APPENDIX D

REPORT ON FLIGHT IN THE GRAF ZEPPELIN AND VISIT TO FRIEDRICHSHAFEN BY LIEUTENANT-COLONEL V. C. RICHMOND AND SQUADRON LEADER F. M. ROPE

This document was written by Richmond and Rope after their trip in late April 1930 on the *Graf Zeppelin*. The airship landed at the Royal Airship Works, where it picked up Hugo Eckener, the visionary who resurrected zeppelin-brand airships after the First World War. Eckener was touring the Works after meetings in London, at which he had discussed standardizing airship mooring before the Zeppelin Company started service to the United States in 1933. Vincent Richmond and Michael Rope returned with Eckener to the Zeppelin Company's headquarters in Friedrichshafen, Germany. They reported on their ride in the *Graf Zeppelin*, their observations of zeppelin's wind tunnel and airship designs, and their visit to the zeppelin factories in Germany.

Although the highlight of the report is their impressions of flying in the zeppelin, their observations of the Friedrichshafen factories reveal how the Zeppelin Company, called the "Firm" throughout, struggled financially. Richmond and Rope observed the manufacture of parts for Opel cars and the production of "large containers for petrol, milk and beer" from aluminum, but "nowhere was there any sign of airship work in progress." They also noted that the cash-strapped Zeppelin Company allowed the public, if they paid a fee, to mill around the *Graf Zeppelin*.

In the report Richmond and Rope mention LZ 128, an airship in the early stages of planning. After R.101 crashed, the Zeppelin Company abandoned LZ 128 because of the public's fear of hydrogen-filled ships. Zeppelin then designed and built two airships—their last two airships—that used helium: LZ 129, known as the *Hindenburg* and LZ 130, the *Graf Zeppelin II*. These ships, though, eventually used hydrogen because the United States refused to sell helium to Germany for them, as it feared helium would transform zeppelins into invulnerable military weapons. Helium, explained a U.S. military officer, "reduces materially the danger of fire from incendiary bullets fired into them; it enables lighter-than-air craft to operate against heavier-than-air craft without the danger of fire from the balloon gas."

Additionally, the report contains three fascinating tidbits. First, Frau Eckener, Hugo Eckener's wife, confided to Richmond and Rope that Ludwig Dürr was "slow." Dürr was the chief architect of zeppelin airships: he helped build the first one, and was involved in the design of every one thereafter. He served as technical director until 1945.

Second, Richmond and Rope's pride comes through in this bureaucratic report when they mention "it was noticeable that they [the zeppelin designers] had in their possession several of the English technical papers on the subject of airships copiously annotated." Likely these were their own papers! This pride also appears when they analyze the wind tunnel results conducted by the Zeppelin Company. And of particular interest is their discussion of the echo sound equipment used to determine a zeppelin's altitude. Engineers at the Royal Airworks had also developed an instrument to measure altitude but it was removed before the flight to India.

Third, Richmond and Rope refer to the "Wembley incident." On the *Graf Zeppelin*'s route to the Royal Airship Works, the ship passed over Wembley Stadium where Arsenal and Huddersfield Town battled for the FA Cup. To honor King George V, who was attending, the zeppelin "bowed" by dipping toward the ground. It swooped so low that players complained that the airship blocked the sun and darkened the field. The *Daily Mail* reported "lively comment during the weekend" about the zeppelin's flight over Wembley. Although only hinted at by the *Mail*, the flyby reminded many spectators of the zeppelin raids of the First World War, especially when they learned that Captain Lehmann, who flew the *Graf Zeppelin* over Wembley, had bombed London in the war. As this report reveals, this anti-zeppelin sentiment was not shared by the British delegation, visiting the zeppelin works. "The British technical public," said a member of the delegation have "nothing but admiration regarding the skill and courage displayed" during the wartime zeppelin bombing raids.

This document mentions seven figures, but they are long lost. The spelling of place names as in the original document has been retained. I have inserted notes in brackets to help clarify ambiguities.

The original of this document is stored at the National Archives, Kew, Reference AIR 5/12. Its title in the archives is "Report by Lt. Col. Richmond and S/Ldr. Rope on their visit to Friedrichshafen, and *Graf Zeppelin* flight, 1930."

Contents

Itinerary

Saturday, 26th April. Left Cardington in the *Graf Zeppelin* 5:49 p.m.

Sunday, 27th April. Landed at Friedrichshafen 6:40 a.m. 1 p.m. visit to Dornier Works at Altenrhein. 4 p.m. returned to Friedrichshafen. Conversation with Dr. Dornier. 8 p.m. Dr. Eckener gave a complimentary dinner to the principal passengers of the *Graf Zeppelin* flight.

Monday, 28th April. a.m.: visited Zeppelin Works accompanied by Capt. Lehmann who conducted us to Dr. Dürr and Dr. Erlich. The morning was spent in a detailed examination of the Zeppelin Works, the new airship shed and the *Graf Zeppelin* in company with Dürr and Erlich. *p.m.:* Further technical discussion with the above.

Tuesday, 29th April. Escorted by Dürr and Erlich visited the wind tunnel, the foundries and the fuel gas plant. At lunch we were entertained by Dr. Dürr and Dr. Erlich. *p.m.* Interviewed Dr. Maybach and were escorted round the Maybach Motor Works by Herr Lutz. 5 p.m. interview with Dr. Eckener. 6 p.m. Dr. Eckener gave us a complimentary dinner, other guests being Doctors Maybach, Dürr, Ehrlich, and Capt. Lehmann

Wednesday, 30th April. a.m. Final interview with Dr. Eckener and further technical conversation with Dr. Dürr. At lunch we were entertained by Capts. Von Schiller and Fleming. *p.m.* Visited the Motor Gear Cutting Works at Lowenthal escorted by Dr. Ehrlich and Herr Dolt, Works Manager. 5:30 p.m. left Friedrichshafen.

Thursday, 1st May. 9:30 p.m. arrived Bedford.

Flight of the *Graf Zeppelin*

The ship left the ground at 5:49 p.m. and was soon put up to cruising speed on all engines which was observed from the speed indicator to be between 31 and 32 meters per second (70.5 MPH approx). The smell of the fuel gas in the passenger cabin, which was very noticeable when the ship was at rest, was found to be not entirely dispersed when the ship was underway. The vertical windows were found to be a great benefit to the passengers and the open windows caused no unpleasant draught. It should be appreciated that the living saloon was comparatively small and well shut off from the rest of the ship. When the door to the control car was opened, an appreciable draught was felt from the windows.

It was observed that the saloon which was heated by radiators fed with hot water from the auxiliary engines, was kept at a very pleasant temperature.

The sound of the engines was quite appreciable, the most noticeable feature being the beats when two wing engines were nearly in step. The various instruments were examined in operation and are reported on more fully below.

