly safe to fly for long periods without seeing sky or ground. The instrument which is chiefly in use in British air transport is the Reid Turn Indicator, a gyro controlled instrument combining in itself an air speed indicator, turn indicator, and lateral tilt indicator.

This development is of considerable significance, because it means that the first step has been taken in making it possible to fly in the comparatively comfortable strata above the clouds instead of at a low height beneath them.

The second step towards which much progress has already been made is a means of fixing position, in or above clouds or fog. It may be said at once that for normal air transport by aeroplane, the sextant as an aid to navigation may be completely discarded. Its results are subject to such errors and take so long to obtain that it can only be considered for long flights of 400 miles or more where other aids are not available.

Air transport looks to direction finding wireless (radiogoniometry) for the assistance which it needs in over-cloud navigation. In this it is in some respects

following recent developments in sea navigation in foggy areas such as the Newfoundland banks, though the actual routine and speed of working necessarily differ somewhat.

Briefly, there are three systems of using radio frequencies for direction and position finding :—

- (1) Direction finding ground stations, working on transmissions from aircraft, and retransmitting positions or bearings to the aircraft.
- (2) Direction finding apparatus in the aircraft, working on any ground W/T stations, or preferably on special beacon stations.
- (3) Directional transmission.*

The first system has been in operation on the London-Continental air route for some years. Stations of the Marconi-Bellini-Tosi type are established on the aerodromes at Croydon and Lympne, and at the airship station at Pulham in Norfolk. These stations, apart from being situated on the two customs aerodromes, so that homing bearings may be given to aircraft requiring them, are so placed as to give bearings which cut at a good angle over a large part of the country it is necessary to cover.

An aeroplane coming in from Paris, say, and finding the Channel covered with fog, calls up by radio-telephony the control station at Croydon and asks for a position. The two stations at Lympne and Pulham listen "out," and when the pilot transmits at Croydon's request, all three stations take bearings. Croydon collects all the bearings and plots them on a specially prepared and mounted chart and then transmits the result to the pilot.

Experience shows that positions so given may be relied on within 2 miles and can be given within one minute. This system has been of incalculable value and on many occasions has been the means of bringing machines safely to Croydon, when without its help they would have had to make a forced landing at considerable risk.

The second system consists of two methods—the Bellini-Tosi and wing coil methods. In each case two large closed loop aerials are fitted, one in the fore and aft plane round the fuselage, and the other in an athwartships plane round the wings. In the Bellini-Tosi method a small radiogoniometer is fitted, with which the direction of the incoming wave may be measured with reference to the fore and aft axis of the aircraft. These bearings are then plotted on a chart by the navigator. This system has only been used experimentally on commercial air transport machines, and it is clearly only suited to aircraft of such a size as to be able to carry a separate navigator and operator.

In the wing coil method, instead of measuring the bearing with reference to the fore and aft line of the aeroplane, the pilot listens to the signal and steers the aeroplane so that it is heading to the transmitting station. This method is therefore suitable for "homing" on a terminal station. Again this method is experimental as far as commercial air transport is concerned.

It should be said, however, that considerable success was attained with the Bellini-Tosi apparatus when fitted on Commander Franco's machine for his flight across the Atlantic and, it is understood, on Captain Amundsen's polar airship, the Norge. Good results have also been obtained with the wing coil apparatus on Royal Air Force machines, and further progress is anticipated at the conclusion of tests now going on.

The third system is still more experimental, and need only be given passing reference. It is not at present being used for aircraft, though experimental stations have been erected for shipping and there are possibilities of its being developed for aircraft use.

With these systems of direction finding wireless, it may fairly be said that the problem of general navigation has been sufficiently solved—in other words an aeroplane may be flown with sufficient precision out of sight of the ground to the near neighbourhood of the aerodrome at its destination. There remains the very important problem of landing in fog, or in conditions of visibility such that the pilot cannot land by the aid of his normal sense of vision.

Before dealing with this, however, a further reference to the problem of control in fog or cloud is necessary. It may be taken as axiomatic that aeroplanes will not be flown in fog or cloud if an alternative is open. Greater comfort for passengers and less strain on the pilot are secured by flying above the cloud. Complete control of the

aeroplane, however, must be secured while passing through the cloud belt and, moreover, there are occasions when banks of cloud reach such a height that it is uneconomic to climb above them with present day aircraft. When the base of these clouds is near the ground it may often happen that the safest and most comfortable and practicable place to fly is at a moderate height within the cloud belt.

In order to secure perfect control of the aeroplane, independent of the pilot's sense of vision, and almost independent of the pilot himself, considerable development work on automatic controls has been undertaken by the Royal Aircraft Establishment. The gyro rudder control has been successfully tested on civil aircraft. This instrument, controlled by a small wind driven gyro, keeps the rudder in a neutral position by the action of two pistons working in compressed air cylinders, the relative pressure in which is dependent on the movement of the gyrostator, which in turn is dependent on the state of movement of the aircraft about its vertical axis. Provision is made for modifying the course of the aircraft so that in effect the aeroplane may be steered by the setting of a small lever. This apparatus is still in course of development to the state at which it may be said its mechanical efficiency renders it of commercial utility.

Apparatus for the control of lateral stability by means of a pendulum is also far advanced. This system may, if desired, be applied to fore and aft stability.

There is no question that this apparatus will, in a short time, enable aeroplanes to be flown without the intervention of a skilled pilot, except for landing. While experimental work proceeds, it must not be taken for granted that the carriage of this apparatus on commercial aircraft is justified by the improvement of revenue returns. To-day, a considerable proportion of scheduled flights are cancelled on account of weather, which means, in nearly all cases, bad visibility. It is probable that within a measurable period, the apparatus described, with other devices for assisting landing in fog, will reduce this proportion to a negligible quantity. It still has to be considered whether the additional weight carried is justified on the aircraft in use, and whether the reduction in paying load is compensated by the increase to 100 per cent. regularity. It also has to be borne in mind that experience in this country is gained in the worst climate in the world for aviation. It seems probable that, as far as weather is concerned, in many of the Dominions and Colonies 100 per cent. regularity could be attained without the intervention of any of these automatic devices.

It is now possible to consider the most difficult problem of all, that of landing in fog. The most promising method at the moment is the leader cable, which is a development of the system already found of value to shipping. A leader cable is established for shipping along the channel from Sandy Hook to New York.

The principle of the system as it is proposed to apply it for the use of aircraft is that a closed loop of cable is laid just below the surface of the ground, in the form of an oval, from one to two miles long and half-a-mile in breadth. Through this cable is passed an alternating current with a frequency of about 34 cycles per second. Around the cable is therefore formed a fluctuating magnetic field, which may be detected by suitable apparatus on the aircraft.

The detecting device consists of two search coils so arranged as to traverse the lines of force of the magnetic field at angles which differ by an amount dependent on the position and altitude of the machine with reference to the cable. The currents induced in these coils differ by a corresponding amount, and are measured by mirror galvanometers reflecting beams of light on to a scale. The apparatus is so arranged that when the aeroplane is flying immediately over and parallel to the cable, the currents, and therefore the indications of the two spots of light on the scale, are equal. When the aircraft turns to port or starboard or when it is displaced laterally to port or starboard, the indications become unequal, and by the nature of the indications the pilot is informed what action to take in order to return to his position and course immediately over the cable. Moreover, by making use of the intensity of the magnetic field, the instrument gives an indication of the height of the aircraft above the cable.

The apparatus has only been made in model form, but a full scale trial is being made at the Royal Aircraft Establishment, in which one straight section of the cable passes across the landing area. In use, the pilot will follow the cable while losing height, and when over that part which lies over the landing area, from which a special signal is emitted, he will bring his machine down to land.

Model tests have shown that it is possible to follow the cable with accuracy and to measure the height of the instrument over the cable within a few inches.

No other system at present shows prospects of solving the whole problem of landing in fog, but experiments are being carried out with a view to guiding aircraft to the landing area by acoustical means.

The problem of carrying on air transport in fog, therefore, involves the control of the aeroplane by the aid of turning indicators or, if necessary, automatic controls; navigation with the aid of radiogoniometry to within a short distance of the aerodrome, and the final guiding of the machine to the exact position of the landing area and its safe landing by means of the indications of some such device as the leader cable.

In general, the aim of developments in navigation is to make it possible to control the aircraft and guide it without visible reference to the surface of the earth, so that the dangers resulting from low flying amidst obstacles may be eliminated. It can be said that the achievement of this object along the lines outlined above is in sight.

SECTION 2.

THE ORGANISATION OF METEOROLOGICAL SERVICES.

I.—The Development of Meteorological Services in Europe, 1919–26.

1. The application of meteorology to a regular air route may be said to date from the inauguration, early in 1919, of a daily air mail service between Folkestone and Cologne, which was operated by the Royal Air Force for the benefit of the British Army of the Rhine. The meteorological service, which was provided by the Meteorological Section, Royal Engineers, was organised on lines which were closely followed at the end of the same year in providing a meteorological service for the commercial air routes emanating from London. Meteorological reporting stations were established at the terminal aerodromes and at intermediate points along the route and coded reports from stations on each half of the route were received by wireless telegraphy at regular intervals at the respective headquarters of the Section at Cologne and Wimereux. On receipt of the reports, collective messages were prepared at each centre and interchanged by wireless telegraphy, so that within a few minutes each office was in possession of a report of the existing weather conditions along the whole route. The complete reports were passed without delay to the terminal aerodromes, where they were decoded and issued to the pilots. A forecast of probable changes in the weather along the route was also issued to each pilot before a flight commenced.

2. The question of the application of meteorology to aviation was considered at Paris in 1919, when the Convention relating to International Air Navigation was drawn up. Annex G (Appendix IV) of this Convention dealt with the collection and dissemination of meteorological information for aviation, and the forms for reports given therein were based largely on those which had been adopted in connection with meteorological reports for the Folkestone–Cologne service.

3. In November, 1919, the question of the organisation of a meteorological service for the provision of adequate reports and forecasts for the civil air routes between London, Paris and Brussels was taken up at the Air Ministry. At a conference held with representatives of the Society of British Aircraft Constructors in that month, an agreement was reached regarding the nature of the reports which should be supplied in connection with commercial air routes. The fundamental information required from points along any route was considered to be—

- (1) Wind at the surface and at 2,000 feet.
- (2) Weather (present and past) in general terms.
- (3) Amount and height of any low cloud.
- (4) Visibility.
- (5) (For seaplanes.) The state of the sea, particularly in regard to the nature and amount of the swell, which greatly affects the power of a machine to rise from the water.

The representatives of the Society of British Aircraft Constructors were so strongly of the opinion that the weather reports should contain no reference to fitness or unfitness for flying, even of supplementing the detailed particulars of the different elements as weather, that it was agreed to omit the estimate of fitness, for which the code for abbreviated reports given in Annex G of the Convention relating to International Air Navigation, Paris, 1919, provided, and a slightly modified form of this

code was adopted as meeting existing requirements. It was further agreed that information given by radio-telephony to pilots of aircraft in flight should be in plain language and not in code.

4. On 1st December, 1919, a meteorological station was opened at Hounslow Aerodrome and reports of weather conditions on the London-Paris route, in so far as they were available, were received there hourly from 07.30 to 14.30. Forecasts for the London-Paris-Brussels routes, prepared at the Air Ministry, were transmitted to Hounslow at about 09.30 and 14.30 daily. Reports of conditions in S.E. England were also prepared and transmitted by wireless telegraphy to Paris hourly from 07.45 to 14.45.

A meteorological station at Lympne Aerodrome on similar lines to the Hounslow Station was opened on 14th January, 1920, and a subsidiary station at Biggin Hill on 17th February. The latter station was opened to meet the recognised need of a reporting station on the North Downs, where frequent difficulty was experienced by pilots on account of low cloud. A feature of the station at Lympne was that weather reports from different parts of the air route were supplied by radio-telephony to pilots of aircraft in flight. The weather reports from S.E. England were further improved by the addition of regular reports from the coastguard station at Beachy Head, which became a reporting station on 2nd February, and later, by the addition of regular information regarding the visibility over the Channel as observed from the coastguard stations at Hythe and Dungeness.

From the 20th February the hourly collective weather reports for S.E. England, which were now much more complete than formerly, were issued by wireless telegraphy to Paris in the code referred to in paragraph 3.

5. The next step was to attempt to secure uniformity between the weather reports issued from the Air Ministry and those issued from continental termini for those portions of the routes passing over the Continent.

During March, 1920, an informal conference took place between the British and French meteorological and wireless representatives, as a result of which it was decided that certain hourly observations should be made at several stations in each country and that these should be transmitted by the French at 30 minutes past the hour and by the British at 35 minutes past the hour, and that the arrangement should take effect from 13th April, 1920. It was also agreed to ask the Belgians to fall into line with this arrangement and to transmit reports at 25 minutes past the hour. Reports from Brussels on these lines commenced on 22nd April.

An extension of the system of hourly reports was rendered necessary by the opening of an air route between England and Holland, and from 17th May, 1920, reports were received by wireless telegraphy from Soesterberg giving the conditions on the Dutch coast and at Utrecht.

6. The informal conference referred to in the preceding paragraph was the forerunner of a regular series of conferences between representatives of Great Britain, France and Belgium. The Meteorological Sub-Commission discusses the practical working of the meteorological arrangements on the air routes and various modifications and improvements in these arrangements have been introduced from time to time as a result of the meetings. Since 1923 representatives of Holland have attended the conferences and, during 1926, a Swiss representative has also been present.

It was not till November, 1920, that uniformity was secured in the codes for transmitting weather reports on air routes. A revised code recommended by the International Commission for Weather Telegraphy (London, November, 1920) was introduced on 1st March, 1921, and early in 1922 a further revision was made, based on the recommendation of the same Commission which had met in London in September, 1921.

The hourly reports have been improved in detail from time to time and extended as necessary to cover a large period of the day in order to meet the needs of the various air services. Mention may be made of the addition to the reports, during 1920, of information regarding the speed and direction of the wind at selected heights, and of detailed short period forecasts of the weather conditions anticipated on the home section of the route. This information is transmitted three times daily.

7. The London-Brussels route was extended to Cologne in October, 1922, and since that month hourly weather reports have been transmitted from Cologne.

Extensions of the London–Amsterdam air service to Berlin and of the London–Paris air service to Zurich were made in 1923. In connection with the latter service arrangements were made for the issue from a Swiss wireless telegraphy station of hourly meteorological reports on the same lines as those adopted by the other countries. Developments also took place by which certain foreign air services linked up with British air services at Amsterdam and Paris. Meetings were held at the Hague during 1923 between representatives of Holland, Denmark, Germany and Sweden, with reference to aviation between London, Amsterdam, Berlin, Copenhagen and Gotenborg, and meteorological arrangements were made for the exchange of reports on these routes on the same lines as those adopted for the routes dealt with at the Anglo-Franco-Belgian-Dutch conferences. Thus agreement was gradually being reached between the different countries of Europe on a common system of meteorological reports for aviation and the practical difficulties which arose in extending a system originally devised to meet the requirements of the comparatively short routes between London and Paris, Brussels or Amsterdam were gradually surmounted.

8. In August, 1920, a system of ground signals was brought into operation at Lympne Aerodrome to indicate to pilots arriving in this country the height of clouds and visibility at Biggin Hill and Croydon. An improved system of signals was introduced in July, 1921, and from February, 1922, the system was extended, for the benefit of pilots about to cross the Channel, by the addition of signals relating to conditions at St. Inglevert. Somewhat similar signals were introduced at a later date at Ostend, Flushing and Abbeville. An improved system of ground signals has been recommended recently by the International Commission for Air Navigation and is being adopted by the countries concerned.

9. The arrangements for transmitting weather reports to pilots of aircraft in flight were improved in 1922 and a form drawn up which was designed to give the necessary information in the briefest way.

10. In 1922 arrangements were instituted whereby, when bad weather conditions prevailed on the normal air route between Croydon and the Channel, supplementary reports were brought into operation from stations on an alternative route via the coast of North Kent. Such reports are made available at Croydon and Lympne and are also issued by wireless telegraphy to the Continent.

11. During 1922 an examination in meteorology became compulsory for all pilots applying for renewal of Class B licences, *i.e.*, licences to operate passenger-carrying aircraft for hire. It was thus recognised that pilots should possess a working knowledge of the application of meteorology to aviation.

12. In 1923 arrangements were made for the prompt issue of warnings of line-squalls or thunderstorms which were likely to affect the regular air routes. Such reports were transmitted by wireless telegraphy between the terminal aerodromes, and were also available at radio telephony stations for transmission to pilots of aircraft in flight.

In the following year the regular hourly reports were further supplemented by special reports of important changes in visibility at stations on the routes, such reports being immediately communicated to pilots of aircraft in flight and also transmitted to the continental terminal aerodromes. The arrangements were extended as from 1st January, 1925, to include important changes in cloud height, weather and wind. The latter reports are communicated by radio-telephony to aircraft in flight, but are not transmitted to continental aerodromes.

13. At a meeting in Paris in December, 1925, a figure code for the issue of forecasts on air routes was discussed and agreement arrived at. It enables the length of the messages to be reduced to about one-fifth of the length of the forecasts in plain language and it also makes the messages easily understood, as difficulties of language or difficulties arising from the special meaning of national terms for meteorological phenomena are avoided.

II.—The Principles of the Organisation of Meteorological Services.

(1) *General.*—The requirements of civil aviation in regard to meteorology vary according to the part of the world in which the air service is to be operated and also depend to some extent on the organisation of the air service itself. Nevertheless, there are certain general principles which may be laid down as fundamental. In enunciating these principles examples will be drawn from the existing meteorological

organisation on the London-Continental air routes, while reference will be made, whenever possible, to obvious variations from this organisation which would be necessary in the case of an air route operated in other localities.

(2) *Preliminary Investigation of Meteorological Conditions along an Air Route.*—

It is of great importance to investigate as fully as possible, before an air route is selected, the meteorological conditions over the area through which the route would pass. The investigation would be based upon past meteorological records analysed and summarised to show not only the weather experienced in the long run over the area, but also the seasonal and daily variations, at representative places, of the elements of importance to aviation. In general, the value of the investigation would be to indicate the prevalence of conditions liable to cause interruption of the service and so to assist the selection of the best route.

The sites proposed for aerodromes along the route should be subject to special investigation. It has been found, for example, that the frequency of fog and low cloud, which are the most adverse factors from the point of view of aviation in Great Britain, shows a marked variation according to the geographical position, and especially the topographical features of the station. Where, as not infrequently happens, a terminal aerodrome is situated near a large industrial town, it is important to place the aerodrome, other things being equal, on the side of the prevailing wind in order that visibility may not be unduly affected by smoke pollution. In the tropics, fog and low cloud are not so prevalent as in north-west Europe, but here, among other factors, the question of minimum air density has to be considered as affecting the load which can be carried by the aircraft without unduly increasing the length of take-off run.

(3) *Meteorological Organisation on an Air Route.*—To ensure the safety and regularity of civil flying, the following meteorological information should be available for the pilots and operating staff of air transport companies :—

- (i) Reports of the existing weather conditions at selected stations on or near the route, made at regular intervals.
- (ii) Detailed short-period forecasts of the weather conditions anticipated on the route, to be furnished to the flying personnel prior to the commencement of a flight.
- (iii) Special reports of violent and sudden phenomena, which may be regarded as threatening the safety of aircraft, such reports to be transmitted to the aerodromes concerned and also to pilots of aircraft in flight likely to be affected.

It is necessary to describe in some detail the arrangements needed for the provision of these three types of reports.

