HOW BALLOONS AND AIRSHIPS FLY

By JOSEPH LAWRENCE

WE are so used to seeing aeroplanes flying about that we are perhaps beginning to think that aeroplanes are the only kind of aircraft which can safely fly. We have read of great disasters to airships and we think of them sometimes as only gasbags. We are reminded that during the Great European War we had a great number of airships, some large and many small, and we sometimes wonder what they are like and how they fly since they are seen so seldom in England. I am going to explain to you here how they fly and how they can do things which aeroplanes and autogiros cannot. To make the explanation easier I shall first talk about balloons which Roger Bacon thought about in the thirteenth century and which were first flown 150 years ago.

We go to a fête or to some sports meeting, and one of the first things for which our money is required is to buy a toy balloon. We purchase one, write our name on a post-card, tie it securely to the toy balloon which has been blown up by the stallholder, and then we send it away on its voyage. It rises rapidly and soon vanishes from sight with all the other balloons, flying down the wind. After the lapse of a fortnight, or perhaps only a day or two, we hear whether our card has been posted back and from where. Perhaps we win the prize for the longest distance or have guessed correctly how far the winning balloon went and what was the district where it fell. Two small balloons released one day in June, 1929, from Manchester made long flights in opposite directions; one came down in Berlin, and the other reached Ontario, Canada.

The flight of a toy balloon is essentially the same as that of an airship except that the former is entirely at the will of the wind and the latter can be directed as and where the pilot wishes. Both depend for their ability to float in the air on the gas contained in the rubber bag or envelope.

The toy balloon used to be, and still often is, filled with coal gas, the gas that is burnt in gas fires and in the gas cooker. More often it is filled with hydrogen. You can hire from the London firm of Allan Liversage cylinders containing hydrogen compressed to a high pressure. The neck of the cylinder has a pipe leading from it to which the rubber balloon can be tied. It is blown up by turning a tap to let out some of the gas from the cylinder into the rubber skin. Coal gas and hydrogen are both lighter than air, but hydrogen is much the lightest gas of the three, and so it is used in large balloons (see Fig. 1), and in airships. Helium is a rare and expensive gas, which is found in petrol in the United States, America, and is heavier than hydrogen but lighter than coal gas, but has the advantage that it cannot be set on fire. Coal gas lights very readily with a match, and hydrogen is much more inflammable. Both gases when mixed with air in certain proportions can be exploded by a light, and this has been the cause of many serious accidents to balloons, and to airships. The risk can be avoided with care, and several airships filled with hydrogen have safely flown very long distances. Several of the more recently constructed airships have, however, been filled with helium.

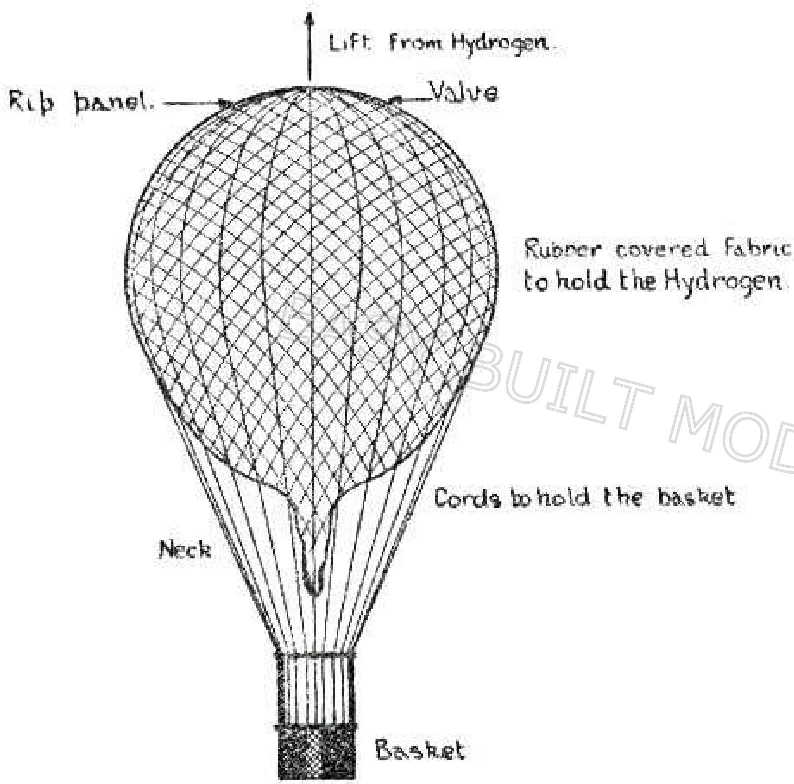

Fig. 1.

The size of the balloon or airship depends upon the weight it has to carry and we have to know the weights of the various gases for a given volume. These are known accurately, but as they vary with temperature and with pressure, the figure always taken is that for an average spring day.