The Officers very courteously allowed most of the passengers to visit the control car and to remain there if they so desired. Indeed one very noticeable feature of the trip was the extreme pains taken for the comfort of the passengers. The itinerary was carefully planned so that the ship passed over all the most interesting vicinities. The food and drink were very good, a special menu having been printed for the trip. The facilities for washing are well thought out, though somewhat inadequate.

The ship reached London soon after six o'clock, and at 6:30 p.m. was over the Houses of Parliament, the height having been reduced to only 300 meters, and the engines throttled down (21 meters per second). After circling London, the ship passed along the Thames and at 6:50 p.m. over Greenwich, the speed and height were again increased. The ship practically followed the coast of Kent round to Dover which was reached about 8:15 p.m. Here a message which had been prepared by Col. The Master of Sempill and signed by Dr. Eckener was transmitted to S. of S. [Secretary of State, Lord Thomson]. The ship then proceeded by way of Ostend and Zeebrugge to Brussels in order to allow the passengers to view the illuminations.

The passengers all went to bed between eleven and twelve o'clock, and most of them reported having slept soundly the next morning. We were roused at daylight and the ship was found to be over Friedrichshafen at 4:45 a.m. As there was a considerable amount of mist about and the landing party had not been ordered for this early hour, the ship was taken across Lake Constance to view the sunrise in the mountains in the region of Bregenz. The ship returned over Friedrichshafen about 6 a.m. with a considerable amount of mist still about. It was noticeable that the pilots made regular use of the echo sounding gear to determine the height of the ship. It was also noticeable that numbered boards were placed on the landing ground close to the tee to indicate the ground temperature (see below). Owing to the limited dimensions of the aerodrome, the pilots followed their usual practice of making a high landing with long trail ropes (100 meters). The ship was brought to the ground without incident at 6:40 a.m. and walked over to the vicinity of the shed where side guys were attached to the trolleys on the handling rails. There was very little wind and only three men were employed on each side guy in coupling up to the trolleys and moving them. It was noticeable that as the process of moving the side guys definitely located the ship, no other precautions had to be taken so that it moved strictly on the centerline of the shed.

Some of the passengers left immediately by motor-car and others proceeded to the Kurgarten Hotel. It was noticeable that there were many visitors to the aerodrome, and it was subsequently discovered that it is now a regular practice of the Zeppelin Company to allow such visitors to view the ship at any time on a payment of a small charge. These visitors are not allowed to go on board. No special escort is provided for them.

In subsequent conversation, the Flying Staff appeared to be considerably worried over the Wembley incident. Capt. Lehmann said that he had only passed over the football ground, which was previously quite unknown to him at the special request, first by telegram and later by letter, of Colonel The Master of Sempill. Two extracts from the German newspapers on the subject are attached to this report. On the whole they seemed to have taken the incident in a very good spirit. It was noticeable, however, that the *Daily Mail* which can normally be obtained the following day in Friedrichshafen, was on Tuesday confiscated by the police, presumably on the ground of unfavorable comment on the *Graf Zeppelin*. This was confirmed by the effort which Capt.

Lehmann strenuously made to endeavour to obtain a copy of the paper for us.

At the dinner given by Dr. Eckener in the evening, most of the Flying Staff were present with their ladies, but none of the technical staff other than Count Soden who is head of the Motor Gear Cutting Works (an allied firm). Group Capt. Gossage, Air Attache, [Ernest Leslie Gossage] was also present. Dr. Eckener made a cordial speech of welcome in which he referred in rather vague terms to co-operation with Great Britain. He especially thanks Col. The Master of Sempill for the arrangements made for his welcome in London. Col. Sempill in reply said that as he was leaving early next morning but Group Capt. Gossage and Colonel Richmond were remaining, he did not feel it out of place to reply to Dr. Eckener. He referred to the wartime flights of the German airships for which he said the British technical public at any rate had now nothing but admiration regarding the skill and courage displayed. He referred to the pioneer work done by Count Zeppelin and his associates, which was all fully appreciated in airship circles in England. He also stressed the value of co-operation but again in somewhat vague terms.

Technical information

Dr. Eckener kindly invited us to spend at least three days in Friedrichshafen, and had evidently instructed his staff to give us the fullest possible information and it was indeed noticeable that to none of our questions did they make evasive or hesitating replies. We reciprocated as far as possible and repeatedly requested them to put to us any points on which they required further information regarding English practice. It was noticeable that they had in their possession several of the English technical papers on the subject of airships copiously annotated.

The principal members of the technical staff appeared to be as follows:

Dr Dürr in charge. Dr. Dürr is apparently one of the oldest members of the Zeppelin Company having been associated in the early days with Count Zeppelin and acts in the capacity of Chief Engineer, since he is in charge not only of work directly connected with the construction of the airship, but also with the other enterprises of the Company, such as their foundry work and manufacture of aluminum tanks and containers of various kinds for the trade. He was also apparently responsible for liaison with the subcontractors for the new shed which is to be erected at Lowenthal. Dr. Dürr whose knowledge of English is extremely limited showed us the utmost courtesy. It was somewhat surprising, however, that at the dinner given by Dr. Eckener, Frau Eckener confidentially volunteered the information that he was now regarded as rather "slow."

Dr. Erlich is in charge of general airship design. He was prisoner at war in England, and speaks extremely good English. He acted as principal interpreter during our visit and displayed the utmost endeavours to be helpful.

Herr Schirmer—the young Engineer in charge of the Wind Tunnel work.

Herr Forster, who was one of the men left in England when the ship returned to Friedrichshafen, is in charge of the Stressing Work.

Dr. Sturn is in charge of all Machinery questions.

Herr Besch in charge of Ground Handling Equipment is an Ex-Naval Constructor and is at present in Pernambuco [Brazil] erecting a stub-mast for the forthcoming visit of the *Graf Zeppelin*.

Herr Hilligarde [most likely this was Erich Hilligardt]—in charge of Electrical Installation and Instruments.

Airship sheds

The new shed at Friedrichshafen is 250 meters long by 46 meters high by 50 meters wide inside (820′ x 151′ x 164′). The whole of the steelwork is inside, the outer vertical walls being made of brick. The floor is concrete covered with wood and apparently considerable importance is attached to this latter feature. It is considered to ease many of the erection problems, and it has been suggested that it has an effect in minimizing corrosion of the structure. It was noticeable that the steelwork employed appeared to be considerably lighter than that employed in England.

In commenting on this, Dr. Dürr said that the Government Regulations under which it was built were quite as strenuous as those laid down in America, and he was surprised to hear that apparently our own regulations had led us to employing a heavier structure.

A small lift was installed at the center of one side of the shed. Double travelling gantries were fixed to the overhead runways on each side of the shed (four in all) provided with winches. From these were suspended horizontal wooden platforms. The doors at each end of the shed were of the curved type running on circular tracks above and below. It was stated that these were not unduly expensive and in any case doors of this shape gave greater clear length inside the shed for less vertical well area.