(i) *Regular Reports from Stations on and near the Route.*—The distribution of reporting stations and the frequency with which regular reports are made will depend upon the climatic conditions which obtain over the area involved. This factor, in turn, is dependent partly on the nature of the country over which the route passes ; in general, it is desirable to obtain reports from any place on the route which is subject to exceptional meteorological conditions.

Meteorological stations in connection with the civil air route in S.E. England are of three classes :—

- (a) *First Order " Distributive " Stations* at important aerodromes. The staff and equipment of such a station depend on the particular requirements of the air services concerned. At the station attached to the London Terminal Aerodrome at Croydon the staff is composed of an assistant superintendent and 2 senior professional assistants (with university degrees in physics and mathematics), 1 higher grade and 6 lower grade technical assistants and 2 telephone-typists. These work in relays to cover the 24 hours.

The duty of the professional staff is to supply information to the pilots and management of the air transport companies regarding the present and probable future weather conditions on the different routes radiating from Croydon. The technical assistants take observations, code outgoing and decode incoming reports, prepare charts and exhibit reports on notice boards. The telephone-typists are necessary as almost constant communication is maintained with the central office at the Air Ministry, which is responsible for the collection and distribution of aviation reports.

The station is equipped as a first order meteorological station, with instruments both for eye-reading and for obtaining continuous records of the various elements at the surface, as well as pilot balloon equipment for upper wind observations.

The annual salaries of the staff amount to £3,300. The initial cost of the instrumental equipment of such a station is about £400. The cost of consumable stores averages £50 per annum. In addition, there are small charges necessary for maintenance of buildings, repairs to instruments, fuel and light.

- (b) *Secondary Air Route Stations.*—This type of station is more modestly equipped than a main station and is manned by technical staff only, the number depending on the requirements of the station. The minimum would be two lower grade technical assistants.

Such a station furnishes regular reports for aviation to the central office for distribution to aerodromes affected.

The initial cost of the instrumental equipment would be about £50. If it were necessary, however, to include pilot balloon apparatus, this figure would have to be increased.

- (c) *Auxiliary Reporting Stations.*—The third type of station has no regular meteorological staff, the observations being made by coastguards, lighthouse-keepers or officials of other departments of the public service whose duties necessitate a more or less continuous watch. A small additional payment is made in return for such observations as they are called upon to make. In some cases it is not considered necessary to provide instrumental equipment, but in others instruments similar to those of a secondary air route station are installed.

In S.E. England, a coastguard station at Beachy Head, to the west of the air route, furnishes regular reports, which are useful as giving warnings of adverse weather phenomena approaching from the west along the English Channel. A second station at Dymchurch reports regularly the sea visibility near the point where the air route leaves the English coast. Reports are also obtained at certain hours from the coastguard station at Dungeness.

The number of main meteorological stations on a particular route will depend on several factors. In general, any aerodrome which is a main port of call for machines should have such a station attached.

It is important to arrange for upper wind stations at frequent intervals along the route, as an accurate knowledge of the upper air currents is of great economic importance in air navigation. By selecting the right height for flying it is frequently possible to effect a considerable saving both in petrol and in time.

(ii) *Air Route Forecasts.*—The supply of forecasts for air routes necessitates the preparation of synoptic weather charts several times daily for which, in the case of S.E. England, data are collected from the whole of the British Isles and also from other countries in N.W. Europe. The forecasts for the air routes emanating from Croydon are prepared by the Aviation Forecast Service at the Air Ministry; but synoptic charts are also constructed at Croydon to enable the local meteorologist to advise the pilots and operating staff of the air transport companies. A detailed short period forecast is prepared for each service leaving Croydon. A more general forecast for the London–Continental air routes covering the following day is issued to all concerned during the afternoon. Forecasts for S.E. England are also transmitted by wireless telegraphy to the terminal aerodromes on the Continent three times daily.

(iii) *Special Reports.*—On the London–Continental air routes, exchange of regular reports from stations on and near the routes takes place hourly, each country issuing a collective message containing reports from stations in its own sector at fixed times after each hour. It has been found necessary, however, to supplement the regular reports by special reports issued with the minimum delay when adverse phenomena such as thunderstorms, squalls and fogs occur. Such reports are transmitted immediately to the aerodromes concerned and are also made available at the appropriate stations on the route for transmission by radio telephony to pilots of aircraft in flight.

While it would not be necessary, probably, to issue regular reports at intervals as frequent as one hour in certain countries where weather conditions are more stable than in N.W. Europe, a system of warnings on the lines indicated would be desirable on all air routes.

Attention may also be directed to arrangements for ground signals and for reports from stations on an alternative route which it may be desirable to include in the general organisation.

(iv) *Ground Signals*.—On the London–Continental air routes, signals are displayed on the ground at certain aerodromes to indicate to pilots in flight the meteorological conditions (height of cloud, visibility and precipitation) existing at other aerodromes along the route. The signals were designed primarily for the use of pilots of aircraft not equipped with wireless apparatus, but they are useful in any case as affording relief to the wireless service and also in the event of the aircraft's wireless going out of action.

The system of ground signals in use is that recommended by the International Commission for Air Navigation and is described in Annex G of Official Bulletin No. 9, dated December, 1925. The cost of a complete set of signals recently installed at Lympne Aerodrome, showing conditions at three stations, was £345.

(v) *Weather Reports on an Alternative Route*.—If any portion of an air route is subject to exceptional meteorological conditions it is desirable to arrange for reporting stations on an alternative route which is not likely to be affected in the same way as the main route. In south-east England the civil air route passes over the North and South Downs, which are sometimes enveloped in low cloud. In such cases, a system of reports is brought into operation from stations on an alternative route which follows the estuary of the Thames and the coast of North Kent, where the country is flat. Three stations are utilised for this service, one (Shoeburyness) being a regular meteorological station, maintained primarily for other purposes, while the other two (North Foreland and Deal) are auxiliary reporting stations established specially for the purpose.

(4) *General Remarks*.—The foregoing summary will serve to indicate the main meteorological requirements of an air route. Details regarding the codes for meteorological messages, forms for the exhibition of meteorological information and the method of exhibiting air route information at aerodromes recommended by the International Commission for Air Navigation will be found in Annex G of Official Bulletin No. 9, already mentioned.

A map is attached showing the meteorological stations in south-east England which report in connection with the civil air route.

SECTION 3.

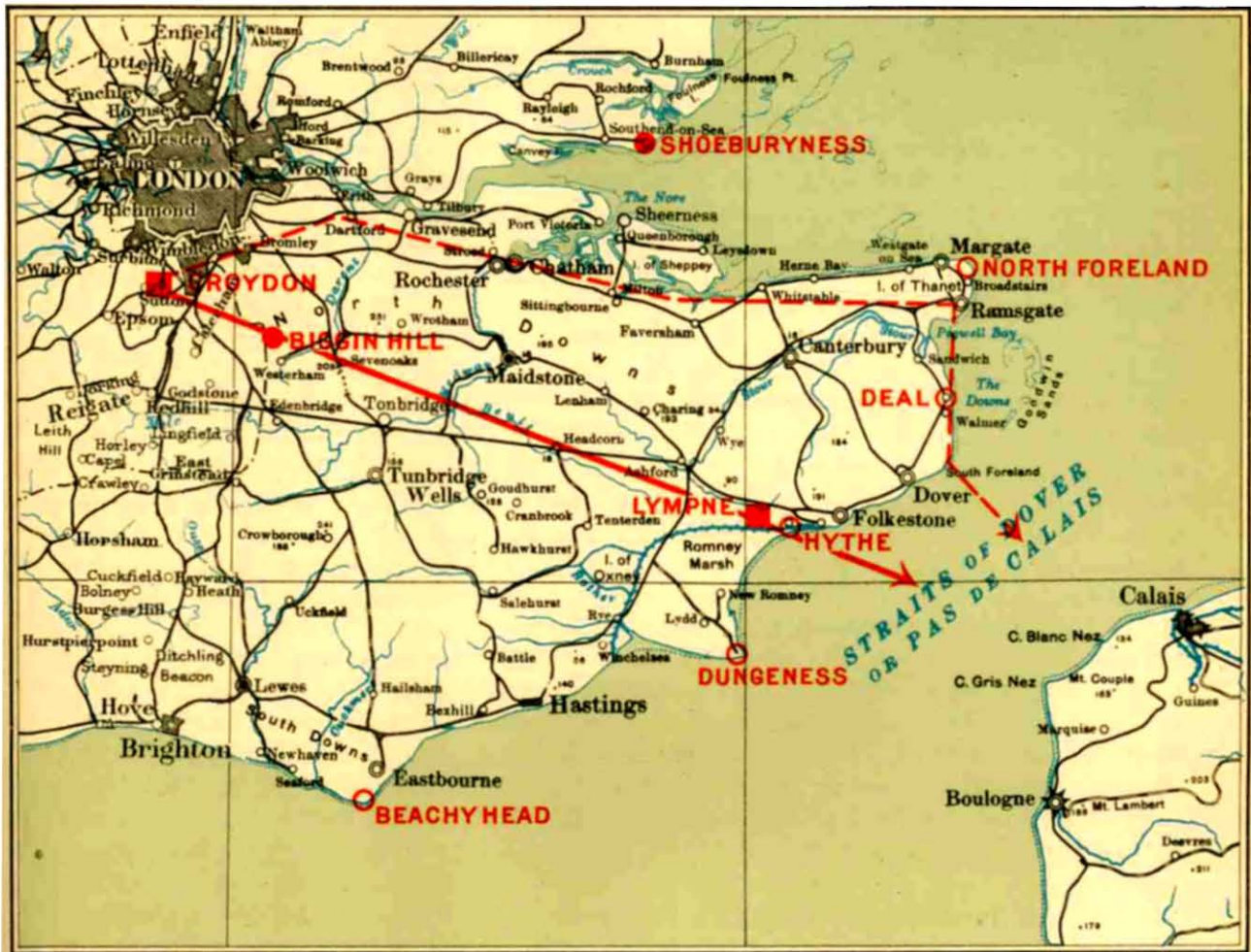
THE USE OF WIRELESS IN AIR TRAFFIC COMMUNICATIONS.

Wireless has proved itself to be peculiarly suitable for communicating with aircraft.

It has hitherto been the accepted idea that to communicate with an aircraft radio telephony should be employed. This was done in the first instance because it was difficult enough at the commencement for the pilot to fly his machine and to find his way, without hindering him with any more complicated method of communication than being able to speak and hear a spoken reply during the time he was in the air. The spoken word is naturally the most rapid form of communication, always provided that it is not misunderstood. But with the development of commercial aviation and all its attendant improvements, it has become more and more evident that radio telephony is not the most advantageous method of communication.

It is an inherent fault of radio telephony in its present stage of development that only a few machines are able to work in a comparatively small area at the same time without causing mutual interference. This fault has not, up to quite recently, given cause for much anxiety, but as the number of machines has increased on the routes it has steadily become more difficult to maintain touch with each individual aircraft. Such a fault is not inherent in the same circumstances in continuous wave

MAP SHOWING METEOROLOGICAL STATIONS ON AIR ROUTES OVER SOUTH-EAST ENGLAND



G.S.G.S. 3823

War Office, 1926

- | | | | |
|-----------------------------|---|-------------------|-------|
| Main Station | ■ | Main Route | — |
| Secondary Station | ● | Alternative Route | - - - |
| Auxiliary Reporting Station | ○ | | |

telegraphy, and for this reason it has been decided that only the small types of aircraft, *i.e.*, those capable of carrying between 5 and 10 passengers shall continue to be equipped with radio telephony, and that the larger machines, *i.e.*, those capable of carrying 10 passengers or more, shall be equipped with wireless telegraphy. It is, of course, probable that future development will be in the direction of larger machines.

It is interesting to enumerate the methods by which wireless is at present employed on organised air routes. Ground stations have been erected at convenient intervals along the routes by the various Governments concerned and are operated by their respective staffs. The introduction of the telegraphic method of communication for the larger aircraft not yet having taken place, every route station at the present time maintains a continuous watch on a normal wave-length of 900 metres, throughout the time that any aircraft is in flight. The actual working wave lies within the aircraft wave-length band of 850 metres to 950 metres and radio telephony only is employed.

It has already been explained in Section I how the aircraft is able to ask for its position by calling up the ground station or stations. This operation and all other communication between the air and the ground are carried out by the same ground stations since the receiver which intercepts aircraft signals is capable of taking bearings of the aircraft making those signals.

After 1st January, 1927, telegraphic apparatus will be introduced on the larger machines and an alternative wave-length will then be set aside for such work on a normal wave-length of 1,550 metres. This will, of course, necessitate the duplication of the ground stations, but will make for infinitely better control and much smoother working.

Apart from the question of communicating with aircraft, there is perhaps the equally important question of notifying various aerodromes along the intended route of the departure or arrival of a machine. For this work—known as "route traffic"—the various States concerned have allocated a wave-length of 1,400 metres. Telegraphy only is used and any message may be passed by an air operating company free of charge, providing it has undoubted reference to the safety of aircraft or regularity of the service.

There is further the necessity of reporting weather conditions from time to time. By international agreement, it has been decided that hourly reports are satisfactory for commercial air routes as they exist to-day; and as a result meteorological readings are taken once every hour at points along the air routes and are consolidated into station reports and exchanged with every other station at pre-arranged times, on a wave-length of 1,680 metres. By this method it is possible for the pilot of an aircraft, prior to his departure, to obtain recent information concerning the weather at the chief points along his line of flight. Sudden changes of weather can, of course, be notified from the ground station concerned to any aircraft in its vicinity, by means of the 900 metre service.

A further use of wireless is in warning machines of their proximity to each other at various points of the route during periods of fog or poor visibility, thereby preventing risks of collision.

It is quite probable that with the trend of development of wireless generally towards the higher frequencies (*i.e.*, "shorter waves") it will prove possible to utilise a wave-length of the order of 200 metres in place of either the 900 or 1,550 metres waves before mentioned. Research is going on in this direction at the present time, but it has not yet developed sufficiently to allow of a more definite statement being made.

Wireless staffs at Government civil aerodromes are specially selected men, frequently ex-wireless N.C.O.s and operators of the Royal Air Force, and they must have had experience in—

- (1) Continuous wave telegraphy.
- (2) Radio-telephony.
- (3) Direction finding.

They must also be able to speak a foreign language, preferably French, and have a good knowledge of aircraft generally, internal combustion engines and petrol electric generating plant, electric direct current and alternating current work, and must be medically fit to fly.

For discipline they are under the control of the Civil Aviation Traffic Officer of the aerodrome on which their station is situated, but for all their technical work

they are responsible to the Signals Branch, Air Ministry, which branch has a special section controlling civil aviation signal matters.

There are two grades of operators and they are paid at the following rates :—

- (1) Operator-in-charge at £6 to £7 10s. per week.
- (2) Operator at £4 10s. to £6 per week.

Increments are 5s. per week per annum ; 75 per cent. of these operators are about to be established on a permanent basis ; overtime is paid at 1½ times for first 6 hours and 1½ times subsequently up to a maximum of 12 hours per week.

A standard terminal aerodrome station (*e.g.*, Croydon) consists usually of :—

- (1) 1½ kilowatt continuous wave and radio telephony transmitters for 900 and 1,550 metre work with aircraft.
- (2) Direction finding receivers for 900 and 1,550 metre aircraft work.

It is intended to include in such a station, in future, other apparatus for carrying out 1,400 metre point-to-point route traffic signalling and possibly 1,680 metre hourly route weather traffic.

The initial cost of (1) and (2) is approximately £2,000, and annual maintenance costs are £200–£300 for plant and £3,000–£4,000 for staff. This excludes buildings.

An intermediate aerodrome station (*e.g.*, Lympne) consists usually of :—

- (1) ¼ kilowatt continuous wave and radio telephony transmitters for aircraft work.
- (2) Direction finding receivers for aircraft work.

The initial cost of (1) and (2) is £1,000, approximately, with annual charges of £200 for gear and £1,500–£2,000 for staff. This also excludes buildings.

SECTION 4.

AERODROMES AND LANDING GROUNDS.

I.—The Development of Government-owned Civil Aerodromes, 1919–26.

At the beginning of May, 1919, the aerodrome situated at Hounslow Heath was acquired from the Royal Air Force by the Controller General of Civil Aviation as a London Terminal Aerodrome for continental traffic, and air transport services to the Continent were inaugurated on 25th August, 1919. Hounslow was established as an appointed aerodrome where Customs clearance facilities could be obtained, and Customs facilities were also provided at Cricklewood Aerodrome, from which the aircraft of Handley Page Transport, Ltd., operated direct to the Continent.

In March, 1920, Hounslow Aerodrome was relinquished for reoccupation by the War Office and it was decided to acquire the Waddon Aerodrome, Croydon, which aircraft flying from the Continent could reach without crossing a densely populated portion of the London suburbs and which, in addition, was less affected by fog during the winter months. A coastal aerodrome at Lympne, in Kent, was also taken over from the Royal Air Force in 1919, and Customs clearance facilities were provided there as well as at Croydon.