The variation of their weights or of the volumes of the gas in the bags in the airship, as I will explain later, affects very much the flying of an airship. One thousand cubic feet of air weighs 75 lb., of hydrogen 5 lb. and of helium 10 lb. Every thousand cubic feet of hydrogen in an airship will lift 70 lb. and of helium a little less—about 65 lb. The amount of weight that can be carried is the difference between these weights and the weight of air at the same volume. The toy balloon is usually very light, being only made of rubber stretched out tight and so it goes quickly up into the sky. If you blow up a balloon with your mouth, it will certainly not float up into the air, as the weight of the rubber will hold it down and the air from the lungs contains a larger proportion of

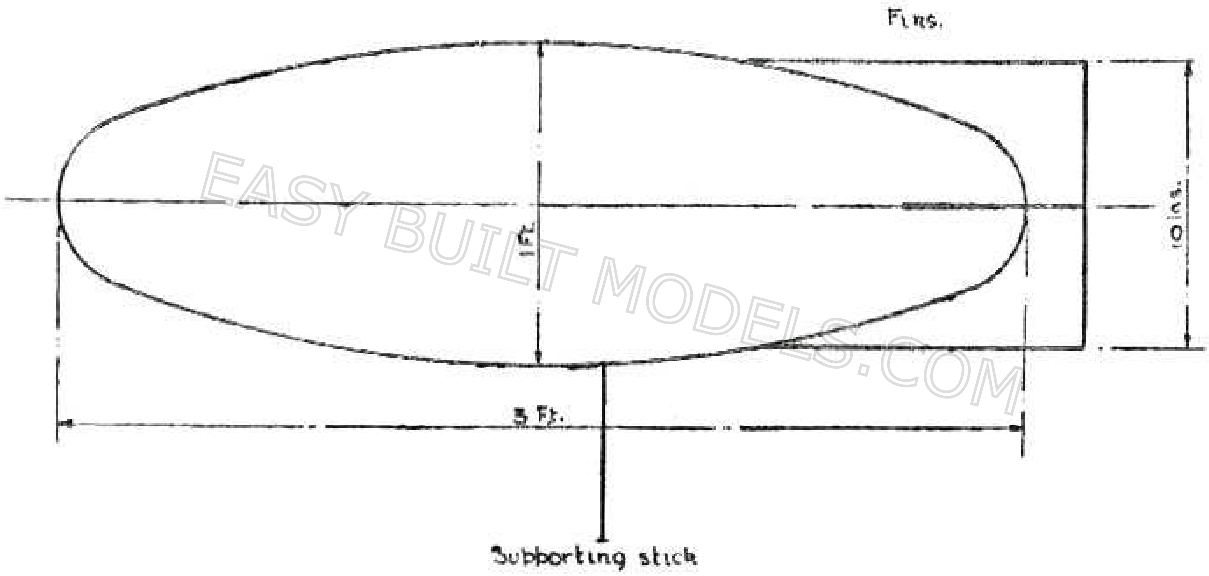

Fig. 2.

carbon dioxide and water than air, and so is heavier than the air around us.

The weight of the rubber making the bag to contain the hydrogen is quite an important matter even in the large balloons used to carry two persons in the Gordon Bennett races for balloons that used to be held each year. Ordinary rubber is not strong enough to stand the wear and tear and so special fabrics are made and treated with rubber. You can make a toy airship like a cigar which will float round the room provided it is filled with hydrogen, but it will need to be about a yard long and a foot in diameter and to be filled with hydrogen. If you do so you will find that when pushed along by the hand it will not fly straight but tends to turn round. If you tied it by a point near the middle on a stick out in a wind, it would not behave like a weathercock but would set itself lengthways at about 30 degrees away from the wind direction.

To make an airship fly straight you must put some fins at the back, one set horizontal and the other vertical. If you are interested to try this, it would be preferable to make a much larger model, say about 6 feet long, as the weight of the fins is considerable even if made of the very lightest material such as very thin balsa wood or mica sheets. You would need to take twice the dimensions drawn on the model. An airship like Fig. 2 will lie head to wind like a weathercock, and you will notice that the support for the model is slightly behind the middle so as to get a balance for the extra weight at the tail.