Dr. Dürr considered that the shed was large enough to accommodate a ship up to 250,000 cubic meters air volume (8.83 million cubic feet).

The operating shed to be erected at Lowenthal has not yet commenced, but Dr. Dürr stated that it is hoped to have it completed by next spring. Its dimensions are up to 270 meters long by 49 meters high by 50 meters wide (886′ x 161′ x 164′).

Workshops

A tour of the workshops showed how excellently the Firm contrived to keep their staff together by the manufacture of various items for the trade. The foundries are extensive and have a good deal of casting work in hand, principally for engine details not only for the Maybach Works, but also for Motor Car Works such as the Opel. Casting is being carried out in aluminum, silumin and elektron. Silumin, however, is only being produced for special high-class work owing to its extra expense over aluminum. The die castings work appeared to be of a particularly high order, some of the items being quite elaborate such as part of the crankcase for the Opel engine.

Amongst other things, we noticed a large casting in silumin for the Maybach twelve-cylinder diesel engine. This was stated to be a heavy engine of about 400 HP for railcar work from which they hoped later to develop an airship engine.

It was noticeable that for the production of elektron castings, 5 percent of sulphur was used in the sand to prevent burning.

In either shops, very large containers for petrol, milk and beer were being constructed from welded aluminum, but nowhere was there any sign of airship work in progress which agreed with Dr. Dürr's statement that they were not yet ready to commence the construction of LZ 128, except that in the big airship shed, the girder structure used for erectional purposes was under way.

Some elaborate metal jigs for the construction of triangular girders were observed in one of the shops.

The Graf Zeppelin

Aerodynamics The following dimensions were given for the ship:

Max. diam.—30.5 meters (100.1 ft)

Length—236 meters (775 ft)

Air volume—121 cubic meters (4.275 million cubic feet)

Max. gas volume—114,000 cubic meters (4.05 million cubic feet)

A convention appears to be adopted for what is called the "declared" volume to represent the condition in which the ship normally leaves the ground. This is taken as 95 percent of the full gas capacity. In this case, however, it was stated that the "declared" volume is 105,000 cubic meters (3.71 million cubic feet) which is considerably less than 95 percent (namely 92.1 percent).

In the wind tunnel which is of the Eiffel-jet type, the models of various ships including the *Graf Zeppelin* and the new ship now under design were viewed. The fan in the tunnel which is driven by two 240 HP Maybach engines gives a wind speed of 46 meters per second (151 foot per second) on a jet of 2.9 meters dia. (9.5 ft). It was noticeable that the mesh of the honeycomb was rather small (about 1½″). All models are made to exactly the same volume and are about 2 meters long. Considerable importance is attached to placing all models in exactly the same position for test, as 30 percent variation in the drag has been experienced by varying the position. The models are hollow and constructed of sheet steel mounted with spiders on a central tube and finally covered with plaster of paris. They present a remarkably neat and elegant appearance. This technique is preferred to the use of wood owing to the tendency of the latter to warp.

The measurements made do not appear to be as complete as these made in the British tunnel. For instance, no measurements of the damping coefficient are carried out and indeed it was stated that no calculations on stability whatsoever are made. This is left to past experience and trial in the air, not always with successful results, as is evident from the alternations which have had to be made to the fins of the *Graf Zeppelin* (see below). Fairly elaborate pressure plotting experiments are carried out with bunches of internal tubes which are connected, eight at a time, to a multiple photo manometer. Certain results were exhibited in the form of curves, but it is not quite clear whether these are exactly on the same basis as employed in this country. Dr. Dürr promised, however, to write us fully on this matter and since the results of our own experiments have now been published in R. & M. 1168 and R. & M. 1169 we promised to send these in exchange. ["R. and M." refers to "Reports and Memoranda," specifically here these reports: Jones, R., and Bell, A. H., "Experiments on a Model of the Airship R.101," ARC RM-1168, London, His Majesty's Stationery Office, 1926; and Jones R., Bell, A. H. "The distribution of pressure over the hull and fins of a model of the rigid airship R.101, and a determination of the hinge moments on the control surfaces." ARC RM-1169, London, His Majesty's Stationery Office, 1926. Here "ARC" is an abbreviation for the Aerospace Research Council.]

From such observations as we were able to make, it appeared that the resistance coefficient from the bare hull of the *Graf Zeppelin* on the basis normally employed in England is 0.0147 (R.101—0.000725). It is noticeable that the *Graf Zeppelin*, owing to the limitations of the shed in which it had to be built, has an exceptionally high block coefficient = 0.7 (R.101—0.59). The calculations as to the speed of the ship (see below) do not agree with the above value for the resistance coefficient, but this is the common experience of the Firm. The fact that their experience is different from ours in this respect is probably due to the nature of their tunnel. Both on the full-scale and in the tunnel, however, the resistance is surprisingly low compared with that of the *Bodensee* and *Los Angeles* in view of the high block coefficient of the *Graf Zeppelin*, and this result was more or less unexpected by the Firm.

We feel that the Company's wind tunnel results may be influenced by a certain amount of turbulence in their wind tunnel, which would explain the variation of drag with position of the model, and on modern theory prevalent in this country would serve to reconcile matters more nearly with the full scale results.

Apparently no experiments are made with engine cars in position, but the passenger car has been included. From a chart exhibited to us it was clear that the Firm are in the habit of making the usual correction of static pressure drop along the tunnel. They stated that experiments were made on the hinge moments of the rudders and the pressure distribution.

It appears that the Firm are still somewhat concerned regarding the loading on the rudder since we noticed in the ship itself equipment in place for measuring the pressure distribution on the bottom rudder.

We endeavoured to discover the exact maximum speed of the ship. Dr Ehrlich gave this as 36 meters per second, but stated that he thought on one occasion they had obtained as much as 37 meters per second, although he did not care to place much reliance on this figure. Capt. Lehmann said that possibly when the ship was new and thoroughly tuned up 36 meters per second might be obtained, but he now preferred to put the maximum speed at about 35 meters per second. Other Officers (Schiller and Fleming) quotes the speed as 33 to 34 meters per second. These figures correspond to 73.8 MPH at the worst and 80.5 MPH at the best.

The propellers were stated to have a diameter of 3.4 meters (11.15 ft) and an efficiency of 85 percent (excluding car interference effects). Our own calculations on such data as is available regarding these propellers would put the efficiency more nearly at 70 percent on the basis, at any rate, which is commonly employed in this country for such calculations. Probably the most reliable method of estimating the full scale drag of the ship is on the basis of the horsepower absorbed at cruising speed.

There was general agreement that the cruising speed of the ship was 32 meters per second (71.6 MPH) at which the propellers run at 1400 RPM and the horsepower absorbed was stated to be 380 per engine. We discovered, however, that this horsepower was estimated from gas fuel consumption probably at a height of about 2,000 ft. which corresponds to a ground horsepower of about 410.