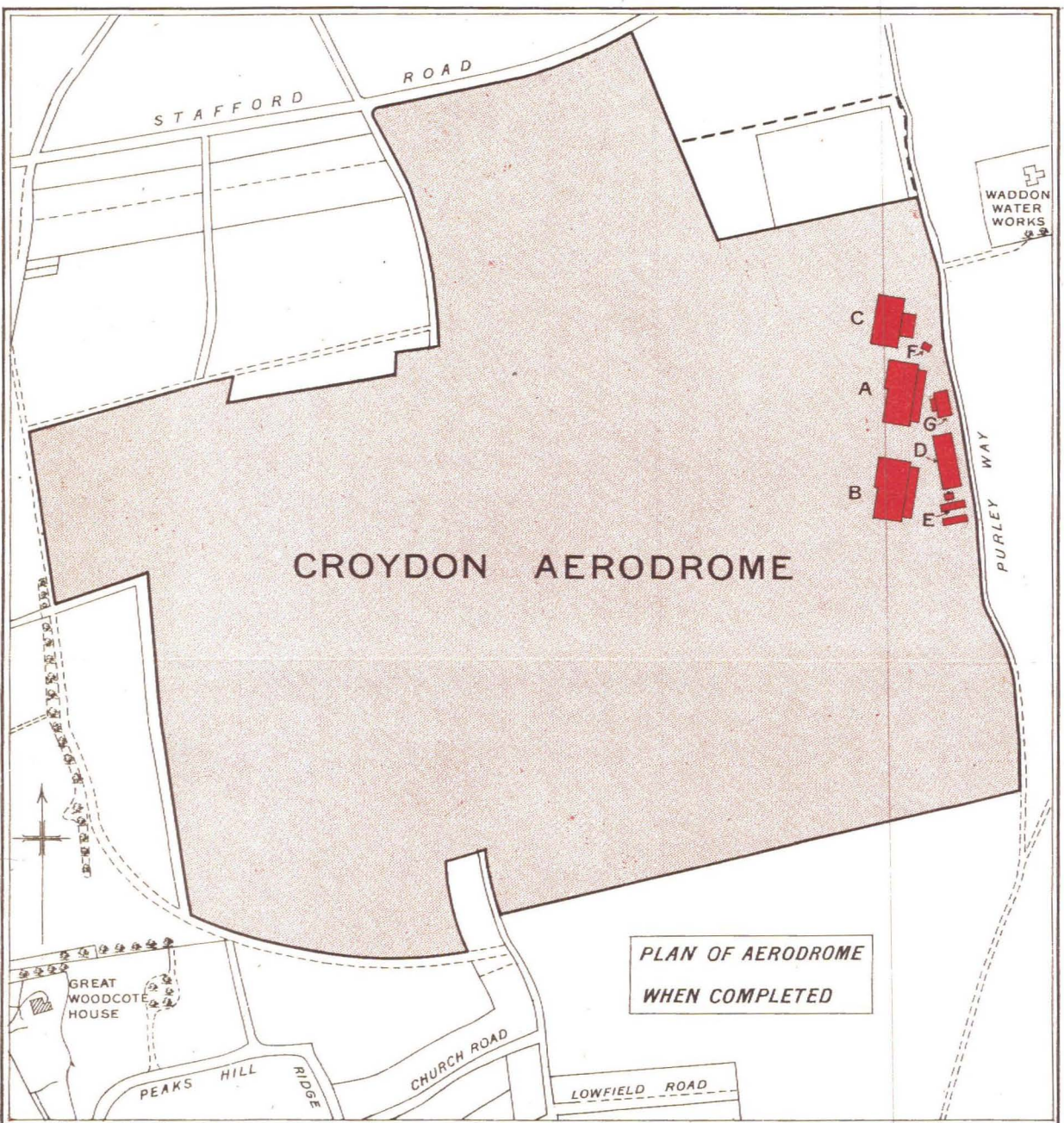
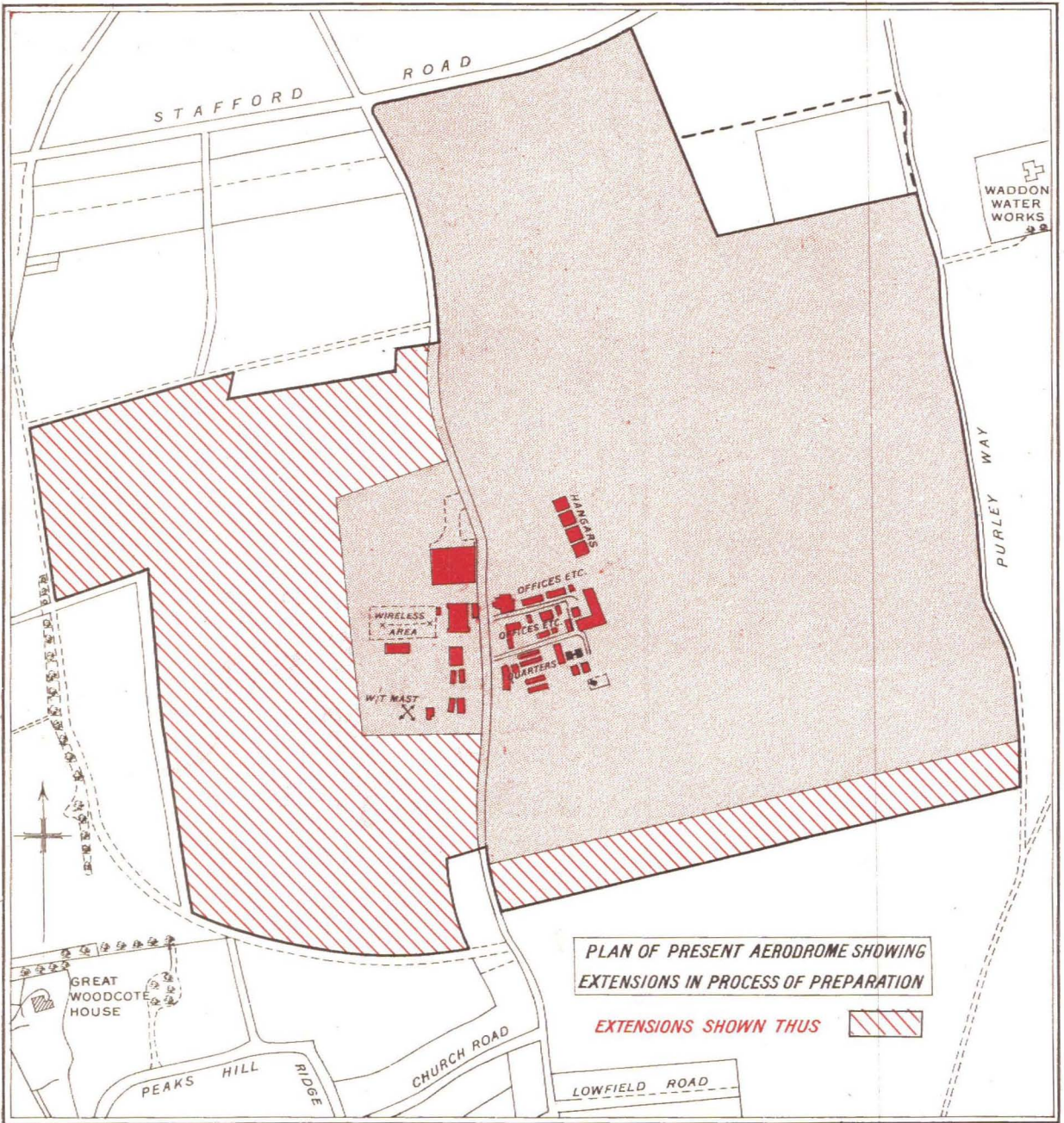
Services to the Continent operated by British and foreign firms steadily expanded until, in 1922, aircraft were plying to Paris, Brussels, Cologne, Rotterdam and Amsterdam, and in the same year a daily service from London to Manchester was inaugurated.

Emergency landing grounds were established at Penshurst, Kent, in 1920, and Marden and Littlestone, Kent, in 1922, for the use of cross-channel aircraft which, owing to weather, engine trouble, or other causes, were unable to proceed to their destination. Combined lighthouses and illuminated wind indicators were later installed at Penshurst and Littlestone for the assistance of night-flying aircraft.

As the traffic developed it was found that the two large permanent hangars and four Bessonneaux hangars at Croydon were inadequate to meet the requirements of the operating firms, and three additional Bessonneaux hangars and one wooden Hervieu hangar were erected as a temporary measure.

In 1924 Imperial Airways, Ltd., extended their services to Zurich and Berlin, employing large twin-engined aircraft on these routes, and in 1926 contracts were placed for three-engined aircraft to carry 23 passengers. The existing hangar accommodation therefore required revision, and the buildings of the London Terminal

CROYDON AERODROME



Aerodrome are now being resited on the eastern side of the aerodrome. Large permanent hangars are being erected, and Plough Lane, which separates Croydon from the Wallington Aerodrome, is being diverted to permit of more land being acquired.

A central control tower has been installed at Croydon, from which a traffic officer constantly on duty is able to control all air traffic on the routes. He is assisted by a wireless operator, who passes orders and information direct to pilots in the air by radio-telephony and is thus able to advise as to weather conditions over the whole route and to issue any orders which from time to time may be necessary in the interests of safety.

The London Terminal Aerodrome is under the immediate control of a civil aviation traffic officer, who is assisted by four assistant traffic officers, one cashier, one stores officer, A.I.D. inspectors, and by wireless, meteorological, and other staff. He has also two traffic foremen and 24 traffic hands under his control.

II.—The Situation of a Terminal Aerodrome.

On a recognised air route a series of aerodromes is necessary, classified according to the purpose which they serve, as terminal aerodromes, aerodromes, landing grounds, and emergency landing grounds.

A "terminal" aerodrome is one that is usually situated as close as possible to the capital of a country, where naturally the headquarters of the main air transport companies are to be found. The London Terminal Aerodrome, situated at Croydon, is the chief centre in Great Britain.

The ideal situation for a terminal aerodrome is near the heart of the city, but in many of the older countries, including England, this ideal cannot be realised owing to the impossibility of finding within the heavily populated area a large unobstructed space, which has not become indispensable as a park or recreation ground.

The next best situation is one provided with good transport facilities, either of road or rail, preferably both. The site should be free from adverse meteorological conditions, especially fog, with well-drained soil and open surroundings.

III.—The Lay-out of an Aerodrome.

The ideal lay-out of an aerodrome, where space permits, would be one in which the main buildings were located in the middle of the aerodrome. This arrangement would avoid all unnecessary taxiing and give the maximum amount of room for machines departing, arriving and manoeuvring on the ground. The drawbacks to this system are that it is necessary to have a road running across a part of the aerodrome, with consequent danger and inconvenience, and that a much bigger area is required, since it must provide a clear take-off in any direction from the departure platform. The normal practice at present is to group all buildings together on the side of the aerodrome on which ground access is most convenient, and it is on these lines that the London Terminal Aerodrome is being rebuilt.

IV.—The Choice of a Site.

(1) The soil should be medium to light. It has been found by experience that heavy soils are unsuitable and become sticky in winter; grass grows too freely and drainage is difficult.

(2) The land should be level and preferably on a plateau. A plateau site sloping away very slightly from the centre to the boundaries on all sides is very desirable and it is more likely to present low approaches into every wind.

(3) Ridge and furrow should be avoided as this usually indicates a naturally wet soil; levelling is expensive and a system of land drainage is a necessity.

(4) The site should afford at least 1,000 yards run into any wind. Such sites are in this country very difficult to find, and preference should be given to a site giving this length of run at any rate in the direction of the prevailing wind.

(5) The neighbourhood selected should be free from fog.

(6) The area should, if possible, consist of large fields, thus saving the work of removing hedges, etc., and subsequent levelling.

(7) A site which consists of permanent pasture is a great asset, especially if time is a consideration.

(8) The land immediately surrounding the site should be free from obstructions. Any obstacles, such as church spires, chimneys, or sharply rising ground near the

boundary of the site, are a great disadvantage, especially if night-flying is contemplated, as night markings will be necessary. High trees can generally be removed by arrangement.

(9) Large sized fields in the vicinity of the site are an advantage as they give facilities for forced landings.

(10) Good road access to the site is an advantage and if an extensive building programme is intended will save a considerable sum of money. The same thing applies to railway facilities in the immediate neighbourhood.

(11) Consideration should also be given to the availability of supplies of water and electric current.

(12) The price of the land is an important consideration and is affected by the number of ownerships on the selected site and the severance entailed.

V.—Accommodation.

The following buildings are necessary at a terminal aerodrome :—

- (1) Hangars for aircraft.
- (2) Workshops for operating firms.
- (3) Petrol and oil storage.
- (4) Traffic control accommodation.
- (5) Wireless installation.
- (6) Meteorological office and space for meteorological instruments.
- (7) General accommodation for operating firms, including offices, booking hall, waiting rooms, etc.
- (8) Vehicle sheds.
- (9) Office accommodation for controlling staff of the aerodrome.
- (10) Accommodation for Customs and alien immigration authorities.
- (11) Bonded stores.
- (12) First aid facilities.
- (13) Accommodation for guard and police.
- (14) Lavatory accommodation.
- (15) Hotel accommodation or refreshment rooms.

The extent of the accommodation provided will naturally depend on the traffic which is expected at the aerodrome, bearing in mind the probability of rapid development ; similarly, the hangars must be of such a size as to admit the largest aircraft that will visit the aerodrome, so far as can be foreseen.

VI.—The New London Terminal Aerodrome.

Owing to development of traffic it has now become necessary to enlarge and rebuild the London Terminal Aerodrome, Croydon. The plans adopted therefore furnish a good example of present-day views on the accommodation required at a principal aerodrome in the present state of air transport in Europe. A plan of the aerodrome, indicating the changes to be made, is on the opposite page.

The present aerodrome has a maximum run north and south of 1,300 yards, and east and west of 900 yards. It is bounded on the west side by a road. This road is to be diverted and further land on the west of the road will be thrown into the aerodrome. This extension, together with a strip of 200 feet at the south of the existing aerodrome, will give a maximum of 1,350 yards north and south and 1,450 yards east and west.

The existing buildings are to be removed and replaced by new buildings on the east side of the aerodrome. The following is a brief description of the accommodation which will be provided in the new buildings, together with the cost of construction. It is hoped to acquire, in addition, hangar accommodation which is already in existence at the north-east corner of the aerodrome. With the two new hangars which are being built, accommodation will thus be provided for 35 large type aircraft.

Hangar Accommodation (A and B).—A total floor area of 90,000 square feet is provided for storage of aircraft in two sheds with a clear span of 150 feet and clear height of 30 feet. Offices, stores, workshops, etc., with a floor area of 36,000 square feet are included in the annexes to the hangars. Total cost, £75,000.

Terminal Block (C).—This building provides 32,000 square feet of office accommodation subdivided as required for the use of control staff, operating companies and customs and immigration authorities.

Waiting rooms and booking hall, 6,000 square feet; customs and immigration examination halls, 5,000 square feet; and freight stores, 9,500 square feet floor area, are also provided in this block.

The building is of two-storey construction with a 50 feet high control tower placed centrally, with a clear view over the aerodrome. Total cost, £62,000.

Fitters', Carpenters' and Fabric Workshops (D).—A floor area of 28,000 square feet is provided in this block. Total cost, £17,000.

Vehicle Sheds (E).—Accommodation is provided for housing transport vehicles in two buildings with a total floor area of 7,200 square feet. Total cost, £6,000.

Police Block (F).—Accommodation for police, together with first aid facilities and detention quarters, is provided in this block. Total cost, £1,500.

Hotel (G).—This will be built by a private company and will contain bedroom accommodation for about 30 visitors, together with suitable dining room, lounge, etc., and canteen for labour employed on the aerodrome.

The total estimated cost of the rebuilding scheme now in progress is £267,000, which figure includes, in addition to the above, all roads and pavings, drains, water mains, electrical services and minor buildings. All buildings are of permanent type of construction.

SECTION 5.

THE LIGHTING OF AERODROMES AND AIR ROUTES.

To carry on successful night flying in this country, experience has shown that lighting is required for three purposes. The first requirement is a series of beacon or route lights, situated on suitable high ground, but not necessarily on aerodromes; secondly, each aerodrome or landing ground requires to be marked by a location light, enabling the position of the aerodrome to be recognised from a moderate range, it being assumed that the aircraft can be navigated by the aid of the route lights to the neighbourhood of the aerodrome; the third requirement is the illumination of the actual landing ground to facilitate landing. In this third category is included the indication of wind direction and the marking of the boundary of the aerodrome.

The following notes briefly summarise the experience gained up to the present in the lighting of aerodromes and air routes:—

(a) Air Route Lights.

At two points on the Croydon–Lympne route high-powered automatic unattended lighthouses of the Gas Accumulator Company's "AGA" design have been erected in order to assist night flying aviators to locate their position; these lights are placed one at Cranbrook in Kent, and the second at Tatsfield Hill in Surrey, both being on high ground and visible in all directions. These units have been constructed to produce the particular requirements of the aviator regarding light distribution, and operate without attention for periods of six months.

It is considered that the automatic unattended apparatus described above will probably remain standard for some years, as it is entirely satisfactory in operation and the maintenance costs are very low.

(b) Local Pilotage or Aerodrome Location Lights.

In order to assist pilots to locate aerodromes from a distance at night aerial lighthouses have been installed on the aerodromes and emergency landing grounds at Croydon, Lympne, Littlestone and Penshurst. At Croydon and Lympne these lights are specially designed to meet the needs of the aerial navigator; at the former aerodrome there is in operation a Neon beacon, consisting of 16 glass tubes, each 20 feet long and charged with Neon gas; suitable transformers, etc., are provided in order to incandesce this gas by the passage of a high tension electric current through the gas from the electrodes at each end of the tubes. The 16 tubes are arranged in the form of a narrow truncated vertical cone, apex upwards, and suitably spaced around a central supporting structure; the net result is that a "pillar of fire" is visible on clear nights up to ranges of about 45 miles. On foggy nights with a ground visibility of approximately 5 yards this Neon beacon is visible at ground level at

50 yards, and has also been seen at some two to three miles from an observer stationed above such a bank of fog, which on that occasion happened to extend from ground level to about 300 feet.

In addition, a white flashing light is exhibited at both Croydon and Lympne aerodromes, the illuminant employed being a number of 1,500 watt, $\frac{1}{4}$ watt lamps placed at the focal centre of a suitable lenticular apparatus, so designed as to project light through 360 deg. in azimuth and 180 deg. in the vertical plane, *i.e.*, from the horizontal to the zenith in an all-round direction.

Experience gained with the Neon beacon at Croydon has led to a decision to instal a similar beacon at Lympne and to dismantle the white flashing light both at Croydon and Lympne.

At Littlestone and Penshurst landing grounds, automatic gas-operated lights are also in operation; these lights also have been specially designed for aviation purposes, having regard to the necessity for the distribution of light throughout the whole of the upper hemisphere; this has been effected by the employment of suitably designed external prismatic elements in conjunction with a panel lens. In other respects these lights are of standard marine type of the latest Gas Accumulator Company's "AGA" pattern, being entirely automatic and operating unattended for periods of six months.

(c) Flood-Lighting of Aerodromes.

Systems tried out are as under :—

(1) Searchlights, with 10-inch projector, and carbon arc lamp.

(2) " " 24 " " " " " "

(3) " " 36 " " " " " "

(4) " " 36 " " " " " "

and with dispersing lenses 16 deg. and 45 deg., placed over the front of the projector.

(5) Floodlights, portable, consisting of 200 mm. drum lenses, split vertically, with a 100 watt, $\frac{1}{2}$ watt electric lamp placed at the focal centre and fitted with a metal reflector behind the light source.

(6) Floodlight, portable, consisting of a 180 deg. drum lens of 500 mm. diameter composed of 21 dioptric elements; this lens is mounted in a suitable sheet metal lantern and has at its focal centre a carbon arc lamp (automatic feed) absorbing about 150 amperes at 75 volts. The necessary adjusting gear, switchboards, etc., are contained in the lantern and the whole mounted on a four-wheeled truck of a type suitable for towing about an aerodrome.

Of these systems, (6) has proved to be infinitely better than any other type for use on civil aerodromes.

It is employed as follows :—

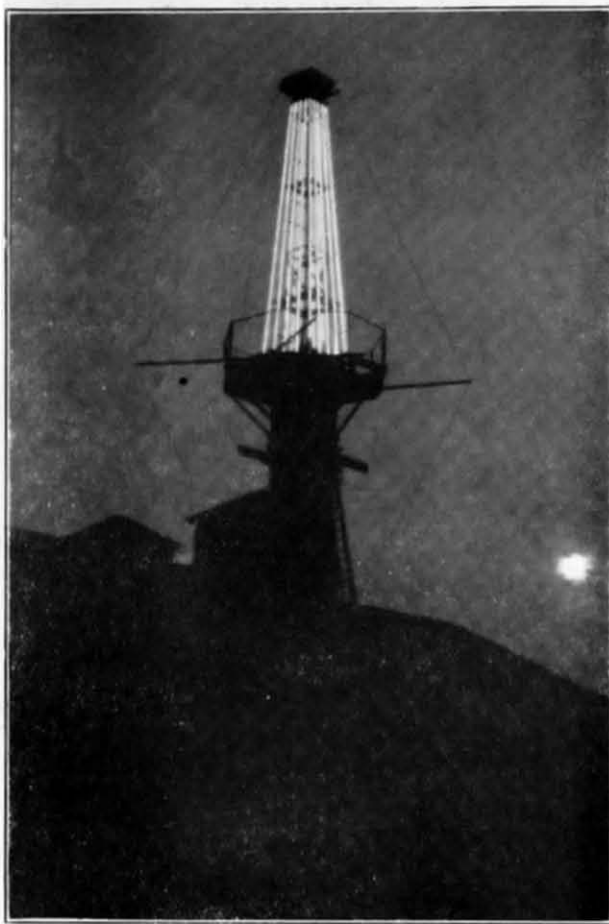
Four petrol electric generating plants are installed in suitable positions on the outer circumference of the aerodrome to enable the 180 deg. beam of light to be directed in accordance with the wind prevailing; the illumination obtained is evenly distributed and does not cast confusing shadows, landings being made into wind and leaving the light source behind and to one side of the aeroplane.