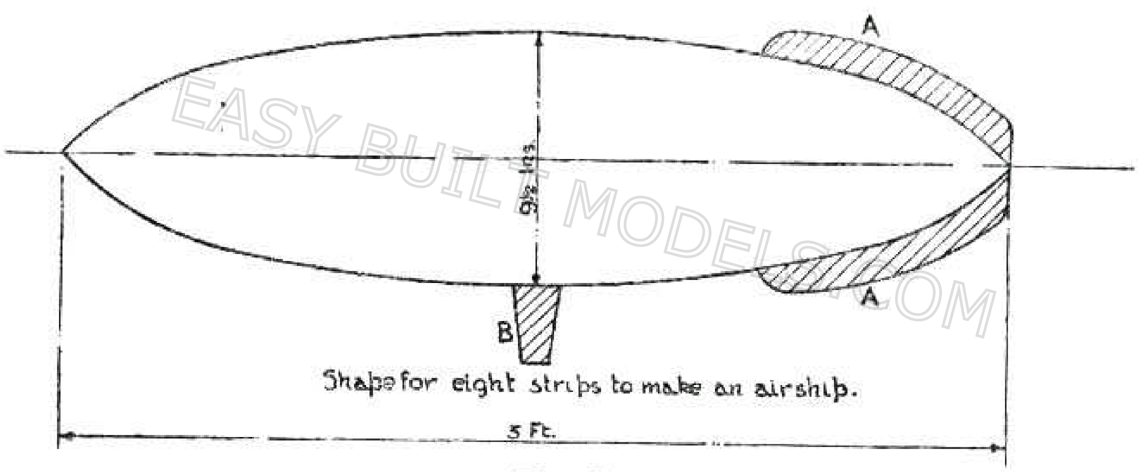

Fig. 3.

To make such a model is not difficult provided you start with the finest, which is also the lightest weight, silk. It should be cut into strips, at least four and preferably six or eight, running from the nose to the tail with a shape like Fig. 3. The extra piece (shaded and marked A) at the back will be needed on the edges of the strips for sewing in the fins. The whole can be sewed together, leaving a small funnel-shaped piece B on two of the pieces for blowing up the model airship. You next paint carefully all over the fabric, and the stitches, the very thinnest coating of rubber solution such as you use when mending a puncture in a cycle or motor tyre. This rubber solution will keep the hydrogen gas from escaping for several days provided it is not exposed to strong sunlight. You may need to put on two coats of rubber. It is better to make your own airship in this way than to try experiments with the long sausage balloons made of rubber that are now sold and which have a shape nothing like an airship when they are blown up.

The fins shown in Fig. 2 on the real airship have a rear portion which the pilot can move up and down. These are called elevators on the horizontal fins and rudders on the vertical fins. On your model floating head to wind when held on the end of a stick, you will find that if you bend the horizontal surfaces down the airship will set its nose down, and *vice versa*. An airship flying in the air behaves in the same way when the coxswains move the elevators and rudders. They have one coxswain for each on a large airship.

An airship can fly horizontally with its nose up even if its weight

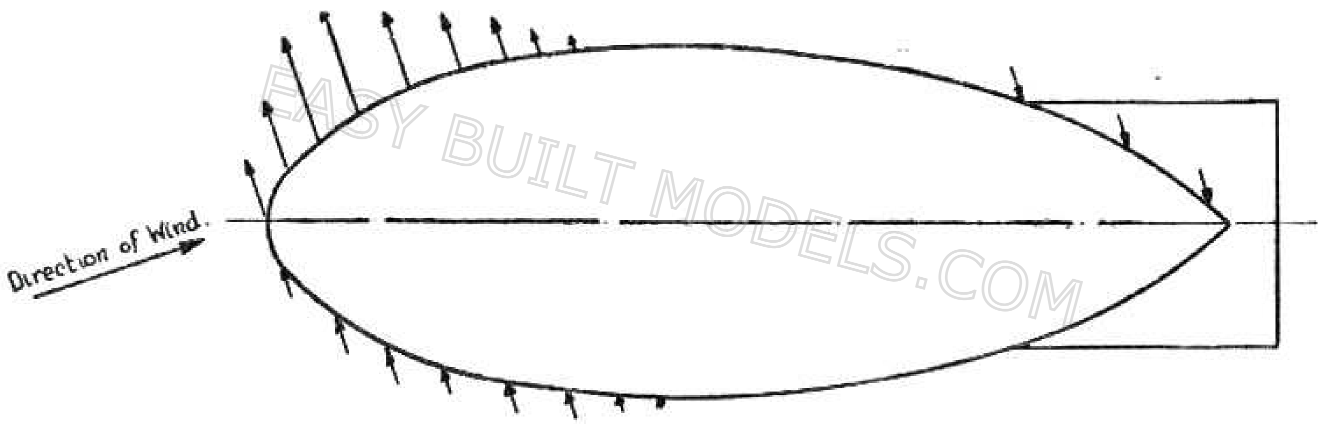

Fig. 4.

be a little greater than the lift obtained from its hydrogen. The air blowing over the airship gives a suction over part of its back like it does over an aeroplane's wing (Fig. 4). All airships set out at the beginning of a long flight in a too heavy condition, maintaining their height by holding their elevators up, and this is called flying with dynamic lift. Gradually as the petrol becomes burnt the ship gets lighter, and she then flies horizontally without using any elevators. If your model tends to drop by the nose, and provided there is a breeze, then it will put its nose up if the elevators are bent up. Incidentally you must blow your model up tight or get it so blown up by some shop which keeps a supply of hydrogen in cylinders for blowing up pilot balloons.