We noticed in the gas supply mains to the engine cars that Venturi meters were fixed for measuring the consumption.

For the horsepower and propeller efficiency stated, the *overall* resistance coefficient of the ship works out at 0.01015 or taking the efficiency of the propellers at 70 percent—at 0.0109 (R.101—0.0115). These results are exhibited and compared with R.101 in Figure 1 attached to this report, the curves of which are taken from R. & M. 1119. [Jones, B.M. "Skin friction and the drag of streamline bodies" ARC RM-1199, His Majesty's Stationery Office, 1929.] On the basis of these curves which represent modern theory regarding the effects of turbulence, the results do not appear as inconsistent as might be expected at first sight, if it be accepted that the conditions in the Friedrichshafen tunnel are turbulent. The fact remains, however, that it is quite evident from the full scale results on the *Graf Zeppelin*, its shape which in the past would not have been regard as very good in this country, has a remarkably low drag coefficient, indeed lower than that of R.101.

With the object of gaining further light on this question, Dr. Dürr very kindly undertook to make and test a model of R.101 in his tunnel, if we would reciprocate with similar tests on a model of the *Graf Zeppelin* in our own tunnel. It is hoped that this procedure can be agreed to, as we feel it will throw valuable light on what is a most vital question in airship design.

These facts serve to illustrate the necessity which has been recently strongly urged by us of comparing the merits of various shapes under turbulent conditions in the wind tunnel instead of merely under the conditions of smooth laminar flow which has been employed hitherto.

Structure The general arrangement of the structure of the *Graf Zeppelin* does not exhibit any noticeable departures from previous zeppelin practice except for the inclusion of the axial corridor which is located rather below the center of the ship, in addition to forming a partial support for the fuel gas bags, it also forms a support for the automatic gas valves which would otherwise be somewhat difficult to deal with in view of the presence of the fuel gas bags below.

It will be evident from Figure 4 that the total head of hydrogen is not so great as in previous ships, which did not carry fuel gas bags. This means reduced pressure on the bulkhead wiring. In addition, the axial corridor helps to support the pressure on the bulkheads (in a similar manner to the axial girder in R.100), and these two facts combined serve to reduce what would otherwise be the very high loads to be carried in the transverse frames. It should be remembered also that the diameter of the transverse frames of the *Graf Zeppelin* is considerably less than that of the British airships (100 ft. as compared with 130 ft. approximately), and even in the new ships which the Firm are designing of approximately the same capacity as the British ships the diameters will be smaller since the fineness ratio is to be 6 as compared with 5.5 in the British ships.

We discovered from a conversation with Dr. Dürr that it was the combination of these facts which led him to the opinion that in the new ship he could successfully employ the same type of transverse frame as they used in the *Graf Zeppelin*. Nevertheless he expressed the opinion that it might be necessary to change to the R.101 type of frame when building ships of still greater capacity in the future.

The question of weights was discussed, and the Firm stated that it was not their habit to publish such data in Germany, and we informed them that similarly so far in this country, we had not published any comprehensive details regarding the weights of the British ships. They offered to exchange a schedule of weights on a quid pro quo basis, provided their information was not published in this country. We said we thought this would be acceptable to our authorities. It is hoped that this procedure can be agreed to, as the information likely to be obtained from the Zeppelin Company in this respect should prove very valuable.

In conversation with Dr. Eckener, we suggested that one of the directions in which technical cooperation between different nations would prove beneficial was on the subject of factors of safety, since this was bound up with such international matters as certificates of airworthiness and rates of insurance. Dr. Eckener thoroughly agreed, and we suggested that in the first instance we should send particulars of our Airworthiness Regulations (R. & M. 970) for comment by his technical staff. [This refers to *Report of the Airworthiness of Airships Panel*, London, His Majesty's Stationery Office, 1925.] Incidentally Dr. Eckener expressed the opinion that the factors of safety commonly employed by his Company were rather less than our own.

Very little novelty was observed in the structural detail. It was noticed, however, that the bracing of some of the girders was of the improved type shown in Figure 2 attached to this report, and it is understood that this is to be employed still more extensively in the new ship. Particulars of the principal channel sections employed for the construction of the girders were also obtained, and are shown in Figure 3. It was stated that the strongest girder in the *Graf Zeppelin* was capable of withstanding an end load of 15 tons, such girders being employed in the transverse frames. An examination of the particulars given in Table 3, however, shows that none of the sections referred to there are likely to be capable of giving a girder to sustain such a high load as this.

Dr. Ehrlich referred to the curves of girder efficiency given in Colonel Richmond's paper to the Institute of Naval Architects. [Richmond, V. C. "Some Modern Developments in Rigid Airship Construction," *Transactions of the Naval Architects* Vol. LXX 1928 p. 173–209; this paper is summarized in "HM Airship R.101," *Flight* April 12, 1928.] On this curve he had marked points to correspond to the efficiency of two of the Zeppelin Company's girders. These showed that at an l/k of 27.2, the efficiency factor was very nearly 10. This corresponded with the efficiency of the best of all duralumin girders in R.101, but was not so high as the efficiency of the composite steel and duralumin girders.

We discussed with Dürr the nature of the material to be employed in bracing members such as shear wires. He stated that all the bracing wires in the *Graf Zeppelin* were of the solid drawn construction, the thickest being 3.4 mm. We estimate that these should be capable of sustaining a tensile load of 1½ tons. The endings employed on such wires are of the bent, bound and soldered type, but it is evident that the limit has been reached with regard to the thickness of wire with which such endings can be made.

The load of 1½ tons as a maximum in the bracing wires of the *Graf Zeppelin* appears to us to be remarkably low, and we think it probable that the wires must be doubled or trebled in some places to give the necessary shear strength, though we had no opportunity of actually observing this.

The Firm's objection to flexible bracing wires was stated to be the low coefficient of elasticity. We pointed out to them, however, that if flexible cables of the straining cord type are employed, the coefficient of elasticity is quite reasonable. For the larger wires which would be necessary in their new ship, the Firm stated that they proposed to experiment with swaging on end connections, but we think that such long thick rods are likely to prove troublesome during erection being very liable to receive permanent kinks.

We carefully examined the bow of the *Graf Zeppelin*, and were also shown a detailed drawing afterwards. The general arrangement for the support of the bow spindle is somewhat similar to that of R.101, except that the aft end of the spindle is radially supported by girders instead of tie rods as in the case of R.101. It was stated that the bow was strong enough to sustain a lateral breaking load of 28 tons, though certainly in our opinion without a detailed examination of the strength of the members, the construction looked somewhat too light to carry such a heavy load. The bow spindle has only a short overhang (415 mm between the forward bearing and the suspension point), and the ship would undoubtedly foul the Cardington mast head unless the mast was fitted with a special adaptor cone.