It is considered improbable that any new system will supersede (6) for some years as a means of flood-lighting an aerodrome.

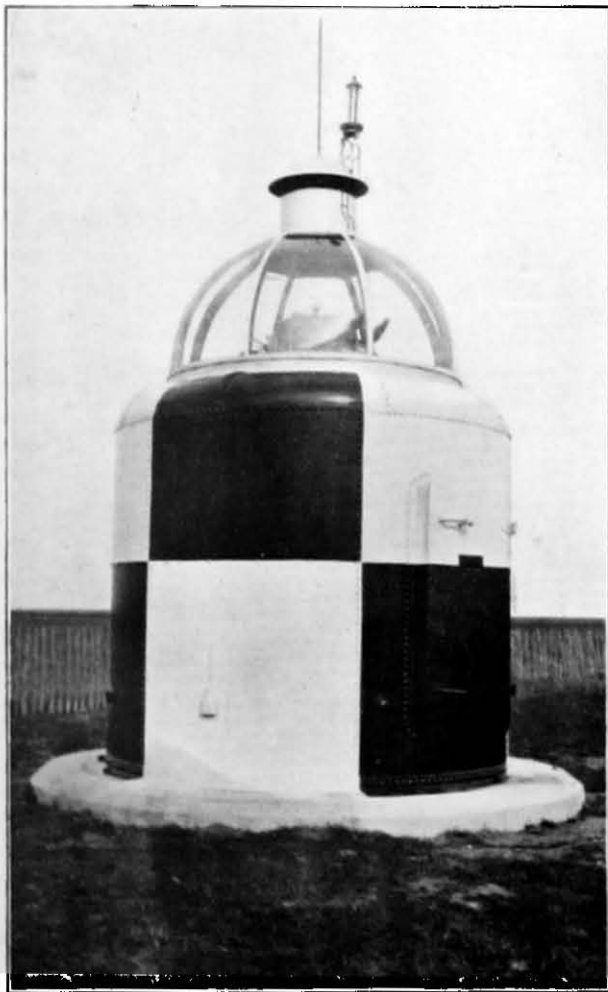
(d) Aerodrome Boundary Lights.

In accordance with the International Air Convention, Annex D, paragraph 48, obstruction lights have been placed where necessary at the Croydon and Lympne aerodromes. The lights are red (fixed character), electricity being employed where convenient, and oil lamps in other cases. This system was satisfactory in the earlier stages of night flying, but with the increase of night traffic it proved desirable to outline completely the landing area on the aerodrome, *i.e.*, even those sides of an aerodrome offering unobstructed approach (except for a low hedge or fence) should be outlined by suitable lights.

This has been done at the aerodromes at Croydon and Lympne and at the emergency landing grounds at Penshurst and Littlestone; the lighting units employed are spaced on the perimeter of the good landing area at intervals of from 150–250 yards, dependent on the circumstances of each case.



The Neon Fog-piercing Light—(Croydon Aerodrome).



Littlestone Location Light.
(This light has a revolving lens and gives a double flash.)



The Portable Floodlight
(which is being superseded by a floodlight mounted on a power-driven chassis).

The lights as at present employed exhibit a flashing red light showing 1/10 second flash and 9/10 second eclipse, the effect being an almost continuous light. Each light is visible through 360 deg. in azimuth and 180 deg. in the vertical plane, *i.e.*, from the horizontal to the zenith, and it was found that the most economical method available was in the employment of "AGA" automatic gas-operated lights, which are in constant operation night and day and run without attention for periods of six months at a time, at the end of which period the exhausted cylinders of dissolved acetylene gas are replaced by fully charged cylinders.

The result of this system is that a pilot approaching an aerodrome to land has indicated beneath him the existing outlines of the area within which it is safe for him to land and manoeuvre his machine when on the ground; this information has proved of great value in assisting pilots to avoid underestimating or over-shooting when making night landings.

(e) Wind Indicating Lights.

The Croydon aerodrome has been equipped with apparatus to conform to the system prescribed in the International Air Convention, Annex D, paragraphs 44 and 46.

Twenty-four 100 c.p. lights, covered by suitable glass lenses, are sunk flush with the ground and arranged so as to show a double "L" formation with a neutral zone between the "L's." These lights are switch-controlled from the aerodrome control office and permit of eight different wind directions being indicated. The system is entirely satisfactory in operation; running and maintenance costs are very low, but it is costly to instal. Furthermore, the present control exercised over the arrival and departure of aircraft, which is itself the result of five years' practical experience, eliminates the necessity for a double "L." There are other objections to this double "L" scheme which need no explanation, and it is now being abandoned, and the Convention amended accordingly. Final agreement has not yet been reached regarding the system which will replace the double "L," but it is probable that either three lights arranged in an isosceles triangle will be substituted for the "L," or that an illuminated wind "T" will be employed. This will effect a considerable economy in installation cost, and will also allow full advantage to be taken of whatever good landing area may be available—an important point on the majority of aerodromes.

In the case of aerodromes at which night flying is a regular feature, it will undoubtedly be found advisable to employ electricity as an illuminant for whatever system is finally specified in the Convention, but at those aerodromes at which night flying is infrequent it should be possible to meet the requirements of the Convention by the use of "Money" flares.

The indication of wind direction at emergency landing grounds, at which neither personnel nor electric current are available, has been carried out at Penshurst on the Croydon-Lympne route, by the installation of an automatic illuminated "T." This apparatus consists of a whitened vane-structure forming a horizontal capital "T," with the long arm 20 feet in length, and kept head to wind by suitable vertical fins. Light beams of 27,000 c.p. illuminate the arms from sunset to sunrise, the illuminant being dissolved acetylene gas. The whole apparatus is automatic and operates without attention of any kind for periods of six consecutive months, and has been found an entirely satisfactory method of attaining the object in view.

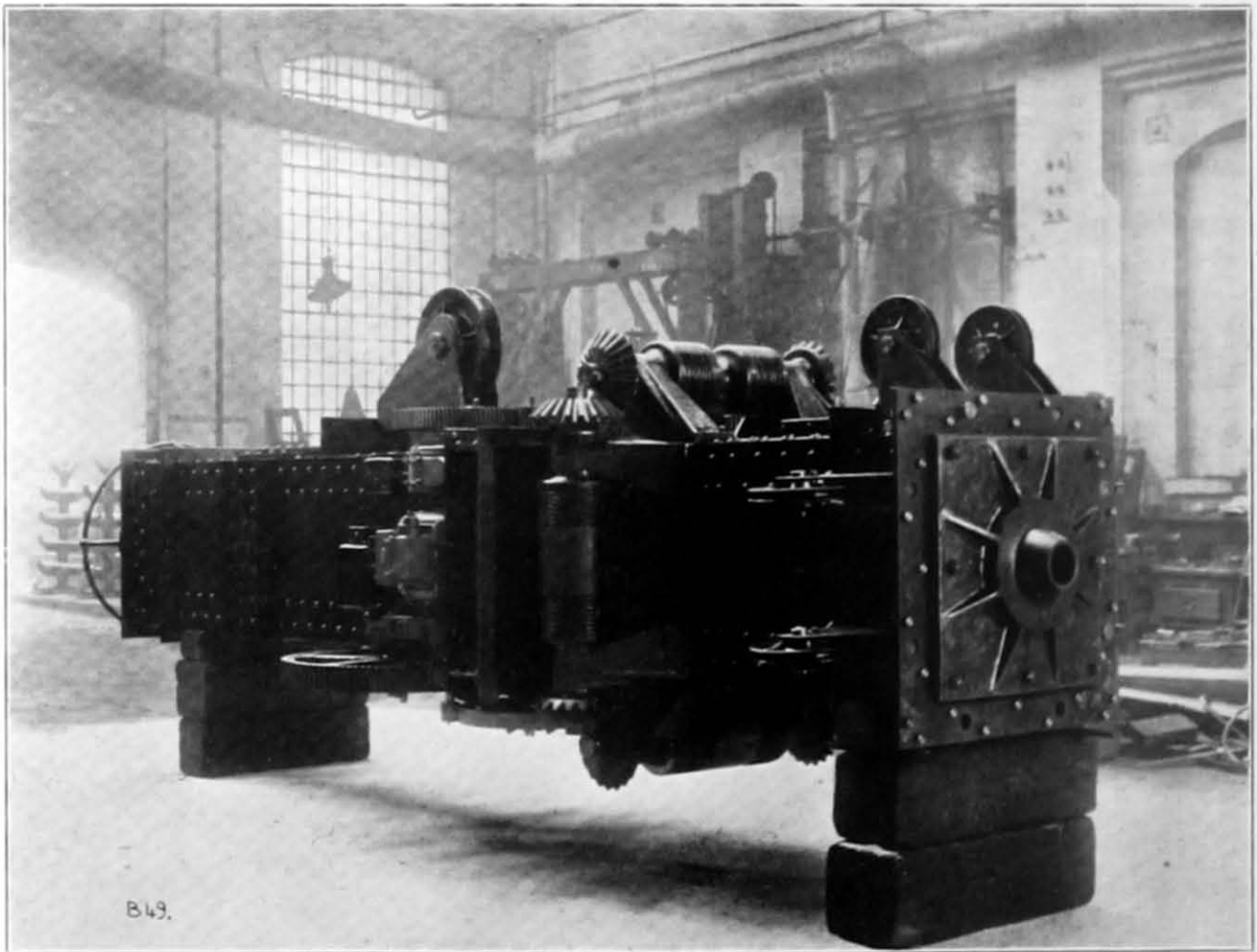
(f) Fog Lighting.

The problem of obtaining adequate illumination during fog and mist is the subject of constant investigation and experiment; up to the present there has not been produced any apparatus which can definitely be regarded as the solution of the fog problem, but recent tests carried out by balloon and aeroplane during fog and mist indicate that the Neon lighting system is of very considerable value in assisting aircraft to locate an aerodrome during fog.

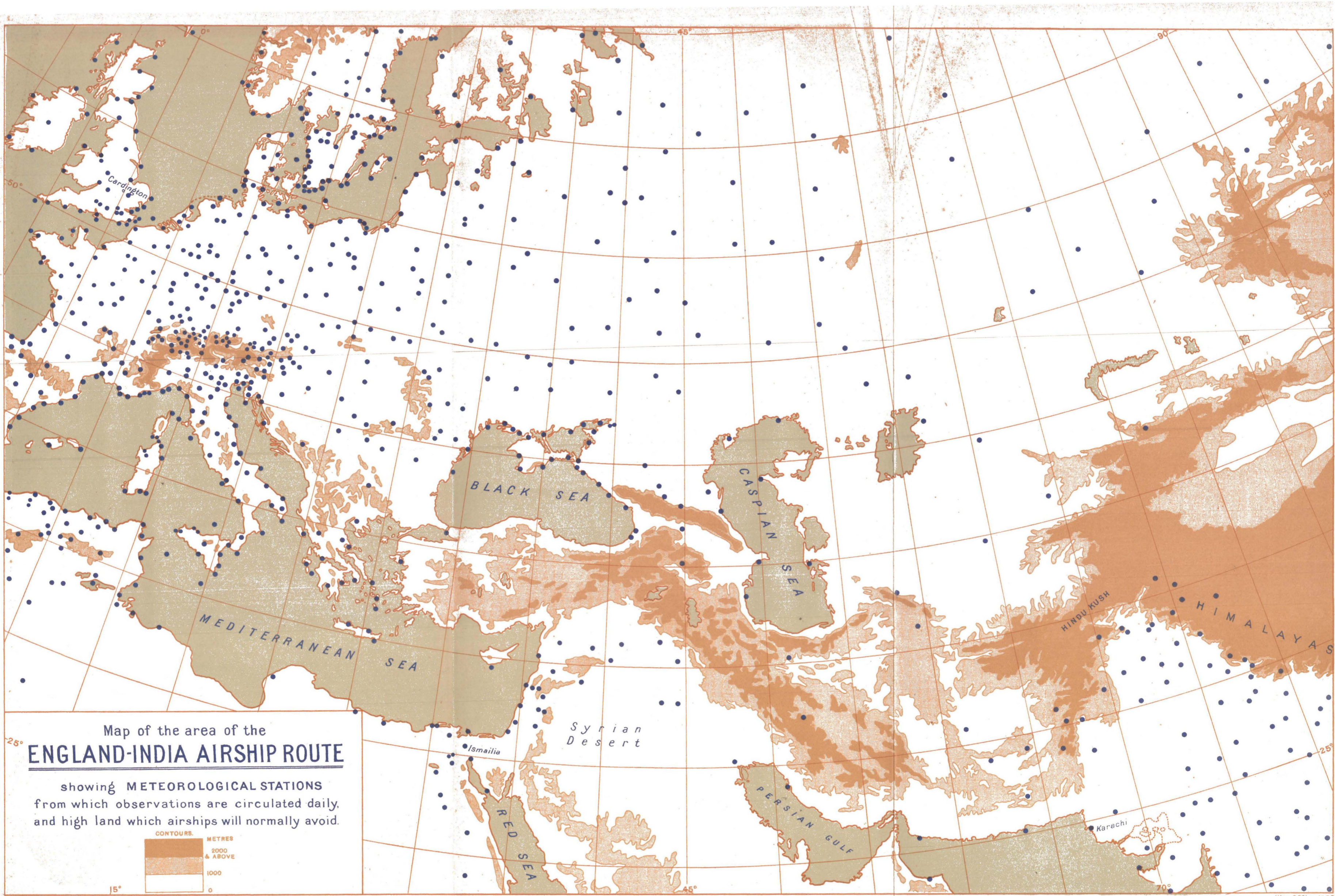
Investigations into the methods of employing the Neon system in conjunction with a form of leader cable apparatus are being pursued, and it is hoped to find a method by which it will be possible to reach, in the operation of civil air transport, a regularity which is at present denied to surface transport during really thick fogs, but this end of course will not be attained without much careful experiment and research.



The Intermediate Refuelling Base in course of construction at Ismailia, Egypt.



The Outer Sleeve of the Receiving Arm which is mounted at the top of the new mooring masts.



Map of the area of the
ENGLAND-INDIA AIRSHIP ROUTE

showing METEOROLOGICAL STATIONS
from which observations are circulated daily,
and high land which airships will normally avoid.



APPENDIX E.

Notes on the Organisation of Airship Services.

I.—THE SITING AND LAY-OUT OF AN AIRSHIP BASE.

Selection of Site.

Whilst the linking up of commercial centres is the main object of high speed airship transport, there are certain operational factors which have to be borne in mind in selecting the precise site for an airship base and settling the type of base to be erected. A commercial airship will normally fly at a height above the ground of about 2,500–3,500 feet. While there is no difficulty in flying higher than this, every 1,000 feet of height means a loss of about one-thirtieth of the total lift, and consequently diminishes the airship's carrying capacity. It follows from this that a site for an airship base should be selected as nearly as possible at sea level, since, if an airship base is situated, say, 2,000 feet above sea level, the airship on leaving would have less useful lift for freight. For the same reason the base should, if possible, not be sited so as to necessitate flying over mountain ranges at the outset or in the early part of the journey, since the ascent can only be made by reducing the load of the airship which is uneconomic from the operating point of view. On the other hand when an airship has been flying for some time and has thus used up a certain weight of fuel, an increase of height can be gained without the same loss of useful load. Due regard should also be paid to weather conditions, especially in choosing a site for a shed base with docking facilities, where an airship may have to be man-handled into the shed. They are not of so great consequence for an intermediate base with mooring mast only, as the airship would always be flown from the mast and not handled on the ground. At the same time local meteorological conditions might affect regularity of service; thus a locality in which thunderstorms are prevalent would generally be unsuitable.

It was on account of climatic conditions that the shed base for India was sited at Karachi, leaving the question of bases at Bombay and Calcutta to be dealt with later.

In the immediate vicinity of a base there should be no obstruction such as hills, high buildings, etc., and any high masts for wireless telegraphy or meteorological purposes should be located as far as possible from the mast and shed, so as not to be a source of danger to an airship landing or leaving.

Local communications should be good to permit of passengers and freight being dealt with expeditiously. A main railway line should be in the vicinity. Feeder services by aeroplane should also be kept in view.

Area for Shed and Mooring Mast Base.

A minimum area of about 600 acres is necessary, but a larger area (up to 1,000 acres) is preferable in order to provide for future extensions, in particular additional mooring masts.

Area for Mooring Mast Base.

A clear space of about 800 yards square (about 130 acres) will suffice for a base with one mast provided there are no buildings of a greater height than 40 feet within 300 yards of the aerodrome. As the space required for landing operations at the mast is only about 100 acres, it is possible to use the remainder for grazing or other purposes. All electric cables in the vicinity of a base should be laid underground.

Drainage and Foundations.

The land should be well drained and not subject to floods. In order to avoid expensive foundations the soil should be suitable for loads of not less than 2 tons per square foot.

Water Supply.*

There should be a plentiful supply of fresh water for ballast and general purposes. Salt water will not serve, owing to its corrosive action on aluminium alloys. The total amount of water required when a base is fully functioning is one of the questions on which the experimental flights will throw light. As an approximate estimate, the following figures may be given :—

For ballast for each airship at the mast	50,000 gallons per day.
For general purposes	20,000 " "
For hydrogen, assuming a production of 1,000,000 cubic feet per week—	
by water gas process <i>or</i>	20,000 " "
by electrolytic process	3-5,000 " "
Average weekly total, say	700,000 gallons.

If a temporary hydrogen plant (silicol) is erected, an additional 200,000 gallons per week would be required.

To meet any emergency a 100,000 gallon reservoir will be necessary, at most sites.

Shed.

The dimensions laid down for the shed in course of erection at Karachi are :—

Length	850 feet.
Width	180 feet.
Height	170 feet.

The shed is constructed to stand a wind pressure :—

- (a) 35 lbs. per square foot horizontally on roof.
- (b) 30 lbs. per square foot horizontally on sides or ends.
- (c) 30 lbs. per square foot horizontally on main sliding doors with doors open or shut.

A shed of the above dimensions will probably meet future requirements for the next 10–15 years, but in any case as sufficient height has been allowed to meet further developments in the design of airships, the question of extension is not a serious matter.

Good ventilation is necessary to allow easy escape of hydrogen, and all electric fittings should be gas tight to prevent explosions.

As contracts for such buildings are of considerable magnitude, the design and execution should be supervised by an Engineer of repute, and only Contractors experienced in this work or used to erecting similar large engineering structures should be invited to tender.

Mooring Mast.

The existing type of mast consists of a steel structure 200 feet high, fitted with a receiving arm at the top to which the airship is anchored. The structure is built to withstand the pull of the airship up to 30 tons in any direction, in addition to a wind force on the structure of 30 lbs. per square foot.

A lift is provided to convey passengers up and down the mast. Mains for hydrogen, water and fuel run up the mast for the replenishment of the ship, and are joined to similar mains in the ship by flexible connections.

The mast should be sited in such a position that an airship arriving or departing does not have to fly over the shed or other high buildings, and in any case these should be at least 800 to 1,000 yards away.

Anchor Points.

Twenty-four snatch block anchor points should be provided to take the sideguys when the airship is landing to the mast. These should be spaced in a circle round the mast at a radius of 750 feet from it, and should be designed to take a maximum pull of 25 tons in any direction. They should be placed flush with the ground to avoid obstruction.

Machinery.

Winches and Boilers.—The machinery for hauling in the airship to the mast, in the existing masts, consists of three steam winches, capable of a 15-ton pull at a speed of 50 feet per minute, and steam is raised by means of oil-fired water tube boilers. The winches are operated by remote controls from the passenger platform

* *Water Supply.*—The quantities stated above are to be regarded as the desirable maxima where normal supplies are available. Where supplies are necessarily restricted, it is estimated that the requirements of a mooring-tower base could be met by the following weekly supplies :—

1-tower base	200,000 gallons.	2-tower base	..	350,000 gallons.
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at the top of the mast, but duplicate controls are also fitted on the winches for use in emergency.

Pumps.—The pumps for fuel and water should have a capacity of 2,500 gallons per hour each, against a head of 400 feet. It is essential that the water pumps should be in duplicate. All machinery is housed in a building at the foot of the mast.

Hydrogen Plant.

The type of hydrogen plant to be provided will vary according to locality and requirements.

There are a number of processes used in connection with hydrogen production, but only three of these have been used to any extent in this country in making hydrogen for aeronautical purposes, viz., iron contact or water gas process, electrolytic process, silicol process.

The latter would not normally be used at permanent bases on account of its high cost of production, but is useful as a temporary arrangement when a large output of gas is required intermittently at low capital cost. An output of 1,000,000 cubic feet per 24 hours can be obtained from a plant costing £20,000 to £25,000. Plants of the iron contact and electrolytic types cost about £80,000, including cost of storage holders of 1,000,000 cubic feet capacity (about £30,000), which are necessary on account of slow rate of production. These figures are for plants capable of producing about 1,000,000 cubic feet per week, which is the amount of gas which should be available at any one time, on a route operated by airships of 5,000,000 cubic feet capacity.

In both the iron contact and electrolytic processes work has to be continuous, and shifts are necessary. The selection of one or the other will depend largely on whether cheap coke or cheap electricity is available.

Power and Light.

If local current is not available, a power plant of 100 kilowatts will probably be required, preferably two 50 kilowatt sets, and two 10 kilowatt sets for light loads such as lighting, and wireless sets, for use when the larger plant is not running. An additional 100 kilowatt set might be needed for a permanent station in regular operation.

Fuel Storage.

A minimum supply of 10,000 gallons of fuel should be available for refuelling airships.

Personnel.*

For the experimental flights of R.100 and R.101 it is estimated that the ground staff at the shed base at Karachi will be about 150, of whom 100 will probably be natives; at the mooring mast base at Ismailia the total may be 100, of whom about 70 may be natives. These figures will be checked and possibly revised as the result of the experimental flights.

Meteorological and Wireless Telegraphy Arrangements.

A local meteorological section is necessary at each airship base to deal with local conditions and to receive reports from other stations, and transmit them to airships in flight. Too much importance cannot be placed on this organisation, as not only is it an aid to safe navigation, but it will also enable an airship to take the most favourable route, and thus facilitate the economical running of an airship line. The main function of Wireless Telegraphy at an airship base will be the transmission of the meteorological data, and the carrying out of direction finding work, as an aid to the usual navigation methods. A local Wireless Telegraphy set should also be available to relay messages through the nearest high-power station. The receiving station and meteorological office should be housed as far as possible in the same building or in the immediate vicinity of each other.

Capital Cost of Bases.

It is very difficult to give a figure for the cost of bases when a regular service is in operation, as so much will depend on the scale and type of accommodation provided for dealing with passengers, mails and freight. The cost of erection will also

* *Personnel.*—It now appears possible in the light of subsequent consideration that the numbers quoted in this paragraph may be capable of substantial reduction; and it is anticipated that for regular flights the ground staff required at the stations mentioned would not be in excess of the following figures:—

Karachi	..	130 (including 100 natives).	Ismailia	..	70 (including 50 natives).
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At a shed base, casual labour (50-100 men) would be required in addition to the permanent staff to handle the airship from the mooring tower to the shed.

vary in different dominions and localities. The following figures, which are based on the cost of the works carried out for the Air Ministry for the purpose of the experimental flights, may serve as a guide to the scale of expenditure involved. Permanent stations on a regularly operated route would probably cost £80,000–£100,000 more to build and equip.

	<i>Mast Base. Demonstration or Experimental Flights.</i>	<i>Shed and Mast Base. Demonstration or Experimental Flights.</i>
	£	£
Shed, 850 feet by 170 feet by 180 feet	—	200,000
Mooring mast, 200 feet, including machinery, fuel storage, hydrogen, water and fuel mains	50,000	50,000
Hydrogen plant, with 500,000 cubic feet gasometer	30,000	30,000
Roads, water mains, electric cable ..	20,000	30,000
Buildings and accommodation for personnel	4,000	14,000
Power house and generating plant ..	6,000	6,000
	<hr/>	<hr/>
Total, exclusive of cost of land ..	£110,000	£330,000

II.—NOTES OF A PRELIMINARY SURVEY OF MAIN AIRSHIP ROUTES.

1. This note sets out the result of a brief preliminary examination of readily available meteorological information with a view to delimiting the areas in which the following main airship routes, if developed with the bases mentioned or with bases similarly distributed, would probably lie :—

<i>Route.</i>	<i>Bases.</i>
(a) England–Egypt–India	Ismailia (Egypt) Karachi.
(b) England–Egypt–S. Africa	Ismailia, Mombasa, Durban.
(c) England–S. Africa via West Coast ..	Bathurst, Cape Town.
(d) England–Australia via India	As in (a) together with Colombo, Perth, Melbourne.
(e) England–Australia via S. Africa ..	As in (b) or (c) together with Perth, Melbourne.
(f) England–Canada	Ottawa.

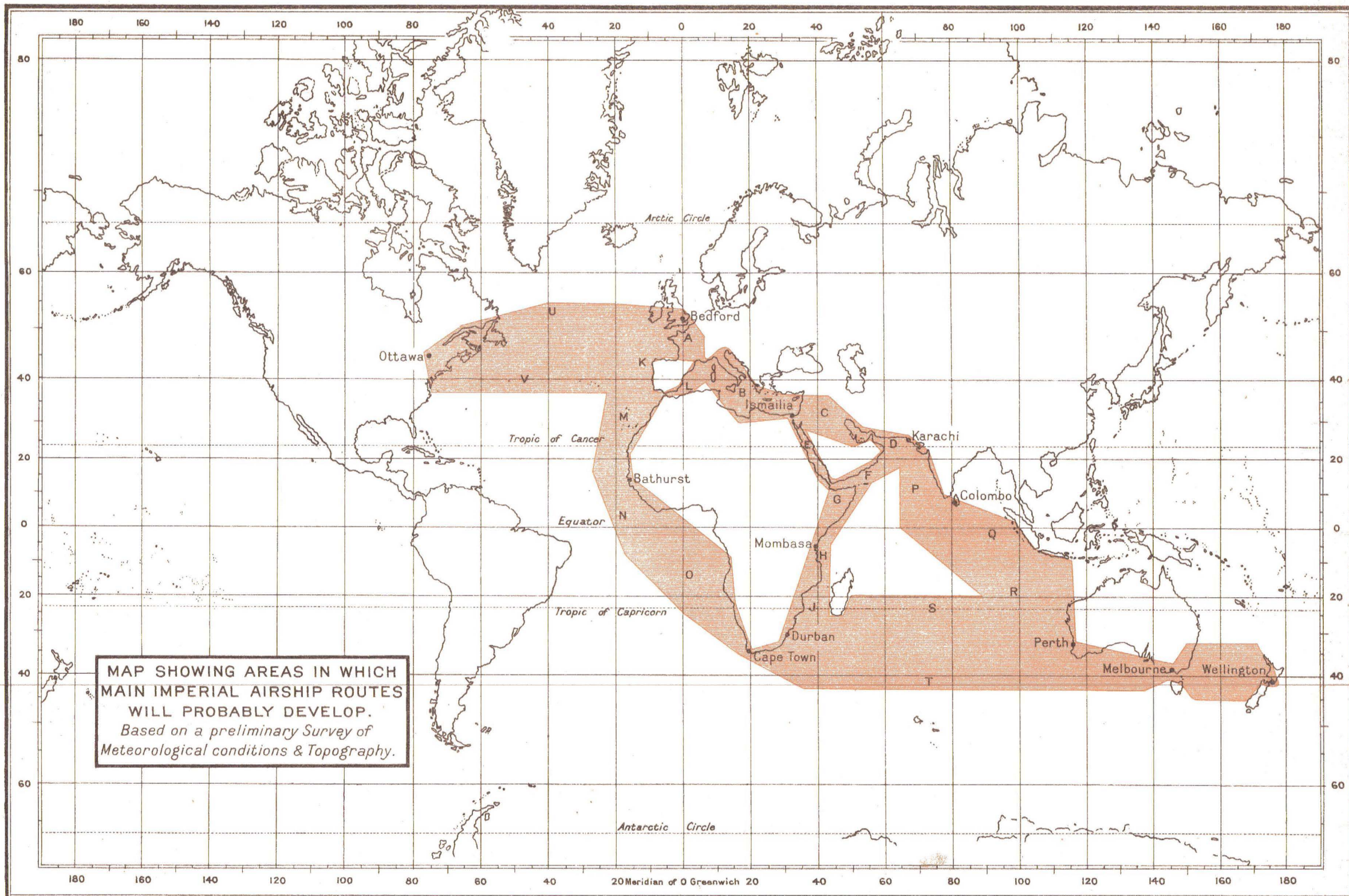
2. The maximum flying height is taken as 6,000 feet above mean sea level so that in addition to meteorological factors the topography of the land areas has to be taken into account.

The meteorological factors to be considered in such a preliminary examination as this are :—

- (i) The prevailing winds and their constancy.
- (ii) Areas particularly subject to strong vertical atmospheric currents such as pronounced thunderstorm areas.
- (iii) Regions subject to heavy rains or to considerable snowfall.
- (iv) Regions subject to strong vertical temperature gradients such as desert areas in the daytime.
- (v) Areas subject to intense disturbances of the tropical cyclone or tornado type.

3. The coloured portion of the accompanying map shows the areas chosen from the above considerations, within which it is probable that the best main Imperial Airship routes could be developed. There are of course no large areas free from the undesirable phenomena mentioned above, but the areas chosen are those which probably offer the best possibilities for long distance airship flying.

IMPERIAL AIRSHIP ROUTES



4. Before the development of actual routes for regular services, the next step is to subject each of the chosen areas to an intensive meteorological investigation, each route needing a period of about two years work, for the purpose of :—

- (a) Choosing the best *normal* routes from base to base. These may be different for different months and may be different in the two directions.
- (b) Exhibiting the various types of conditions which may be met in individual flights.
- (c) Developing a meteorological and communications organisation for reporting actual conditions along the routes and for forecasting changes, so that the *normal* route, which would be followed in the absence of any reason to the contrary, might be varied on any particular occasion if necessary for safe or economical flying.
- (d) Examining in detail the conditions in the vicinity of airship bases.

Such an investigation involves the examination and co-ordination of all relevant data and information, and the supplementing of those by special observations where necessary.

The intensive investigation of the England–Egypt–India route is now in progress, and a later section sets out details of what is involved in such a study of any route. In the next paragraph, which briefly describes the generalised routes indicated on the accompanying map, reference will therefore be confined to one or two points special to each route, requiring particular attention.

5. (a) England–Egypt–India.

The areas in which the *first part* of this route, viz., England–Egypt, are likely to develop are indicated on the map by the letters A, B, i.e., France and the Mediterranean. Apart from any political reasons which there may be, routes via Central Europe and the Balkans, although possibly shorter in actual distance, are not considered practicable, on account of the distribution of high land, summer thunderstorms and winter snowfall, as compared with the areas chosen.

The distribution of summer thunderstorms over France will play a large part in deciding the route across the South of France, whether by the Rhone Valley or over the Toulouse area.

The wind distribution over France and Southern England will play an important rôle, too, in the choice of routes. For example, with light winds over the south of France and stronger south-westerly winds over northern France and southern England it would be economical for an airship to follow a route from the south of France to England via the *west* coast of France to secure the assistance of the wind during the latter stages of the passage.

The “Mistral” or strong northerly winds which often occur on the south coast of France need special investigation, both as to horizontal and vertical extent, and as to persistence, as all possible routes here pass through a relatively narrow neck in which the “Mistral” occurs.

In the Mediterranean area B, there is a marked contrast of weather conditions between the south and north of the area, especially in winter and this merits special attention.

The *second part* of the England–India route is calling for the examination of alternative areas, viz. : via the Persian Gulf, lettered C, D, or via the Red Sea, lettered E, F, these alternatives being suggested by the prevailing winds at different seasons, e.g., during the period of the south-west monsoon a following wind should be obtained along the whole route from Egypt to India via Aden, N.W. winds in the Red Sea, area E, and S.W. in the Arabian Sea, area F.

Area C may have to be crossed in the night during the hot weather on account of strong vertical temperature gradients. This is possible in the direction Egypt–India but the prevailing north-westerly winds need close examination as to variability of strength, horizontally, vertically and in time, as affecting the passage in the other direction.

Areas F and D are affected by Arabian Sea cyclones in the seasons April to June and October to November.

At the airship bases two important investigations in connection with airship mooring are (a) the rate of change of wind speed and direction in gusts and the horizontal extent of these, which is being treated experimentally at the Cardington

base in England ; (b) the vertical temperature gradient in the first 250 feet above the surface and its diurnal variation, which is important at bases in *hot* climates such as those of Ismailia and Karachi.

The above are given as examples of special points needing attention. The systematic meteorological investigation of this route is proceeding in the manner indicated in a later section.

(b) England-Egypt-South Africa.

The *first part* lies in the areas A, B, already referred to in connection with the England-Egypt-India route.

The *second part* from Egypt to South Africa would probably develop in the area E, G, H, J. A direct inland route from Lower Egypt to South Africa compares unfavourably as regards thunderstorms, tropical rains and probably as regards vertical temperature gradients while the distribution of high land is an additional factor.

Section G may have to be crossed by night in view of strong vertical temperature gradients during the day. The route crosses the "Doldrum" belt H, with its tropical rains and thunderstorms, as any route from northern to southern hemisphere must, but on this coast of Africa this belt is very much reduced in intensity during the period of the south-west monsoon in India.

The need for crossing the tropical rain belt would call for special examination of the distribution of rain and thunder from day to day, its variability, diurnal variation over the land, relative width of the belt over land and sea, etc.

In area G strong persistent head winds would be met on a southward passage during the south-west monsoon period. Investigations would be needed as to whether a route over the inland part of the area G would be an advantage when southward bound at this time, or whether a variation of flying height within the possible range of 6,000 feet would serve. A special investigation by pilot balloon ascents would be called for.

The hurricanes of the South Indian Ocean normally remain east of Madagascar, and do not as a rule affect area J, but the bad reputation this area has with seamen as regards squally weather calls for special examination from the airship point of view.

The rate of rainfall at Mombasa during tropical rains may have an important bearing on the mooring of airships there and would require attention.

(c) England-South Africa, via West Coast.

The route would be either via K, M, N, O, or A, L, M, N, O, the second being employed, for example, on a southward passage when strong south-westerlies were blowing over southern England and the Bay region to Portugal.

The use of the west coast route to South Africa turns largely on the variation of wind with height in the north-east trade wind, region M, and the south-east trade wind, region O. Available records suggest that the trade winds in both these areas, which lie on the eastern side of the Atlantic Ocean, are often shallow, calms or an anti-trade being encountered within the first 6,000 feet. During a passage in either direction a low altitude would be chosen at first and a higher altitude later, when the "Doldrum" belt N, had been crossed. This would be convenient, for it is during the latter part of a long voyage that it is most practicable to increase altitude. Further observations of upper wind in areas M and O would be required, by means of pilot balloon ascents from ships and island stations.

The "Doldrum" belt is crossed in the region N, and as in the case of the Indian Ocean, conditions here as to showers, thunderstorms and squalls need special attention.

The area chosen avoids the part of the Gulf of Guinea where thunderstorms and tornadoes are particularly prevalent.

(d) England-Australia, via India.

The *first part* from England to India would be as already mentioned.

The *second part* from India to Australia would probably develop in the area P, Q, R, thus avoiding the Java area, which is the worst known region in the world for thunderstorms, and the Bay of Bengal, where cyclones are more frequent than in the Arabian Sea.

The prevailing winds are an important factor in this case. For example, during the south-west monsoon period a following wind would be obtained all the way from Perth to Karachi by following the western margin of the area, the south-east trade serving first and then the south-west monsoon.

In the reverse direction the south-east trade would be encountered as a head wind at all seasons, especially the south-west monsoon period. A special investigation would be called for in this connection to determine whether the south-east trade is shallow in area R. More favourable conditions from the wind point of view would probably be obtained by keeping to the east side of the area in the direction India-Australia, but investigation would be needed to see how near the Java thunderstorm maximum it would be practicable to go in area Q.

Area P in common with D and F, is subject to tropical cyclones in the seasons April to June, and October to November.

Area R is subject to tropical cyclones in the period December to April.

(e) England-Australia, via South Africa.

The *first part* would be as in (b) or (c) above.

The *second part*, South Africa to Australia, would lie in the area S, T.

The route from South Africa towards Australia would lie in the southern area T, where westerly winds prevail, and the route in the other direction would lie in the northern area S, where advantage would be taken of the south-east trades. There would be a small north and south seasonal displacement of the routes, within the area S, T.

Special points for consideration are (a) the occurrence of hurricanes in area S, in the period November to May; (b) to what extent line squalls or snow occur in area T, which lies on the northern margin of the belt in which the depressions of the southern temperate zone move from west to east.

(f) England-Canada.

This route would probably develop in the area U, V, the passage from England to Canada tending to be made in the southern part, and the passage in the other direction more nearly along the great circle track which bounds the area on the north.

The whole area is subject to the depressions of the northern temperate regions, and a special subject for attention would be the occurrence and intensity of line squalls, thunderstorms and snowfall over the sea.

III.—METEOROLOGICAL ORGANISATION IN CONNECTION WITH THE DEVELOPMENT AND OPERATION OF AIRSHIP SERVICES.

1. General Procedure.

1. The meteorological work in connection with airship development and operation falls into two sections:—

- (a) Investigational work.
- (b) Provision of a meteorological reporting and forecasting service in conjunction with the communications organisation.

2. The purpose of the investigational work is to provide essential information in connection with—

- (a) The development of airship design.
- (b) The development of airship mooring.
- (c) The choice of airship bases.
- (d) The choice of "normal" airship routes.
- (e) The development of the meteorological reporting and forecasting service.

3. The purpose of the meteorological reporting and forecasting service is to provide, on the occasion of actual flights, immediate information as to the existing meteorological conditions over the area between the bases, and at the bases, together with forecasts of changes.

4. The information provided by the meteorological organisation serves two distinct purposes by assisting in securing—

- (a) Economical flying.
- (b) Safe flying.

5. A division of the Meteorological Office, Air Ministry, was created early in 1925, to deal specially with the projected England–Egypt–India airship service, and the experience gained forms the basis of this memorandum.

6. Having decided the points between which it is desired to develop an airship service, the first step is to make a preliminary examination of meteorological conditions on the basis of existing knowledge and, considering this, together with topography, since 6,000 feet above mean sea level may be taken as the maximum flying height, to delimit *areas* within which the most practicable routes from base to base would probably develop.