It was noticed that the bearings worked direct on the surface of the spindle, and the Firm stated that this was made possible by the employment of a special steel for the construction of the spindle. The diameter of the spindle at the forward bearing was about 250 mm, which is considerably larger than that of R.101's spindle. The spindle tapers considerably towards the aft and where the inner diameter is only about 65 mm which would not be capable of passing the stopper normally employed on the mooring ropes of the British ships. The casting at the forward end of the bow was noticed to be of elektron metal.

We discussed the use of this material for airship work with Dr. Dürr and discovered that this was practically the only place in the ship where it was employed. He did not seem to have any very definite views about its further employment in future airships.

We did not notice any instrument in place for measuring the lateral force on the bow, and the arrangement of the spindle did not appear to lend itself particularly well to the inclusion of such an instrument.

The fins were noticed to be remarkably wide for their depth, so much so that we suspect from our own experiments in this country that they are not particularly efficient. Owing to the fulness of the shape of the tail, the fins are relatively long in comparison with their depth, which is again not a particularly efficient arrangement. It is evident that the fins have given a certain amount of trouble, and Dr. Eckener stated to us that the ship was originally too unstable. Since first they were constructed, however, the horizontal fins have been increased in size, and the bottom fin has had a projecting piece added, and a deeper rudder fitted to correspond.

From our observations of the steering of the ship in flight, it appeared that it was not particularly stable in direction, though Capt. Lehmann blamed this on the lack of experience of the rudder coxswain.

It was noticed that the surface of the fabric in the fins was very well supported by a system of light intermediate ribs and it is evident that the support of the fabric has given the Firm considerable anxiety since their experience on the Atlantic flight when the fabric was badly torn.

We were informed that one complete turn of the wheel in the control car corresponded to a movement of the rudder 3 degs. The travel of the main control was stated to be 2 meters.

Valves The automatic valves which were of the conventional type were stated to be capable of allowing a rate of rise of 10 meters per second (approx. 2,000 ft. per minute) with a super-pressure of 10 mm at the valve. This was stated to be equivalent to a super-pressure at the bottom of the gas bag of about 1 mm, as the valves were located above the axial corridor are considerably above the bottom of the bags.

Blau gas installation The *Graf Zeppelin* is fitted with seventeen hydrogen gasbags. Fuel gasbags are fitted underneath twelve of these extending from the fourth bag from the nose to the third bag from the tail inclusive. The suspension of the fuel gasbags is illustrated diagrammatically in Figure 4. These bags are made of exactly the same material as the hydrogen gasbags, which we were informed had a strength of 800 kilograms per meter width (45 lbs. per inch approx.).

A noticeable feature of the arrangement was the fact that when the fuel gasbags are empty, the hydrogen bags are not of sufficient volume to completely fill the hull space. On the other hand, no special support is provided for the bottom of the hydrogen bags when they are up to pressure, the strength of the fabric being considered sufficient to sustain the super-pressure which is only of the order of 1 mm at the bottom. The support of the fuel gasbags is of a very rough and ready character, and is sufficiently indicated in Figure 4.

An alarm communicating with the control is fitted under each fuel gasbag in the roof of the keel indicating when the ship has reached a pressure height or when the Blau gasbags have been completely filled in the shed. As far as could be ascertained, this alarm consists of a simple dome which when pressed down by the gasbag against the action of a spring makes an electrical contact. Two of these alarms are made to give quantitative measurements of pressure by the action of a contact moving over a resistance coil.

The principle gas main is of 100 mm dia. and is located at the top of the keel, and passes from end to end below the twelve fuel gasbags. It has three filling points, one in the form of a flexible fabric pipe at the forward end for filling from the mast, and two tee connections one forward and one aft, for filling in the shed. There are flexible joints in the main at intervals, made of ordinary rubber hose fixed with metal clips which are bonded together. The main is provided with isolating valves of the type shown in Figure 5, so that the fuel gasbags are divided into three groups, corresponding to the three engine positions. Gas is, however, only drawn from one bag in each group at a time. The bags are connected to the main by a simple branch piece, provided with an isolating valve and the connection to the bag is made in that portion of its lower surface which forms the roof of the keel.

The branch mains supplying the power cars are of 60 mm diameter. Immediately above each engine, the branch main is connected to the automatic suction valve illustrated in Figure 6, and from this four separate branch pipes, pass to the four carburettors (two at each end of the engines). Immediately before entering the carburetor, each of these branches is provided with a suitable flame trap. This trap is extremely simple in construction, and consists mainly of eight layers of fine gauze supported between by two layers of heavier gauge. The disc area of the gauze is about 120 mm in diameter. This flame trap appeared to be so simple and light in construction as compared with similar devices contemplated in this country that we asked the Firm if they would be prepared to supply one on repayment for experiment in this country. This they readily agreed to do. They stated that it was quite effective either for Blau gas or hydrogen.

The object of the automatic suction valve illustrated in Figure 6 is to prevent gas passing through the engine and into the exhaust pipe, except when there is suction on the induction pipe.

For the same reason the engine is started on liquid fuel only since otherwise the Firm were emphatic that there was serious danger of a big flame of gas or even an explosion in the exhaust pipe.

In the supply pipe to the particular engine car which we visited, it was noticed that a Venturi meter was fixed for measuring the fuel gas consumption.

The density of Blau gas at present preferred appears to be between 1.1 and

1.05.

Dr. Eckener stated that the gas being slightly denser than air, it always percolated down to the keel where there was ample ventilation to clear it away. Although this was advanced as an argument in favor of safety, it might be equally said that since the most likely sources of ignition will lie along the keel of the ship, it would be better to have a gas which is less dense than air.

The consumption of gas per horsepower hour was given as 0.135 cubic meters (4.77 cu. ft.) at 0 °C, 760 mm pressure and 1.05 density. This corresponds to a weight of gas burnt of 0.404 lbs per HP hour.

If allowance be made for the weight of hydrogen saved in the space occupied by the Blau gas, then the figure of 0.404 lbs per HP should be reduced to 0.366 for the purpose of comparison with all liquid fuel burned in a normal installation. Against this, however, must be offset any excess of the weight of the Blau gas installation itself over the corresponding installation for liquid fuel. In any case it must be borne in mind that the installation actually employed is one combining both liquid fuel and fuel gas.

It was stated that the composition of the liquid fuel normally employed is 80 percent Benzole, and 20 percent Petrol.

It was stated that the calorific value of the gas normally used is 15,800 kilogram calories per cu. meter at RTP (1,775 BTUs per cu. ft). This figure appears to us to be somewhat higher than has been stated in previous publications.

Auxiliary machinery & electrical installation The *Graf Zeppelin* has now been fitted with a special cabin to carry the auxiliary machinery only. We regard this as a most useful and progressive feature. The cabin which is located immediately aft of the passenger car is egg-shaped with about one-third projecting outside the outer cover. It is gas tight as far as the interior of the hull is concerned, having double doors for entry which constitute a gas lock. It is well-ventilated to the outer air by openings in the bottom. In it are located the two auxiliary engines, two dynamos for cooking, two for lighting, the Gyro compass and the electric switchboards. Only one of the auxiliary engines with its train of dynamos is used at a time, the other being held in reserve.