In the case of the England–Egypt–India service, this was done when meteorological work commenced. It has now been extended to Australia and New Zealand, South Africa and Canada. Further details are given in the preceding section.

7. The next step is to undertake an intensive and systematic meteorological investigation of the chosen areas (and such other areas as the development of methods of forecasting for the airship routes may demand). This meteorological investigational work is considered in greater detail below, where illustrations are given from the work already carried out in connection with the England–Egypt–India route.

8. The systematic meteorological investigation having reached a sufficiently advanced stage, the choice of “normal” routes in each direction for each month of the year may be made, avoiding as far as possible regions where undesirable phenomena, such as thunderstorms, have a maximum frequency and selecting as far as possible regions (or heights) where favourable winds predominate.

9. It is an important principle that these “normal” routes are not necessarily routes which will *always* be followed. In the absence of any reason to the contrary, the “normal” route would hold, but it is to be expected that alternative routes on either side will be followed from time to time when the meteorological reports indicate that it would be in the interests of economy or safety to do so.

10. A two years’ systematic study of the area in which each main airship service is to be developed should result in the collection of sufficient information for the preparation of a first edition of a handbook and a meteorological atlas for each service, providing for the upper air descriptive matter and charts, such as the mariner has for the oceans.

Investigational work would then proceed, having in view the periodic amendment and amplification of these, and by this time the airships themselves would be in a position to assist by the keeping of a systematic log on board.

11. In addition to the systematic meteorological investigations, it is necessary to undertake the development of the required meteorological reporting and forecasting service. The two pieces of work can proceed simultaneously, the results of the former being taken into account in connection with the latter. The reporting and forecasting service is dealt with in more detail below where reference is made to the organisation at present being developed between England and India.

A period of two years’ work on these is the minimum required prior to the inauguration of each airship *service*, though circumstances may necessitate a shorter period of preparation for demonstration flights.

2. Meteorological Investigational Work.

1. The first step in the meteorological investigational work is the provision of a suitable working chart, conforming as far as is practicable to the resolution of the International Meteorological Committee, on the subject of the projection and scale of meteorological charts, passed at the meeting in London, 1921.

(The working chart specially prepared for the investigational work for the England–Egypt–India route is an outline map in green on paper 40 inches by 30 inches, shaded to show contours for 200, 1,000, 2,000 and 3,000 metres. The projection is conical orthomorphic with two standard parallels, 50° N., and 20° N., where the scale is $\frac{1}{10}$ of 1 : 10,000,000. The area covered embraces Iceland, Jan Mayn and

Bear Island in the north, the Azores, Madeira and Canaries in the west, the Sudan, Abyssinia and Ceylon in the south, and Rangoon and the Andaman Islands in the east. This area is considerably greater than that in which the actual routes between England and India are likely to develop (areas A, B, C, D, E, F of accompanying map), the reason being that in studying meteorological conditions in that area with a view to forecasting, it is necessary to consider those outside it, especially to the north, on which they largely depend.)

2. The study divides itself into two sections :—

- (a) Conditions in the vicinity of airship bases ;
- (b) Conditions in the areas chosen to contain the airship routes ;

and consists in co-ordinating all available data and information and the supplementing of those by special observations where necessary.

3. In each section of the study it is necessary to consider not only

- (a) the average conditions for each month of the year, but also
- (b) the meteorological conditions which may occur on individual occasions and the way in which they change,

the latter being the more important in many ways.

4. The study of the meteorological conditions in the vicinity of airship bases aims at the provision of—

- (a) An ordinary climatological summary giving the monthly means and extremes of the usual elements and the frequency of occurrence of gales, thunderstorms, etc.
- (b) Information as to the wind, temperature and humidity régime at the surface and up to a height of about 10,000 feet, particularly diurnal variation.
- (c) More detailed information as to wind and temperature in the first 250 feet above the surface, which includes the level at which an airship is moored. This is specially important in hot climates.

(It may be mentioned, by way of example that, in connection with the England-Egypt-India service—

- (1) A special study of the rate of change of wind in gusts and the horizontal extent of gusts has been initiated at the Cardington Airship base, employing an electrically synchronised network of four self-recording anemometers of pressure-tube type.
- (2) The study of the diurnal variation of wind in the upper air at the Ismailia base in Egypt is being made by a special programme of pilot balloon ascents, and a study of the diurnal variation of temperature and humidity in the upper air is proceeding by means of a special programme of observations from aeroplanes with the co-operation of the Royal Air Force.
- (3) Details of a suitable installation for giving a continuous record of temperature and temperature gradient from the ground up to a height of 250 feet have been worked out with a view to erection at Ismailia.)

5. The study of conditions in the areas chosen to contain airship routes aims at the provision of—

- (a) Charts showing the average monthly distribution of the usual meteorological elements, sea-level pressure, temperature, rainfall, etc.
- (b) Information, as detailed as possible, of the average distribution of thunderstorms in each month.
- (c) Information as to the occurrence of hail, snow, heavy rain, sand storms, water-spouts or tornadoes, line squalls, tropical revolving storms, etc.
- (d) Information as to the normal distribution of wind and temperature up to about 10,000 feet ;

and, in addition to the above,

- (e) Particulars of the types of meteorological conditions which occur on individual days and their day to day changes, necessitating the preparation of a series of daily synoptic charts for the whole route, for a period of at least a year.

(In the case of the England–Egypt–India service this work is proceeding, the results being represented cartographically, wherever possible, on the charts described in paragraph 1 of this note.

Particular mention may be made of—

- (1) the monthly charts of the average frequency of thunderstorms. These are found to exhibit regional variations likely to play a large part in the choice of “normal” routes.
- (2) the distribution of upper winds. Observations by pilot balloon are available over a large section of the area, including Egypt and Iraq, and these are being summarised on the plan recommended by the International Commission for Air Navigation, which provides for frequency summaries for the levels 500, 1,000, 2,000, 3,000 m, for each month. The results are being represented by means of “wind roses” on a set of 48 charts (for four levels for twelve months), and these charts are also to show the computed distribution of barometric pressure at the corresponding level. This will provide for the upper air a set of charts analogous to those for the surface, which have long been available to seamen.
- (3) the examination of the types of conditions which occur on individual days along the whole stretch from England to India. Various sections are covered by the daily weather charts published by various countries. Utilising these, and supplementing them by data extracted from climatological registers, ships’ logs, etc., a set of daily weather charts for a whole year is being constructed on the working charts described in paragraph 1 of this note, and covering the area of those charts. The map on the opposite page shows approximately the distribution of stations readily available. These charts will provide valuable experience before flying commences and will provide the means of studying the various types of conditions, their evolution or persistence, situations in which dangerous or undesirable phenomena occur and the warning obtainable.)

3. Meteorological Reporting and Forecasting Service.

1. The service must be arranged to meet the separate requirements of—
 - (a) Airships moored at a base.
 - (b) Airships in flight.
2. The main requirements of airships moored at a base embrace the provision of—
 - (a) A meteorological register, and continuous records from self-recording instruments of all the usual meteorological elements.
 - (b) Continuous records from special self-recording instruments, of the vertical temperature gradient from the ground up to a height of 250 feet, and also of the wind at a level approximating to that of the top of the mooring mast (200 feet).
 - (c) Routine reports and forecasts of local conditions, normally four times a day.
 - (d) Special warnings at intermediate times when necessary.
 - (e) Charts showing conditions along the routes, for discussion with the airship officers and copies of the latest charts to be handed to the responsible officer when an airship is leaving a base.

The meteorological elements of *special* importance in the present connection are—

Wind.—Strength and direction, gustiness and sudden changes.

Temperature.—Vertical gradient, fluctuations, and sudden changes.

Precipitation.—Rain, hail or snow. Rate of fall.

3. The main requirements of airships in flight embrace the provision by wireless of—

- (a) Data for the construction of weather charts on board the airship.
- (b) Routine forecasts, for use in conjunction with these charts.
- (c) Special warnings at intermediate times when necessary.

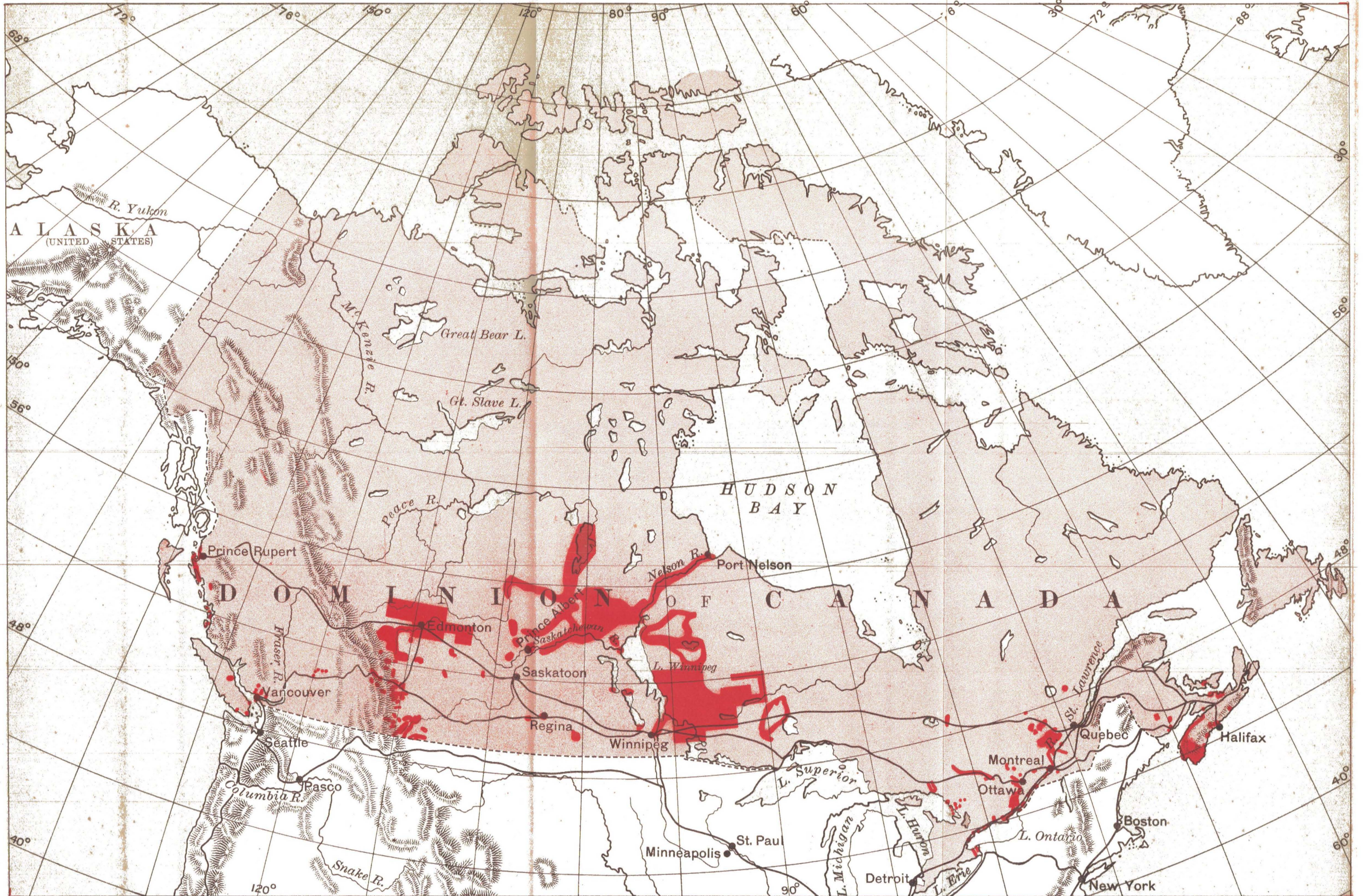
The meteorological conditions of *special* importance in this connection are—

Wind.—The wind distribution at various heights up to 6,000 feet.

Vertical atmospheric currents.—Indication of areas where they are likely to be pronounced.

MAP OF CANADA

Areas in Canada covered by Aerial Photographs taken prior to July 1st 1926, shown in Red.



Temperature.—Vertical Gradient up to 6,000 feet, especially levels of stable layers or “inversions.”

Thunderstorms or squalls.—Particularly as being associated with pronounced vertical atmospheric currents, or with violent whirls such as tornadoes or waterspouts.

4. In order to meet the above requirements it is necessary to have—

- (a) A network of meteorological observing stations along and for some distance on either side of the stretches containing the airship routes, a selection of the stations being equipped for the measurement of upper winds (and some, when practicable, for upper air temperature and humidity). In addition, a first order, specially equipped station at each airship base.
- (b) A number of centres for the collection of reports from this network of observing stations normally four times a day, for the co-ordination of the reports and for the distribution of information to the airship staff. These centres consist of the airship bases, with intermediate centres where necessary, with a staff so qualified as to be capable of developing the meteorology of their section on modern lines based on physical principles, and sufficient in number to maintain a continuous 24 hour watch, when an airship is in the air or moored at a mast.
- (c) A communications organisation for—
 - (1) the transmission of the individual reports to the centres.
 - (2) the transmission of information between any centre and the airship in the air in the region between that centre and the next.
 - (3) rapid intercommunication between adjacent centres.

The efficiency of the meteorological service depends largely on that of the communications organisation.

(In the case of the England–Egypt–India service—

- (i) the network of observing stations will be composed largely of the existing network of the various countries, the observations at which are broadcast by wireless from the meteorological centres of these countries at fixed hours daily, forming a regular international exchange of information. It remains to establish certain new stations in the eastern half of the route, and to bring this section into the scheme of international broadcasting. Further it will be very necessary to supplement the land network by reports from ships in the Mediterranean, Red Sea, Arabian Sea and Persian Gulf, and this is under consideration.
- (ii) the proposed forecasting centres are four in number, viz., the three airship bases Cardington (England), Ismailia (Egypt) and Karachi (India), together with an intermediate centre at Malta.
- (iii) the proposed communications organisation for the distributive part of the meteorological service involves the use of high power wireless stations associated with each of these four meteorological forecasting centres, together with intermediate wireless stations at Baghdad and Aden.

In addition, there is the organisation required for the collection of data at the forecasting centres from individual stations in its own area, and for the interception of the international broadcasts for other areas).

APPENDIX F.

SOME SPECIAL USES OF AEROPLANES.

1. Air Survey.

It is doubtful if there is any branch of aviation which holds out a greater prospect of commercial success, with corresponding benefits to the service which it aids, than air survey.

It is hardly necessary to recall that while some of the problems had been studied in connection with ground photography, particularly in mountainous regions, and while attempts had been made to obtain photographs from balloons, air survey had its real birth during the war, when, following the use of air photographs for reconnaissance purposes, they were used for such purposes as the revision of trench maps and the plotting of hostile battery positions. In the brief space of 10 years immense progress has been made in the study of the many mathematical and physical problems involved, and in the design of apparatus, both for photography and for plotting from the photographs.

In the application of air survey in a practical way, no country has gone further than Canada, where it was early recognised that the peculiar conditions of terrain to be dealt with, while opposing great difficulties to the ground surveyor, lent themselves very readily to treatment by air photography. A simple graphical method of plotting was evolved which gave all the accuracy required, and in consequence, a constantly increasing area has been surveyed each year, reaching 40,000 square miles in 1924 and approximately 60,000 square miles in 1925.

While no other country has carried out air survey on this scale, experimental work, as well as actual surveys have been carried out in all the more progressive countries of the world, with the result that many countries have now definitely included air survey in their survey programmes. In Great Britain, which is generally recognised to possess the finest survey in the world, there has been little scope for practical work on a large scale, and activities have mostly centred in the Air Survey Committee, an inter-departmental body, whose function is to study the whole problem, mainly from a military point of view.

The principal difficulty in air survey—that of plotting from the photographs—is introduced by the departure of the camera axis from the vertical, the inequalities of height of the ground surface and to a less extent, the imperfections of the camera, particularly the lens. Were these disturbing factors removed, the air photograph would be the pictorial equivalent of a map of slightly varying scale. The means by which they are corrected and the scale rendered uniform depend on the provision of adequate control points fixed by ground surveyors. Many different methods of carrying out the corrections depending on graphical, mathematical and mechanical means have been devised in this and other countries. Some of the more recent developments in this direction have gone far to remove the difficulty, which once existed, of plotting from an air photograph of hilly country. Not only can the plan be drawn, but contours of considerable accuracy can also be plotted. An excellent idea of the graphical method, as applied to oblique photographs in Canada, can be obtained from the illustration on the opposite page.

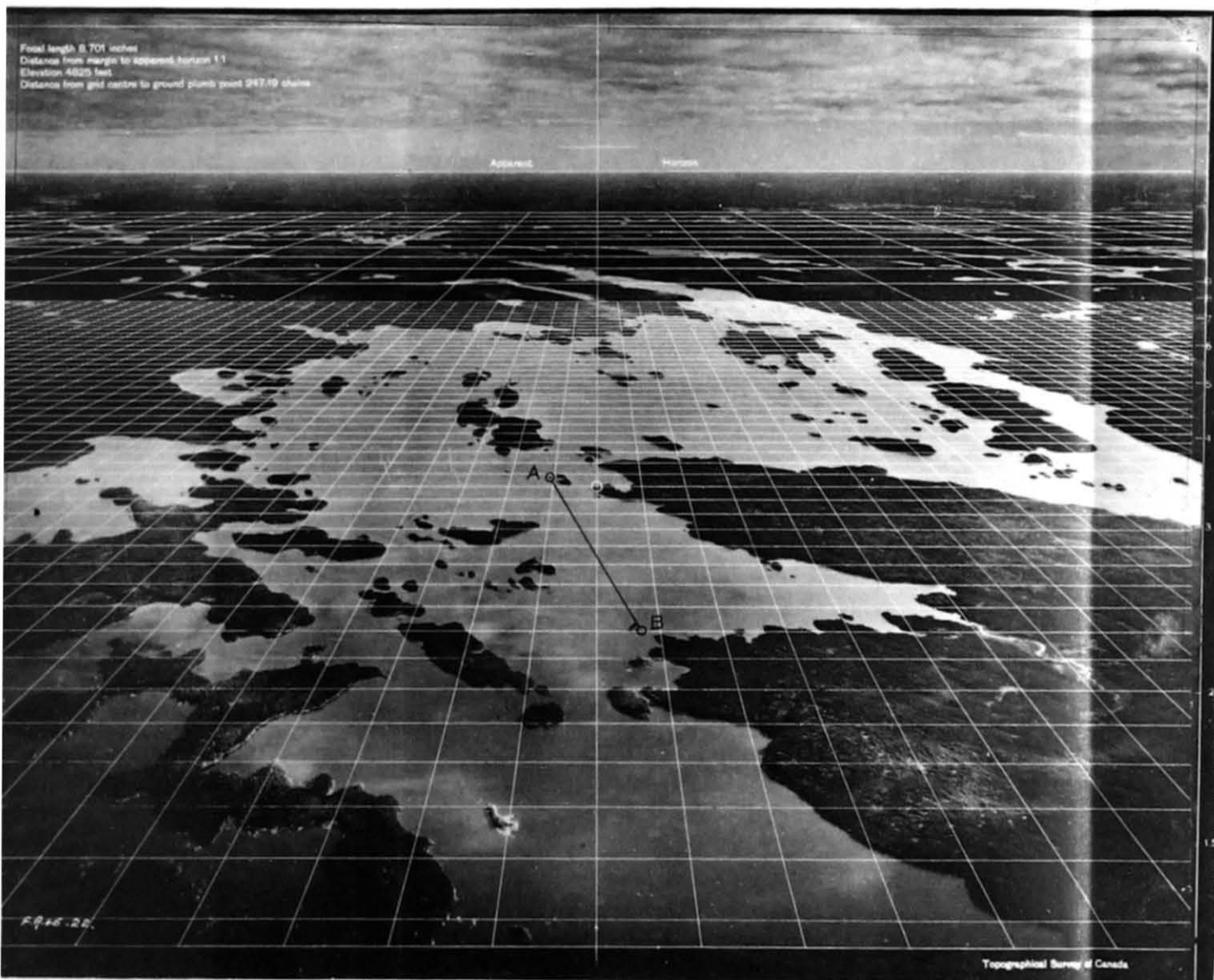
British Apparatus.—The most notable development in this country has been the production of the "Eagle" aerial camera, which is the commercial prototype of a camera developed by the Royal Aircraft Establishment; it is now marketed by Vickers, Ltd. This is a film camera taking film spools of 100 exposures, 7 inches by 7 inches, and interchangeable lenses of varying focal length. It is entirely automatic in action, and provision is made for recording on the film certain essential data with regard to time, altitude, etc. It is generally considered that this camera represents a marked improvement on other existing cameras for topographic air survey.

The Air Survey Committee has also been responsible for the development of instruments to assist in plotting, notably the tilt finder, the camera plastica and a photogrammetric plotter, which is now nearing completion.

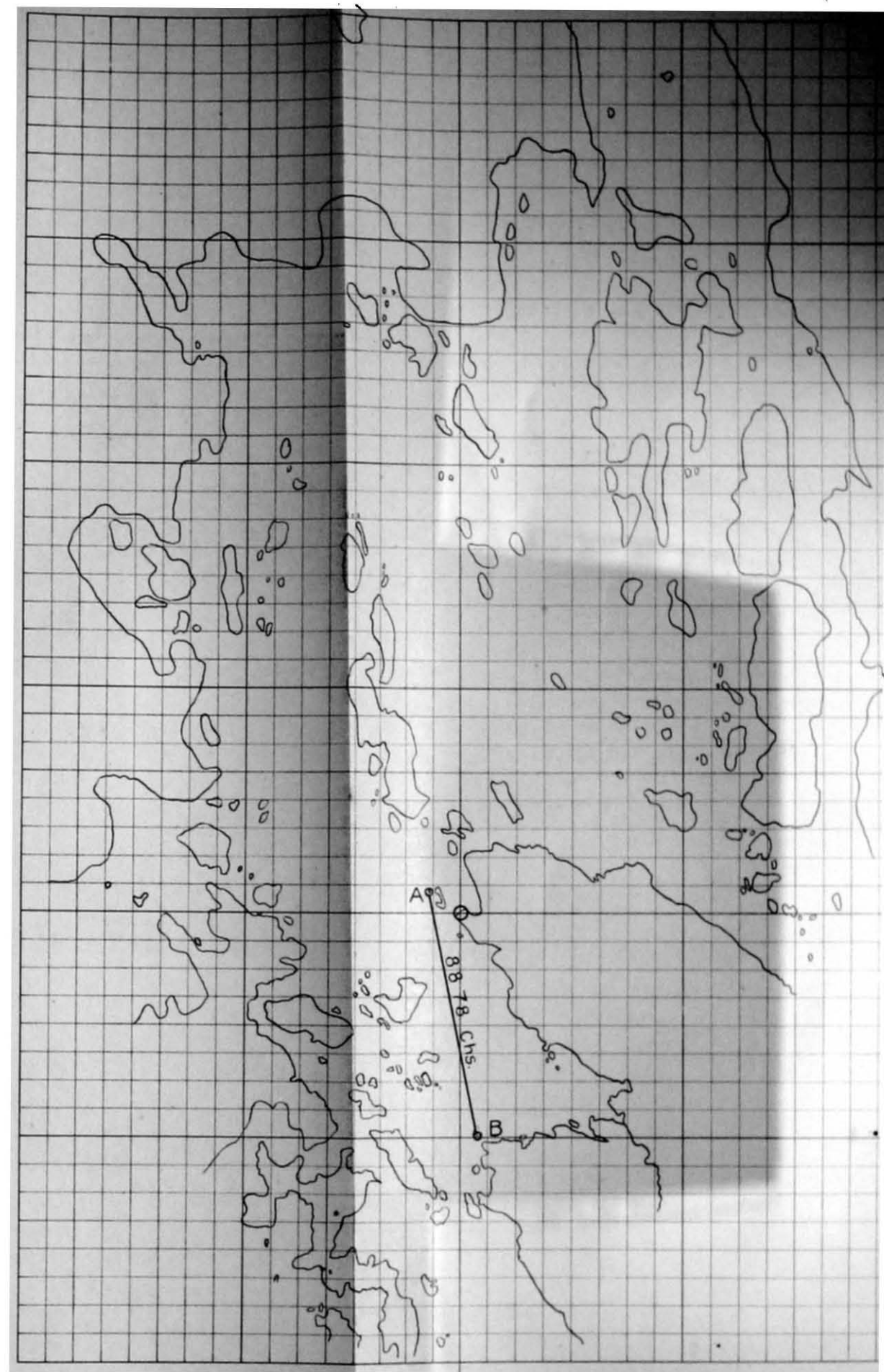
CORRECT GLASS GRID SUPERIMPOSED ON PHOTO

ELEVATION—4825 FEET

MARGINAL DISTANCE—1.1 INCHES



An illustration of the method used in Canada for plotting the detail from an oblique photograph of level country, by means of a perspective grid.



COMPILATION FROM OPPOSITE PHOTOGRAPH

○ Ground Plumb Point

Instruments have been produced also to assist the pilot and photographer in the more accurate navigation of the aircraft, a point of very considerable importance in relation to costs. The most notable of these sights is the Aldis camera aiming sight.

While, as yet, no aircraft has been produced in this country specially for air survey, there is fairly general agreement among all operators in this and other countries as to the type of machine required. Such machines will go far to reduce costs, and will be produced as soon as the volume of commercial air survey warrants it. It is of interest to note that a special machine is being produced in Canada for this work.

Surveys done, and Costs.—It is not possible to give anything approaching a comprehensive statement of the air survey work which has been carried out. It would in itself be too extensive, and the task is rendered more difficult because the work has been spread over a vast number of minor operations, many of which have been of an experimental nature. For the same reason, it is difficult to give figures which give any indication of commercial costs for future work. Estimates are of little value, since varying conditions greatly affect costs. There are now, however, clear indications from many countries that air survey has reached a practical stage, and on purely economic grounds is taking its place in the normal mapping programmes of the world, particularly under the conditions for which it is specially adapted.

The survey work of Canada has already been referred to. Most of the photographic work has been carried out by the Royal Canadian Air Force. The survey work, the mapping from photographs, and the co-ordination of the demands of all Departments for air photographs is carried out by the Topographical Survey Department. The Province of Ontario established its own civil air service of 15 aircraft in the spring of 1924 for air survey and forest protection work. The Province of Quebec on the other hand has adopted the practice of placing work out to contract. In this Province, the Dominion Aerial Exploration Co., the Fairchild Aerial Surveys (of Canada), Ltd., and Brock & Weymouth all carry out photographic air survey work. While most of the photographic survey work carried out both by the R.C.A.F. and the civil organisations is mapping of undeveloped regions or forests, a considerable amount of map revision of settled districts has been carried out by air photography. The Report on Civil Aviation in Canada for 1924 emphasises that "the survey services are now certain that by the use of aerial photography they can reduce this ground work by more than half; and, at the same time, can produce maps infinitely more complete and accurate, in much less time, than by the older methods." At the same time, with regard to map revision in settled districts, it is emphasised that a mass of useful information is immediately available from air photographs which "could be obtained by ordinary survey methods only after laborious field work." The opinion is quoted that "there is a remarkable saving of time and labour by having available the air photographs."

Costs of work in Canada are not available, but the Report referred to leaves no doubt that all Departments are satisfied that they obtain economy, not only of time, but of money by the use of aircraft in survey operations. One authority says: "We use the aerial sketch method of survey for economy as well as for speed in obtaining required information. Although the ground work necessary to complete the report on the area surveyed has not yet been done, we are confident that we shall effect a saving of one-third of the cost of our regular 2½ per cent. strip survey, by this method."

Australia, through the medium of the Royal Australian Navy and Royal Australian Air Force, has undertaken a task of great interest in the photographic survey of the Great Barrier Reef.

In the United States, operations of considerable magnitude have been carried out both by the military air service and by commercial organisations. Brock & Weymouth, and Fairchild Aerial Surveys Inc., are the principal commercial air survey operators. In 1925 the United States Geological Survey used air photographs for the mapping of 6,857 square miles, this being 39 per cent. of the entire area mapped by them. The Department's demand for 1926 covers 36,000 square miles. In the "Report of the Committee on Photographic Surveying of the Federal Board of Surveys and Maps" it is stated that "as a result of the recent work of the United States Geological Survey, savings have ranged from 0 to 50 per cent. and there has been a considerable shortening of the time required to accomplish the field work."

In the United States, as in Canada, air photographs are used in the preparation of plane table field sheets, with results which indicate greater savings than those quoted above. The report quoted states that the greatest saving is shown in map revision by air photography. In some cases practically the whole of the work has been done by air photography, with a saving of as much as 75 per cent. of the cost of ground methods. In all cases the time has been greatly reduced and "in practically every case where aerial photography has been employed, improvement in the quality of the maps has resulted." In conclusion the report states that, in estimating the cost of the standard topographic mapping programme, "If the use of aerial photography had not been contemplated, the estimate of total cost to the Federal Government of the mapping part of the work would have been about \$43,000,000 instead of \$33,000,000."

In France, a recent law enforced the production of up to date large scale maps of all communes. As a result, the photographic companies in that country have carried out a large amount of air photography for the production of large scale maps of towns and villages, in some cases to a scale as large as 1/1000.

In Great Britain, the only noteworthy operation has been the experiment carried out by the Ordnance Survey Office, in conjunction with the Aircraft Operating Co., Ltd. (a company whose personnel have gained their experience of air survey in British Guiana, the Orinoco Delta and elsewhere) to determine whether air photographs can be usefully employed in the revision of the large scale (1/2500) Ordnance Survey maps. The factor which makes this of note among much larger operations is the high standard of accuracy which is maintained in the Ordnance Survey of Great Britain. While it is not yet possible to state definite results, there are indications that, even in a survey of this order, the use of air photographs simplifies the work and gives all the accuracy required in highly developed areas, where the wealth of detail at the same time ensures adequate control for the rectification of the photograph. Thus, the development which necessitates map revision itself places difficulties in the path of the ground surveyor, while easing the task of survey from the air.

British companies abroad have carried out very successful air survey operations. In 1924 Mr. R. C. Kemp, who afterwards formed The Air Survey Co., Ltd., carried out the photographic work for the survey of 1,350 square miles of forest and creek country in the Irawaddy Delta. The mapping was done by the mosaic method. The cost of the photography was £14 0s. 6d. per square mile, the total cost of the mapping being £18 5s. 0d. per square mile. In spite of the fact that the photographic costs were very high, and do not in any way represent commercial costs of the present time, it was estimated by the surveyors that a ground survey would have cost nearly double this figure and would have taken three to four years as against some six months. The surveyors also expressed the opinion that a ground survey of this area "would compare most unfavourably with air survey as regards accuracy of local detail and would scarcely be superior in accuracy of position."

The Air Survey Co. has since obtained further contracts in the east, notably a contract to map, by photography and sketching, the forest in Tenasserim. A contract for the photography of 1,400 square miles of swamp and jungle in the Miri oilfields of Borneo for the Anglo-Saxon Petroleum Co. was completed in 1925. The company is now working on a similar area amounting to about 1,750 square miles in the Rejang Delta for the Sarawak Government.

A contract of considerable magnitude has been negotiated by the Aircraft Operating Company for a reconnaissance type of survey in Northern Rhodesia for a firm of mining concessionaires—Minerals Separation, Ltd. The whole area of the concession covers about 52,000 square miles. An expedition will shortly be despatched to Rhodesia to carry out reconnaissance work, using oblique photography, from the results of which areas will be selected for a more detailed survey by vertical photography.

An illustration of a special type of survey in which air photography is peculiarly useful is afforded by the survey of the Nile at high and low water, which was carried out with the aid of the Royal Air Force.

In the following table are given some figures of the cost of air photography for survey purposes. The figures are quoted with some reserve, bearing in mind the



NOTE—
 Alterations to ground to show land
 developments shown on this map, which
 do not appear on the 1910 Ordnance Sheet
 printed above. These areas are marked
 by corresponding letter references.

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A vertical photograph taken during the survey of the Chittagong District, Bengal, by the Air Survey Company, Ltd., showing forest and paddy fields.

incorrect conclusions which may be drawn from a study of figures without the relevant data, which it is not possible to compress into a small space :—

COSTS OF AIR PHOTOGRAPHY.

Date.	Place.	Operator.	Area (sq. miles).	Scale of map.	Cost per sq. mile.	Remarks.
1924	Irawaddy Delta, Burma.	Air Survey Co., Ltd.	1,350	3 miles to 1 inch.	£ s. d. 14 0 6	
1924	Tenasserim Forests, Burma.	Do.	600	—	10 0 0	
1925	Eastbourne, England	Aircraft Operating Co., Ltd.	50	1/2500	5 0 0	Area too small to allow of economic price.
1925	Quebec	Fairchild Aerial Surveys (Canada) Inc.	400	1/14400	4 3 4 (approx.)	
1926	Gaspe (Quebec) ...	French firm ..	2,200	—	9 5 0 (approx.)	Includes ground control and complete production of map.

Air Survey and the Empire.

In conclusion, it is proposed to examine the case for air survey as a factor in the development of the British Empire, and to state in broad outline the conditions in which it can usefully be employed.

The most obvious demand for air survey is in regions which by reason of the difficulty of access, present insurmountable obstacles to the ground surveyor. Such regions are often of great value either actual or potential on account of their timber products and mineral deposits, as in Canada and the Irawaddy Delta, or their survey is vital to the development of the country for reasons of health or transportation. In such regions, the figures quoted for the Irawaddy Delta are an illustration of how air survey costs become a fraction of those which would be incurred by a ground survey, while time is reduced still more and the result, by reason of the record of timber types and conditions, geological outcrops, etc., is of more value than the most complete ground survey. On the score of accuracy it is of course patent that greater accuracy *can* be obtained by ground than air methods, but the surveyor responsible is in the best position to judge how often, in such conditions, the organisation required to obtain this greater accuracy is necessary.

At the other extreme there is, in the British Empire, much territory of such a nature that it presents no difficulties to the ground surveyor working with his plane table. In such conditions, ground survey costs can be reduced so low that, in the matter of cost alone, air survey cannot at present compete. In this type of country the justification for the use of air survey rests on certain problematical factors. It may be that the urgent need for development calls for the speed which only the air method can give, or it may be that the requirements of an important developing area call for a more detailed survey than the normal topographic map gives, and to supply such detail involves an increase in the cost of the ground method to a point at which the air method competes, not only in speed, but in price. An example of this is the survey of property boundaries. It is for this reason that Canada has undertaken the survey by vertical photography of rapidly developing areas in the prairie provinces. The method is chosen with a full realisation that there is hardly one of the public services which does not find its own peculiar use for the photographic record so obtained. The air photograph if made to do its full work, thus serves the geologist, the forestry officer, the railway engineer, irrigation engineer, draining engineer, the town planning department and the department of agriculture, the archæologist and the medical officer, as well as the surveyor himself, and the hydrographer in coastal regions.

Air survey in this paper is not referred to as a substitute for ground survey, but as a means of reducing the labours of the ground surveyor, extending his field of activity, and providing him in a convenient form with the detail which he would otherwise have to obtain with the plane table or the chain.

Air survey is in its infancy. Improvements in methods, instruments and machines are continuous. Each one contributes its quota to the reduction of costs and the placing of the industry on a practical and economic basis. Lower costs, increase of accuracy and reduction of time and labour can all be looked for in the future. In this development British air survey companies are well fitted to take their part.

2. Forest Fire Protection.

Experience in Canada has shown that in certain circumstances aircraft patrols are the most efficient method of controlling the fire hazard in forests. The maximum efficiency is reached in areas where population is sparse and ground forces cannot be fully organised. In these localities the higher cost of protection by air is amply justified.

The organisation for fire patrols in Canada takes three forms.

The Royal Canadian Air Force undertakes forest patrol duties in conjunction with other civil duties, on behalf of the Dominion Forest Service, and it has been responsible for most of the pioneer work. In 1925, the R.C.A.F. operated 33 aircraft on civil duties, and out of 2,443 hours flown in 1925, 1,347 hours of flying were done for the Forest Service.

The Province of Ontario operates its own fleet of aircraft as an adjunct to the Provincial Forest Service. Nineteen flying boats were employed in 1925, and they carried out 2,739 hours of flying.

In the Province of Quebec, the necessary air work is carried out by contractors, who are paid a fixed rate per hour flown. Two companies were employed in 1925.

Almost the whole of the Canadian forest area is dotted with small lakes, and the most suitable type of aircraft is therefore the flying boat, or float seaplane. During the period of high fire hazard in the summer months the aircraft are stationed at lakes in the vicinity of the area to be patrolled. In the winter they are withdrawn to bases for overhaul.

The outbreak of a fire is reported by an aircraft, usually by W/T, to the nearest ground station, and forest rangers are despatched immediately to the spot. If the fire is difficult to get at on foot or by canoe, the fire fighting party and their kit are carried by air to the nearest lake affording a landing place.

As to the actual results of aircraft protection, the Province of Ontario have published the following comparison between fires in 1923, before aircraft were in extensive use, and in 1924, when they were operated by the province on a large scale :—

	<i>Size (in Acres).</i>					<i>1923.</i>	<i>1924.</i>
$\frac{1}{4}$ and under	15.1	31.0
Over $\frac{1}{4}$ to 5	26.1	35.1
Over 5 to 10	8.4	6.7
Over 10 to 100	19.8	17.8
Over 100 to 500	14.3	5.9
Over 500 to 1,000	5.0	1.4
Over 1,000 to 10,000	8.4	1.5
Over 10,000	2.9	0.6
Total	100.0	100.0

It will be noted that, in 1924, 90 per cent. of the fires did not spread over more than 100 acres, which was largely due to the fact that as soon as a fire was detected men were placed in a position to control it immediately.

Not only was a considerable improvement effected, but the total cost of the Forest Protection Service was actually decreased by over \$200,000 in 1924, notwithstanding the fact that the purchase price of aircraft and equipment was included in the operating expenses and more than usual was spent on ground installations and equipment, apart from the air service. The cost of flying in 1924 worked out at \$54.12 per hour, this figure including an allowance for depreciation on aircraft and buildings, and interest on capital.

The making of inventories and surveys of the forests is combined with fire protection and in this way the patrol aircraft serve a double purpose. Moreover, the machines are frequently used for other duties as well, as for example, investigation



Aeroplane discharging calcium arsenate dust over cotton field for control of cotton boll weevil.

of sites for water power and lumbering plants, transportation of prospectors and Government inspectors, investigation of the spread of plant and timber diseases, etc. The time saved in transportation is enormous in a country where the only alternative to flying is travelling on foot or by canoe, with a load of provisions and kit.

In the United States a similar system exists, though on a smaller scale. Nine U.S. military aeroplanes were engaged on forest duties in 1925.