These engines are of the type normally employed in the Wanderer Motor Car, and have an output of about 12 HP. They are run on Blau gas. They are started by means of the ordinary motor car starting gear run off the ship's accumulators. The generators used exclusively for cooking are rated at 110 volts, 72½ amps (8 kilowatts). They are enclosed DC machines running at 2,000 RPM and manufactured by Siemens Halske.

The other electrical services of the ship are maintained by batteries in conjunction with smaller generators running at 24 volts, and cannot be run for over thirty minutes off the batteries. For this reason, it is necessary to keep the auxiliary engines running if any protracted stop is made in the course of a flight. The Gyro compass was stated to take about three hours to set itself after first being started up.

The auxiliary engine can in an emergency be started by means of a strap on a pulley.

Fans are provided for cooling the radiators of these engines, but a certain amount of cooling is also provided by the fact that the hot water is passed into heating radiators in the passenger saloon.

Visits to Maybach Motor Works & Lowenthal Gear Gutting Works

It is not proposed to comment at length on these Works since a very full report was recently rendered by AD/RDE. It was quite evident in the course of our conversations with Doctors Eckener and Maybach that they were very anxious to persuade us to use the Maybach engine in the British ships, and they were therefore extremely pressing in their invitations to visit the Maybach Works.

We pointed out that the horsepower of this engine was rather too low for our purpose especially as it was ungeared, and in order to draw as much information from them as possible, expressed surprise that the engines were normally only run at 400 HP and that the efficiency of the propellers employed was as low as 65 percent. This produced some discussion between Dr. Eckener and his Constructors regarding new propellers, and also elicited the information that a gear for the Maybach engine was well advanced, or which the Firm promised to give us details (see below).

Dr. Ehrlich informed Dr. Eckener in our hearing that new propellers were being constructed, and should be ready with a month or two. As far as he can ascertain these propellers will probably give better efficiency and absorb more power at a cruising speed, but are liable to reduce the top speed of the ship. Dr. Maybach was emphatic that the engine was capable of a considerably greater continuous power output which he suggested might be made as much as 500 HP.

It was evident that the resonance characteristics of the shaft were so adjusted with the aid of the coupling as to make 1,400 RPM the most comfortable speed for cursing. It was not clear, however, why this particular speed with its corresponding power of 400 HP with existing propellers was fixed upon.

At the Gear Works, we were shown a drawing of the reduction gear to be employed on the Maybach engine for airship purposes. This gear is of the Farman type, and it is to be bolted directly on the engine without the interposition of a coupling. It is designed, however, to drive a tail shaft, and it is possible that it might be found necessary to insert some form of flexible coupling in this shaft. The gear is to be carried in a simple dome-shaped casing made of silumin, and provided with cooling veins on one side. We saw some of these castings in the process of manufacture.

We noticed that one of the bevels has forty-two teeth, and the other twenty-four teeth, but no arrangement is made for inclining the bevels to give other reduction ratios than 2:1. The large bevel was roughly 8″ in diameter, and the small one 5″ in diameter. The length of the teeth was estimated to be about 2½″. No arrangement is made for taking the airscrew thrust in the gearbox, but only the thrust of the vertical bevel. The low speed shaft is spigotted into the crankshaft with a plain bearing.

The whole gear is oiled from the engine via the crankshaft.

We were told that 95 percent of the steel employed for gears in this Factory was of the oil hardening type, we noticed that the gears were held in a special press during quenching to prevent distortion.

In the Maybach Works we were shown copies of the results of the endurance test carried out on the airship engine. This appears to have been run at 1,600 revolutions for 225 hours. The horsepower was given as 550 at 1,300 feet above sea level. During part of the run, the power appears to have been raised to the equivalent of 605 at sea level.

We noticed that the Firm were manufacturing a considerable number of 150 HP Diesel engines for railcar work. These were of the six-cylinder in-line type with air injection. The Firm stated that they had adopted this method of injection because the compressed air was useful for other purposes in the railcar and also because it gave greater economy at low speeds.

We observed that the bottom half of the crankcase of these engines were manufactured of silumin, and that long vertical steel bolts were employed between the cylinder head and the main bearing caps.

Blau gas plant

A new plant for the production of Blau gas has been erected at Friedrichshafen, but was not in operation at the time of our visit, as it has been found necessary to make certain alterations in order to adjust the temperature in the oil cracking retorts. At present supplies of gas are being obtained in high pressure wagons from Bitterfeld. This gas referred to by the Firm as Lehner gas is transported in liquid form at a pressure of about forty to fifty atmospheres. One truck is stated to be capable of transporting seven tons of liquid. The density of this gas at atmospheric pressure is 1.4 and has to be diluted with hydrogen. As far as we could gather, it was being manufactured from waste fat products.

The new plant at Friedrichshafen is manufactured by the German Blau Gas Company, Augsburg and consists of four units. Each unit is built up of an oil vaporizer, a superheater, or retort, and a condenser. The total cost of the plan was stated to be 150,000 marks (£7,500). The output of each of the four retorts was stated to be 120 cubic meters per hour (4,240 cubic feet per hour). The cost of the gas thus produced is stated to be 60 pfennigs per cubic meter (17/– per 1,000 cubic feet).

Incidentally Dr. Dürr stated that hydrogen was produced in the Friedrichshafen plant at about one-third of this cost.

The main retorts are heated by water gas. They consist of about 300 vertical tubes of small diameter through which the oil vapor passes. The cracking temperature is between 400°C and 500°C.

It was stated that the oil employed is ordinary "gas oil."

The gas is cooled in the condenser by further supplies of oil. The gas as produced in this manner is of somewhat low density, and has to undergo two further processes. In the first it is mixed with hydrogen, and the mixture is passed over steam heated nickel where apparently the catalytic action causes the hydrogen to combine with certain constituents of the gas. The next process is to submit the gas to high pressure in order to remove certain constituents. The exact pressure employed for this purpose is not known. We noticed, however, that the compressor was marked for a maximum pressure of eighty atmospheres, and the Lehner gas at twenty-five atmospheres.

The density of the gas produced up to this stage is apparently about 0.95 at atmospheric pressure, and it was stated that it is finally treated with a small proportion of Lehner gas to bring its density up to the desired figure of 1.1 to 1.05.

The gas in the compressed form is passed for storage into a special building equipped with a large number of ordinary size gas storage bottles.

Operational details including instruments

We endeavoured to obtains some general views from the Flying Personnel regarding water ballast. Captain Fleming stated that for long flights they rarely carried more than about 3½ tons, and he seemed to regard 5 percent of the gross lift of the ship as about the maximum likely to be required at any time.