3. Protection of Cotton and other Crops.

The protection of cotton plants, fruit trees and crops generally from the attacks of destructive pests has been developed to a commercial stage in the United States.

In 1921, an aeroplane was used successfully to apply insect poison to catalpa trees near Dayton, Ohio, and the possibility of similar treatment in cotton fields immediately became apparent. Tests were made in 1922, by the United States Bureau of Entomology, in co-operation with the Army Air Service, and it was shown that the "boll-weevil" and the "army-worm" could be controlled as effectively by aeroplane as by ground methods, and with a much smaller expenditure of larvicide. Powdered calcium arsenate was used, carried in a hopper on the aeroplane and released at an even rate under the control of the pilot.

On large and favourably situated fields 400 to 500 acres per hour were treated by air, rising to 1,000 acres under the best conditions. Each run of the aeroplane across the field dusted a strip 250 feet wide at a speed of 70-90 miles per hour. With a single aeroplane 45 acres were dusted a minute—equal to the work of 40 cart dusting machines.

An aircraft constructing company took up the question of producing a special type of aircraft for the work, and in 1924 developed two machines, one for small fields, carrying 500 lb. of arsenate, and another for large fields carrying 1,000 lb. On the basis of experience with these machines a subsidiary company, the Huff Daland Dusters, Inc., was formed to undertake dusting operations on a commercial scale.

Eight districts have been selected and a flying base is located in each district. Contracts are arranged to dust between 5,000 and 7,000 acres within 10 miles of each base. Two aeroplanes, two pilots, and an entomologist are stationed at each base, and the company is under contract to dust immediately upon notification from the farmer. The work is supervised by Government agricultural officers and all farmers using the service can have their crops insured against weevil damage. During 1925, the company applied 375,000 lb. of poison.

Up to nine applications may be necessary, the average being about five. The charge made at present is \$7 per acre for five applications, as against an average of \$7.26 for ground dusting. Moreover, the work is done by air 100 times faster. 98 per cent. of the farmers who have subscribed to the service are contracting for increased acreage.

There are very big possibilities of expanding this service. Of 40 million acres under cotton cultivation, about 15 millions are suitable for dusting by aeroplane. It is estimated that the improved yield brought about by dusting this area might be expected to produce about \$130,000,000 to the farmers, whilst approximately 3,000 aeroplanes would be needed.

The machines would not be required in the cotton fields all the year. Cotton dusting starts at the earliest in April, and finishes at the latest in September. For the remainder of the year the machines might find employment elsewhere in treating other crops or mosquito swamps. For example, early in 1925, before the cotton dusting started, the Huff Daland Dusters, Inc., treated 200,000 peach trees in Georgia, and have used the method on pecans and sugar canes.

4. Destruction of Mosquitoes.

The United States Department of Agriculture have tested the efficacy of dusting the breeding places of malarial mosquitoes with poison by means of aeroplanes.

A detachment of the U.S. Army Air Service was engaged in cotton dusting experiments at Tallulah, Louisiana, only a short distance from the mosquito investigating station at Mound, and opportunity was therefore taken to utilise their services for this experiment.

The machines were already fitted with hoppers for holding and distributing the poison dust. Paris green mixed with a diluent was the larvicide used. Several kinds of dust of a density about equal to the Paris green were found suitable as a diluent ; that principally used being finely ground silica earth.

Preliminary experiments were made to determine the approximate number of granules of the poison per square inch required to kill the larvæ.

Tests were then made on open ground of the drift of the dust distributed from the air and the quantity which settled on the ground. In the best of these it was found that a strip from 300 to 400 feet wide was effectively dusted at one time and that the quantity of Paris green required was about 1 lb. to 20 acres. A mixture of 10 lb. of Paris green to 100 lb. of dust was found suitable.

The next tests were made to determine whether the dust would descend through a growth of leaves and brush. Two or three trips were made by the aeroplane along approximately the same line and a satisfactory dosage was found almost everywhere over a strip 750 feet wide.

Practical tests over lakes and on a small field of rice were finally undertaken. As had been anticipated, the most difficult conditions were encountered in heavily wooded areas where the water was protected by dense overhead foliage and marginal vegetation and the aeroplane had to fly high enough to clear the tallest trees. Even in such places the dust penetrated the thick growth and reached the water in sufficient quantities when enough was applied to offset the increased wastage. The most favourable conditions were those represented by the rice field and open water. One $\frac{1}{2}$ lb. of Paris green per acre was considered sufficient for open conditions, the amount being increased as necessary for protected areas.

The two final tests carried out in 1924 gave particularly clear cut results. The lakes selected were overgrown with aquatic vegetation and had an abundance of larvæ well distributed throughout. In the first test a reduction of 88 per cent. of the larvæ occurred as a result of the treatment and in the second over 99 per cent. were killed. For testing the effects of the dusting, pans of water containing a known number of larvae were laid down at different points on the surface treated.

5. Investigation of Spread of Wheat and Timber Diseases.

The Royal Canadian Air Force is giving assistance to the Canadian Department of Agriculture in experiments to determine the origin and spread of the wheat rust disease which occurs in the prairie provinces.

The objects are to detect when and where the spores first appear, to ascertain the direction from which they come and the rate at which they increase in the upper air over various areas, to establish whether the spores found in the upper air currents are living and capable of causing infection, and to investigate the conditions governing the precipitation of the spores.

Striking results have already been achieved. It has been definitely established that the spores responsible for the epidemics are wind borne. They are carried high up in the air, apparently from the south, and spread over the entire region under wheat culture and far beyond.

Further experiments will be necessary, and as more complete data is collected it is hoped that the origin of the disease will be traced and means found eventually to stamp it out.

The method of trapping the spores is to expose microscope slides lightly smeared with vaseline at suitable heights. Before and after exposure the slides are protected from contamination by being enclosed in corked bottles. The presence of spores on the slides is easily detected under the microscope.

Experiments of a similar character have been made in British Columbia in connection with the control of a disease known as white pine blister rust, again with successful results. An examination of the slides exposed showed a great variety of spores and traces of insect life. Blister rust spores were evident at all heights.

Incidentally, in the course of this work, a special flight was made in order that the officer in charge could examine the progress of the disease on marked specimens of affected white pine. This operation was completed in one day, whereas a trip of probably two weeks would have been necessary if the ordinary method of travel had been taken.

Experiments on similar lines have also been carried out with aircraft in the United States.

6. Ambulance and Medical duties.

In undeveloped countries, where methods of transport are elementary if they exist at all, and particularly in countries where tropical diseases are rife, one of the greatest drawbacks to settlement is the difficulty of countering outbreaks of disease and rendering medical attention to the sick.

Aircraft offer a means of solving this problem and there are already a considerable number of lives that have been saved through the prompt action made possible by aircraft.

The only organised medical service by air is in Siam, where the military air service is available at all times for the despatch of doctors and vaccines to places where outbreaks of disease are reported. This service, however, owes its existence to special conditions, since the Siamese military air service is on a somewhat different footing to those in other countries. It is supported partly by voluntary contributions, and carries out postal as well as medical services in addition to its military duties.

An example of a different type is found in British Guiana, where the proprietors of a balata estate have purchased a seaplane, fitted up as an ambulance, for the conveyance of fever patients from up-country plantations to the hospital at Georgetown. A journey which formerly occupied from 17 to 21 days can now be made in two hours.

From February to November last year this machine made 54 flights. It was chartered on two occasions to carry out the relief of sick Wireless Telegraph operators at the Government Wireless Telegraph station at Apoteri.

In Australia, as we have seen, the aircraft which normally operate on regular routes are utilised by doctors for getting to urgent cases in inaccessible districts, and for conveying patients quickly and comfortably to hospital. There is no doubt of the material and moral effects of this improvement in medical facilities on the opening up of the remoter parts of the country. A man who would hesitate to take his family out of the ordinary reach of medical aid, has little to fear when he knows that in case of need he can obtain help promptly.

In Canada, the aircraft engaged on fire patrols and survey over the forests are often able to render assistance to sick or injured individuals encountered at remote points. Three cases occurred last year in Manitoba. A mining engineer seriously ill with pneumonia, a woman who was too ill to travel by canoe, and a miner who had lacerated his foot were each brought in by air. The miner was operated on by the doctor at the Air Station. In addition, the visits of medical officers to the Indian Reserves are made regularly by aircraft, in conjunction with the payment of treaty money.

7. Fishery Protection.

The duty of protecting fisheries is often most difficult to fulfil. On the west coast of Canada, particularly in the salmon fisheries in the Prince Rupert district, the task of the Fishery Officers has been made much easier and their work rendered more effective by the use of aircraft patrols. Following operations in 1924, three flying boats were based at Carey Cove, near Prince Rupert, during the fishing season of 1925 and carried out 122 patrols. The area patrolled extended from the Alaskan boundary on the north to Cape Caution on the south. 5,000 miles of coast line and intricate waterways lie between these points, and the fishery patrol boats in the past had found it almost impossible to cover the ground completely.

The main offences against fishing regulations are fishing with too great length of net, or nets of illegal mesh, fishing during the week-end closed season, fishing in restricted areas, and fishing without a licence.

In the early part of the 1925 season numerous offenders were detected, and it was soon made evident that the regulations were to be strictly enforced. During the season 24 breaches of the regulations were detected and the offenders prosecuted. In cases where fishermen were using illegal nets, these were confiscated immediately and taken on board the flying-boats if the loading permitted.

There is no evidence available as to the cost of the aircraft patrols in comparison with the possible cost of effecting equal results by additional surface patrols. That the aircraft patrols have proved remarkably effective is indicated by the following

extract from a letter addressed by the Chairman of the International Fisheries Commission to the Officer Commanding, Vancouver Air Station :—

“ Permit me to state that in my forty odd years of fishing service, I have never seen such an effective patrol of seine fishing as has been conducted by the Canadian Air Service on the Skeena and Naas Rivers during the last two years. It is a masterly way of handling such a situation, the most effective yet devised.”

The use of aircraft in this manner is not confined to Canada. During June and July, 1925, the Danish Government stationed a seaplane at Skagen to assist the Fishery Inspectors. It was intended as an experiment and it gave very good results.

8. Observation of Shoals.

Experiments with the object of assisting the fishing industry by employing seaplanes to report the presence of shoals have been started in many parts of the world.

The results obtained in Europe are so far inconclusive. On occasions it has been found possible to observe shoals with an ease that encourages great hopes in the system. On the other hand, the spotting of shoals from the air is not always an easy matter ; if the fish are not close up to the surface or if visibility is poor they are difficult to see. More experience must be gained before any final conclusions can be drawn.

The sealing industry of Newfoundland is also interested in aircraft observation and has made tests, likewise without definite results. As the whole success of a sealing expedition rests on good fortune in coming upon the seals in the limited period available a means of extending the range of vision is obviously very important.

9. Prevention of Smuggling.

Several countries have experimented with aircraft observation as a possible solution to the problem of preventing drug and liquor smuggling. The most interesting results are those secured in Canada.

The Canadian Government found it extremely difficult to check the smuggling of drugs from ships entering Vancouver Harbour. It was known that members of the crew or passengers were evading the Customs examination by throwing overboard packages of drugs, buoyed and made up in watertight covers, at selected spots where they were picked up by launches and landed secretly. The smugglers used very fast boats and it was difficult to catch them.

Arrangements were therefore made to escort incoming liners from the Orient by aircraft. While the liner is under air observation it is practically impossible for any package dropped overboard to be picked up without detection. Launches have been seen unmistakably standing by for no good purpose and apparently chagrined at the presence of the aircraft. Not every ship is so escorted, but only selected vessels, at intervals and without warning. The smugglers are therefore unable to make arrangements for smuggling by any particular boat and the risks of identification and capture are immeasurably greater.

Besides escort duty, the aircraft are employed for transporting Customs officers on urgent business, the examination of suspected steamers and launches, etc. One flight resulted in the seizure of a fast motor boat which was suspected of illicit traffic in liquor.

10. Conveyance of Administrative Officers.

There is nothing visionary in the idea of aircraft being used for the conveyance of administrative officers over long distances in undeveloped country, as freely as motor cars are used where roads exist to-day. Such an aeroplane as the “ Moth,” easy to fly and maintain, and comparatively cheap to buy and operate, brings this prospect fairly close.

Colonial Legislators, Political Officers, Justices, Officers of the Health, Agricultural, Lighthouse, Postal and Customs services, and many others, must certainly benefit from the establishment of a system of air communications, on whatever basis it is organised.

The French, in West Africa, Syria and Indo-China, make extensive use of the local units of the Military Air Service for conveying urgent official despatches and moving political officers from place to place. Flights by the Governors-General on official visits are not infrequent. In West Africa, particularly, administration and aviation are closely linked.

In Australia, the regular air services carry administrative officers on the same footing as the general public. Law officers, Lawyers, Cattle Inspectors and many others, whose business keeps them constantly moving, find the services a great boon in visiting places separated by days of travelling on the ground. The Governor-General, His Excellency Lord Stonehaven, has an aeroplane for his own use.

In Canada, the transportation of Government officers by the Royal Canadian Air Force and the Ontario Forest Air Service is a general practice. One notable example is the carriage year by year of treaty-money parties to the Indian reserves.

The Soviet Russian Government are relying more and more upon aircraft to uphold their system of Government in the remoter parts of their enormous territory. Machines carrying officials are sent to many districts not easily reached by ground transport.

What has already been done merely indicates the possibilities. Although the time is still distant when air communications have become the principal arteries of political and administrative organisation, there are many opportunities to-day for the increased use of aircraft in administrative service.

Furthermore, almost every aviation scheme, be it transportation, survey or crop protection, has a bearing on administrative work in some form, and it is therefore important that the possibilities of assisting the administrative services should be given due weight in every scheme put forward. The effects on prestige with native races is also important. The power of the white man to fly is extraordinarily impressive to the native mind. When that power is allied with administration the moral effects must certainly be valuable.

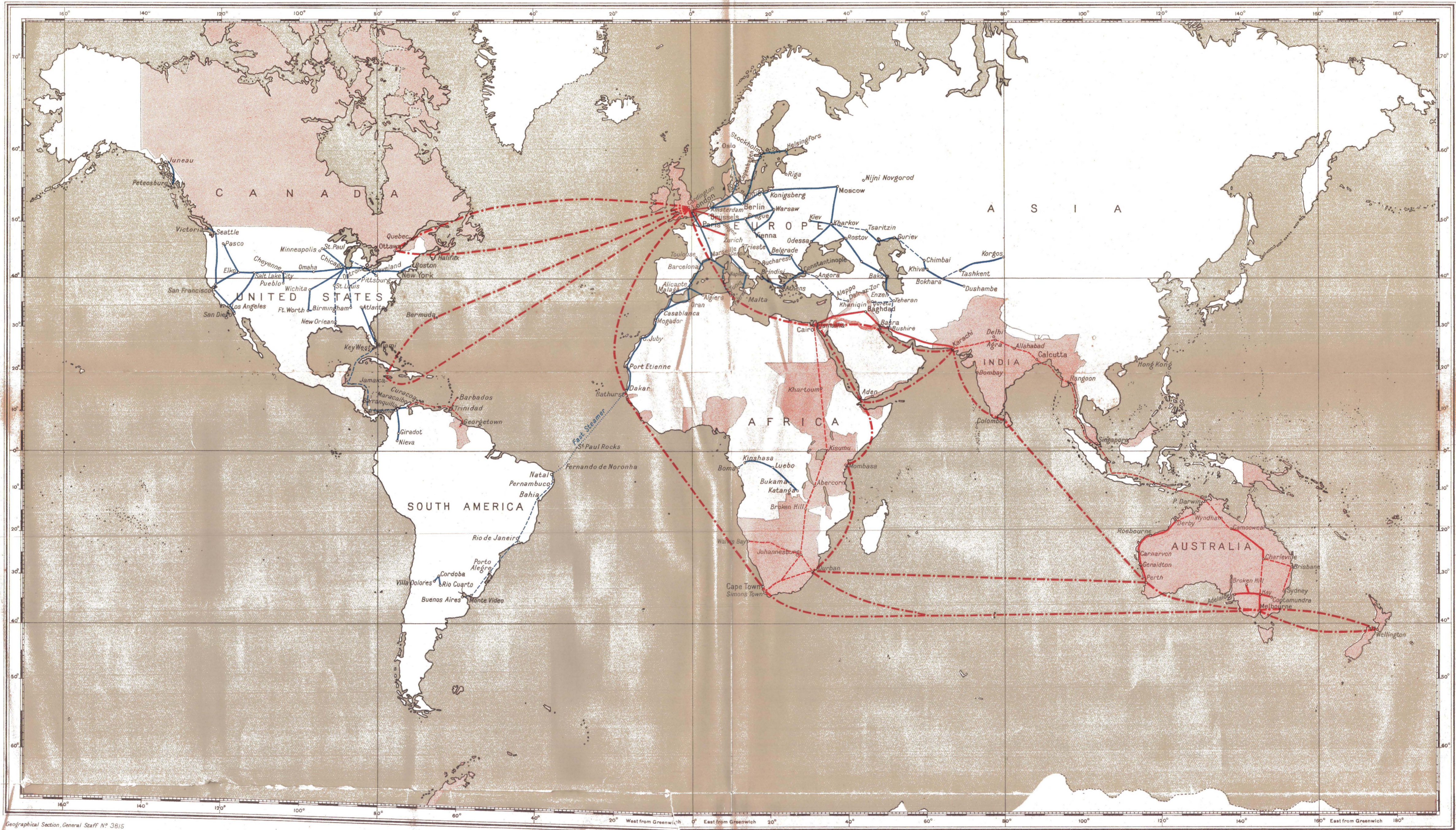
11. Light Aeroplane Clubs and Private Flying.

The encouragement of private flying is recognised to be of high importance in developing an "air sense" among the public, but it has been found that in order to overcome the initial difficulties due to the present high costs it must have special assistance. In England and Australia the formation of light aeroplane clubs which provide facilities for flying at a comparatively small cost has been facilitated by Government grants. For each of the six light aeroplane clubs in England, the Air Ministry has provided equipment worth £2,000 and a grant of £1,000 towards expenses in the first year. A further grant limited to the same amount will be paid in the second year, the actual amount depending on the results of the first year's operations. The Australian Government has given assistance on similar lines to two clubs and intends shortly to extend assistance to five more. The English clubs have already a total membership of over 640 flying members and 410 associate members and some 50 flying members have qualified or are about to qualify as class A pilots.

The French Government provides private aircraft with free accommodation at aerodromes for 48 hours, and reduced charges thereafter. Many Frenchmen learn to fly during their period of military service, and keep in practice afterwards at schools run by private individuals on behalf of the State. Private flying is a natural consequence.

In Germany, private flying is encouraged by numerous privately operated schools, and by large gliding and flying competitions, the expenses of which are contributed mainly by patriotic citizens and associations. Aerodromes have been established by local efforts in all parts of the country and flying clubs or associations exist almost everywhere. As a sport, flying has made an intense appeal to German youth.

MAP OF THE WORLD SHOWING EXISTING AND PROPOSED AIR TRANSPORT ROUTES.



Geographical Section, General Staff No 3815

War Office, 1926.

REFERENCE.

- | | | |
|--|---------|-----------|
| Existing Aeroplane Routes | British | — |
| | Foreign | — |
| Possible extension of Aeroplane Routes | British | - - - |
| | Foreign | - - - |
| Possible Imperial Airship Routes | | - · - · - |

NOTE—Local services in Europe are not shown.