He expressed the opinion that possibly landing to a mooring tower might introduce special requirements in addition to this. The only protection employed against the freezing of water ballast is the old method of dissolving a certain amount of calcium chloride in the water. We referred to the now well-known objection to this practice, namely that it might cause serious corrosion in contact with duralumin. The Firm considered, however, that this was merely a question of taking proper precautions and the alternatives of using glycerin or ethylene glycol were too expensive.

We noticed that the *Graf Zeppelin* carried reserve water in a very neat form of rectangular ballast bag provided with a long neck which could be tied up. We were unable to ascertain, however, the precise purpose for which this was reserved.

The ship carries about 600 kilograms (1,332 lbs) of spare machinery parts including a propeller on long flights, and also a small sling for lifting engines.

The question of experience in vertical currents during the *Graf Zeppelin*'s world flight was discussed at length. No accurate estimate appears to have been made of the maximum rate of rise or fall experienced by the ship, but Captain Lehmann stated that an allowance of ten meters per second (approximately 2,000 feet per minute) made on the gas valves was ample to cover any movements which they had experienced. The greatest extent of the vertical movement which the ship had undergone was stated to be 300 meters (approximately 1,000 feet) on more than one occasion. It was stated that the only occasion on which the ship had been forced down to a within a few hundred feet of the sea was when the fabric tore on the horizontal fin. Members of the crew were sent out on the fin to examine the girder work for which purpose it was necessary to reduce the speed. The ship was then struck by a heavy squall of rain and began to descend. It was impossible to open out the engine in order to regain the height before getting the men back again into the ship, and this accounted for the low altitude to which the ship descended.

It was noted that extensive use was made of the echo sounding gear to determine the exact height of the ship especially just prior to landing. On long flights we were informed that it was the regular routine practice to determine the ship's height accurately at 8 a.m. each day and set the barometer accordingly. The method employed was stated to give an error of loss than one percent at a height of 200 meters (656 feet) even in the hands of an inexpert operator. With an expert operator reasonably good readings could be obtained up to a height twice this.

The sound is produced by an ordinary 11 mm rifle firing a blank cartridge through a vertical tube and we were informed that for first-class accuracy it was important to have the ship on an even keel at the moment of firing. We were also informed that experiments with the type of instrument which employs a siren to make the sound had not been successful.

Details of the Behm sounding instrument which it is understood was employed in Germany, are well-known in this country. We had no opportunity of witnessing the use of the instrument fixed in the *Graf Zeppelin*, but the description given us by Captain von Schiller does not appear to agree very well with the details previously published in this country.

As described to us, the effect of firing the shot was to release a pendulum, the oscillations of which were carefully counted. The effect of the echo was stated to be to deflect the pendulum sideways from the scale over which it was swinging and the reading on the scale when this occurred was carefully observed.

Prior to landing, the meteorological data usually called for in this country is supplied by wireless. In addition large boards marked with figures are laid round the landing tee to indicate the ground temperature, barometer, and wind.

We observed that the ship carried a recording electric thread thermometer similar to the type used in the Cardington Meteorological Office. This instrument appeared to be giving three records, presumably one for the atmosphere and two for the gasbags. It was noted that the ship also carried an Assman psychrometer. In addition to the ordinary aneroid the ship carried a continuously recording instrument.

Considerable importance was obviously attached to accurate statoscopes and inclinometers. In addition to the ordinary aneroid a low-range instrument usually referred to in this country as a landing altimeter, was carried. In addition to this a very sensitive aneroid manufactured by Askania was observed. This instrument has a range of twenty meters rise or fall from zero, which could be set at the will of the coxswain by pushing the pointer to the mid position to which it could be set at any moment. Two instruments of the Thermos Flask and Leak type were carried to indicate the rate of rise and fall.

The pilots expressed the opinion that the Askania instrument referred to above used in conjunction with a stopwatch was the most accurate means available for determining the rate of rise or fall. Two bubble inclinometers were carried of different sensitivity.

For determining the air speed of the ship, an air log appears to be preferred to a Pitot tube, which is in agreement with our own experience in this country. The method of recording the airspeed is interesting. The same instrument is used for indicating the speed of revolution of the engines through the medium of a multiple switch which can be connected to each of the engines in turn or to the air log. The indicating instrument is a frequency meter of the tuned reed type manufactured by Hartman and Braun. The transmission between the engines or the air log and the indicating instrument consists of a simple type of alternating current generator which transmits impulses through electric leads to some form of vibrating mechanism in the frequency meter.

The pilots referred to what they considered to be a very useful form of ground speed indicator which has been evolved in Germany, but was not yet fitted to the *Graf Zeppelin*. This consisted of a coarse wire spiral rotated by an electric motor, the speed of rotation being capable of adjustment at will. The spiral rotates over a slot through which the ground is observed. The speed of rotation is adjusted until the lines of the spiral appear to remain stationary with respect to the ground. The rate of rotation of the spiral then gives an indication of the ground speed.

Very great importance was obviously attached by the pilots to the use of the Gyro compass, which is now installed in the *Graf Zeppelin*. The compass is carried in the auxiliary machinery cabin with a repeater in the control car, and also a second repeater giving a continuous autographic record. This compass was stated to weigh 150 kilograms (331 lbs) including one repeater. This weight was considered to be amply justified in view of the greatly improved steering which resulted therefrom. It was stated that the improved steering increased the actual air speed of the ship by 1 to 2 meters per second (say 3 miles per hour). It should be borne in mind, however, that the more stable the airship in direction, the less will be the value of such a device, and we have already commented elsewhere on the fact that the *Graf Zeppelin* is apparently somewhat lacking in directional stability.

Experiments are contemplated in this country with a gyroscopic turn indicator which as far as can be seen should be just as effective as the Gyro compass for ensuring good steering for less weight.

It was observed that a single engine room telegraph dial was used for each pair of wing engines. Each dial, however, carried two independent handles. There were no marks on the dials corresponding to full speed on the engines, and we were informed that on the comparatively few occasions when full speed was used, it was customary to send for the chief engineer and instruct him verbally or alternatively to give three rings on the engine telegraph gongs.

The question of mooring and handling airships was discussed at some length especially with Dr. Eckener. He stated that he had studied American methods at some length, and also that he was impressed with what had been done in England but would like to have more experience regarding operations to and from a high mast. Dr. Eckener said that he regarded this as an important international matter on which he hoped we should all finally come to as close an agreement as possible. It was evident that he had not yet made up his mind on the subject, as he stated that it was proposed to carry out certain experiments in Germany, but that he hoped to be ready to discuss the matter about next August, when he suggested a conference on the subject should be arranged between representatives from America, Germany and Great Britain. We could gain little information regarding the exact nature of the experiments proposed except that we observed that a small stub-mast was lying on the Lowenthal Aerodrome, and Dr. Eckener referred to attempting to land at this mast with the aid of blocks and side guys somewhat similar to those employed in England for landing to a high mast. Dr. Eckener stated that he was satisfied that an airship could ride at a stub-mast provided it was made heavy on the aft car, but he was by no means satisfied that successful landings could be made to such a mast, except under exceptional weather conditions. Until he had made his experiments, he preferred to preserve an open mind on this question.

We discussed with Capt. Lehmann the necessity for keeping an airship trimmed up by the nose during the process of hauling into a mast, and pointed out that this might involve difficulties with the stern of the ship as it approached the ground. He reported that close to the ground, the air flow should be practically horizontal, but it was obvious that he had not thought very deeply on the matter especially with regard to the downward kiting effect caused by the main hauling in wire.

Capt. Fleming objected to the considerable weight of the ropes which had to be carried for landing to a high mast.

A short discussion also took place on the subject of mechanical handling on the ground. Capt. von Schiller referred to the difficulty which might be caused by the noise of the tractors employed in such an operation and referred to the Citroen tractor manufactured in France, which was provided with rubber tracks, and was much quieter than the ordinary type. He was against the use of sunken rails owing to the difficulty of their becoming clogged with stones and ice, but Capt. Lehmann considered that the sunken type of rail was essential and that if properly designed and maintained should not lead to any difficulty.

Capt. Fleming volunteered an interesting explanation of the circumstances which have been previously reported under which the *Los Angeles* assumed an almost vertical position whilst riding at the high mast at Lakehurst. He stated that the stability wheels or rollers had been loaded with lengths of heavy chain. Owing to the fact that they were not being carefully watched, he thought that some of this chain was resting on the ground and hence provided a drag which prevented the ship from rotating in an azimuth under the action of change in wind direction. A fresh cold breeze was probably thus enabled to strike the ship on the tail, and this accounted for the subsequent events.

Projected design of new ship LZ 128

The following general points regarding the new zeppelin airship which is now being designed were obtained in general conversation. The ship is to have a capacity approximately equal to that of the British ships. It is to have a fineness ratio of barely six. The block coefficient is to be 0.65. It will have thirty-six longitudinals all of equal strength, and transverse frames of a similar design to that employed in the *Graf Zeppelin*. It is admitted that the strongest girder required in the ship will have to withstand an end load of approximately twenty tons.

The ship is to carry eight Maybach engines mounted in tandem, but we were unable to ascertain the exact arrangement proposed for the engine cars.

The Firm stated that they did not like the tandem arrangement, but this was only a temporary measure until they could obtain engines of greater horsepower. They hoped to realize a cruising speed of 36 meters per second (80.6 MPH). Observing that this speed is higher than the cruising speed of the *Graf Zeppelin*, we asked for their views on this question. The designers stated that they were naturally averse to being asked for a very high speed, but this requirement had been laid down by the operating staff. We questioned them as to whether this was result of experience gained under bad weather conditions or whether it was merely with the object of shortening the time of passage. They stated that it was the latter reason.

The passenger car is to be located entirely within the hull of the ship, but bulges are to be fitted on the sides of the ships in order to provide vertical windows. It is interesting to note that the Firm have arrived at the same conclusion as ourselves regarding this point.

The accommodation is to be sufficient to carry not more than thirty passengers, but the Firm consider it essential that it should be on a fairly luxurious scale. They also consider that they will be fortunate if the structure weight of their passenger accommodation does not exceed eight-and-a-half tons.

Visit to the Dornier DOX machine at Altenrhein and subsequent conversation with Dr. Eckener

The following brief observations may be of interest if the facts stated are not already known to the Air Ministry Officers who have previously inspected this machine. This visit was arranged by Col. The Master of Sempill, and the Firm very courteously sent a launch to take the party across Lake Constance on Sunday afternoon. We were escorted round the Works by Herr Bernard whom it was understood acted in the capacity of Works Manager.

Subsequently on our return to the Kurgarten Hotel at Friedrichshafen, we encountered Dr. Dornier himself. A number of searching questions were put to him by Col. The Master of Sempill, all of which appeared to be answered very frankly. Amongst other things, Dr. Dornier stated that the Jupiter engines in the DOX are only good for a continuous HP of 300 and that at a greater output than this, they give continuous trouble. He hopes that the Curtis Conqueror engines which are being substituted, will give a continuous output of 420 to 430 HP without trouble. The extra weight involved in the radiators will be compensated for by the lower fuel consumption after ten hours flight.

This mean propeller efficiency of the tandem combination was stated to be 60 percent. Dr. Dornier stated that apart from the engines, the modifications required in the machine were trifling, and would cost less than 1,000 dollars.

The controls which consisted originally entirely of metal tubes were found to have insufficient elasticity, and consequently a length of flexible steel cable had been inserted. The back step is being sharpened by a few degrees to give a smoother braking on landing, thought it was admitted that this might affect the take off.

Dr. Dornier contemplates a still larger machine in which the wing area will be increased by about 100 sq. meters, but we gather that this represented a maximum which would satisfy him for a considerable time to come.

We referred to the very heavy duralumin sections which it had been necessary to develop for this machine, and Dr. Dornier stated that he would prefer to employ steel except for plating, but could not obtain the necessary sections in Germany.

We noticed that some of the channels and plates employed were as much as [fraction illegible in original]″ thick. We also noticed some large 4″ steel tubes in the struts and enquired if these were made of high tensile steel. We were informed that these were made of comparatively low grade material (thirty-two tons per sq. inch) and were manufactured by the Mannesman Tube Company.

Col. Sempill asked Dr. Dornier if he was still a believer in the use of stub wings in place of wing tip floats, and was informed that Dr. Dornier whilst not regarding them as ideal, still thought they were the best solution available at present.

Arrangements are now being made whereby fuel or mail can be carried in these stub wings.

Dr. Dornier stated he was now working on a now four-engine machine which differed in many respects from the Super Wal. [For details see "A New Dornier Super-Wal," *Flight* March 22, 1928.] Apparently he hoped great things from this machine. Both the factories at Pisa and Mansell were working on this machine.

The allied company which he was forming in America and which was financed by General Motor Ltd. had only reached the stage of surveying a suitable site near Philadelphia. His company in Holland had just completed an order for forty machines and were now working on twelve more for the Dutch East Indies. Dr. Dornier also stated that day bombing machines were being built in Japan to his design. [This was likely the *Do Komet III* built under license by Kawasaki.]

We observed that there was a good aerodrome for land machines in the possession of the Dornier Works at Altenrhein with a clear length of about two kilometers.

We were informed that when the new engines are installed in the DOX it is proposed to carry out an endurance flight in the Mediterranean of 4,000 to 5,000 kilometers. If this is successful, an attempt will be made to cross the Atlantic. Dr. Dornier emphasized the ease with which the machine can be handled in the air and stated that it had ridden out six-foot waves on Lake

Constance without any sign of distress.

[Signed] V. C. Richmond, F. M. Rope
RAW
Cardington,
7th May, 1930