The vertical fin surfaces on the airship are to keep it head to wind like a weathercock. To these the rudders are fitted, and when the rudders are turned to the left the airship flies round towards that side as the resistance to the air is greater on that side than on the other. The action is the same as steering a boat on the sea or a river.

The above does not explain completely how an airship flies. It floats because hydrogen (or helium) is lighter than air, it moves up or down at the coxswain's will by alteration of the elevators, and it turns right or left with the rudder. If the air was always steady, if the barometer read the same each day and at different heights above the ground, and if the temperature did not alter, then all would be well, but as we all know this is not the case. To explain what happens in a simple manner, I am going to tell you first about the easier case of a large balloon carrying a pilot.

A balloon for carrying a man is nearly spherical (Fig. 1) in shape, hollow and with an opening called a neck at the bottom of the bag always open. Over the sphere are hung cords which reach down below the neck and are tied on to a basket or car in which the pilot and passengers sit. At the top of the balloon is a valve which can be opened by the pilot and also usually a panel which can be torn when pulled by a rope, called a rip panel. This panel is only used when the pilot wants to land, as it lets all the hydrogen very rapidly out of the top of the envelope and the basket sinks to earth. Such a panel is not used in an airship. The airship valve, on the other hand, is large and is used in the same way as in the balloon to let out quantities of gas (hydrogen or helium).

Before making an ascent the envelope of the balloon is filled up to 95 per cent. of its volume with hydrogen and the basket contains several bags of ballast (usually sand), sufficient so that when the balloon is loosed it will just rise from the ground. After casting off the mooring ropes the balloon slowly rises, and as it does so it moves into air which is less dense and at a lower pressure than at the level of the ground. The hydrogen expands because the pressure is less until it fills the gasbag completely, and the height at which the bag becomes just full is the best at which to fly. This height is called the operational height.

If the balloon ascends above this height the pressure of the air will be still less, so that the hydrogen will expand to a volume greater than the envelope and will pour freely out of the neck of the balloon just like a full kettle will overflow on a fire as it gets hot and long before the water boils. In the same way, if the sun beats down on the balloon and heats the gas inside, the gas will expand and boil over. For this reason balloons and airships prefer to avoid remaining too long in the sun and seek, when possible, the shelter of clouds. At night, when it is colder or if the balloon floats into a cold downward current of air, the gas will contract, and air will flow into the neck. The balloon then becomes heavier and sinks towards the earth, and, as it sinks, the effect of descent increases the weight still farther. The balloonist has then to throw out ballast to lighten his balloon or he will come down to the earth and have to land. This he does until the weight of his balloon is equal to the lift of the gas inside when he stops at the same height above the ground and carries on with his voyage. A rigid airship like the Graf Zeppelin has several bags, all full of hydrogen, each with a valve at the top and an open neck at the bottom (Fig. 5).

At times a pilot may wish to change his height above the ground in order to seek a more favourable wind. Here I should mention that the wind is rarely the same on the ground as it is higher up. Almost any day if you watch the clouds you will find that they are travelling faster than the wind on the ground and also in a different direction. Owing to the rotation of the earth the wind in the northern hemisphere veers or blows more from the west as you proceed upwards, and this fact has to be borne in mind by the balloonist. To go the farthest distance before coming down, which is the aim of a balloon race, the pilot has to change his height, and so also will the airship pilot in order to have as favourable a wind as possible.

To change to this height he must either valve (let off gas by opening a valve) so as to make the balloon heavier, or he must throw out ballast to become lighter. Both methods usually involve some adjustment, and it means that the pilot lets out gas and also throws out some ballast. He has only a limited amount of ballast, and when he has used nearly all this up he must come to earth. He retains his last load of ballast to help him to land in case he is coming down too fast to the ground and has to lighten everything so as not to bump too hard when he lands.

A rigid airship carries several tons of ballast, and it has sometimes to be quickly dropped to avoid an accident. A few seconds before H.M. airship R 101 and the U.S.A. airship Akron crashed, orders had been given to release what was called emergency ballast, which is only done as a last resort. Sand in very large quantities is difficult to handle, and so the airship pilot usually carries instead ballast in the form of water in tanks which can be very quickly emptied (Fig. 5). He, too, like the balloonist must reserve a little ballast for the end of his voyage for landing purposes.

As an airship flies its engines burn up the fuel, which is usually petrol or paraffin. This makes the ship lighter, and to balance the loss of weight arrangements are made for recovering from the exhaust gas of the engine the steam which is condensed into water

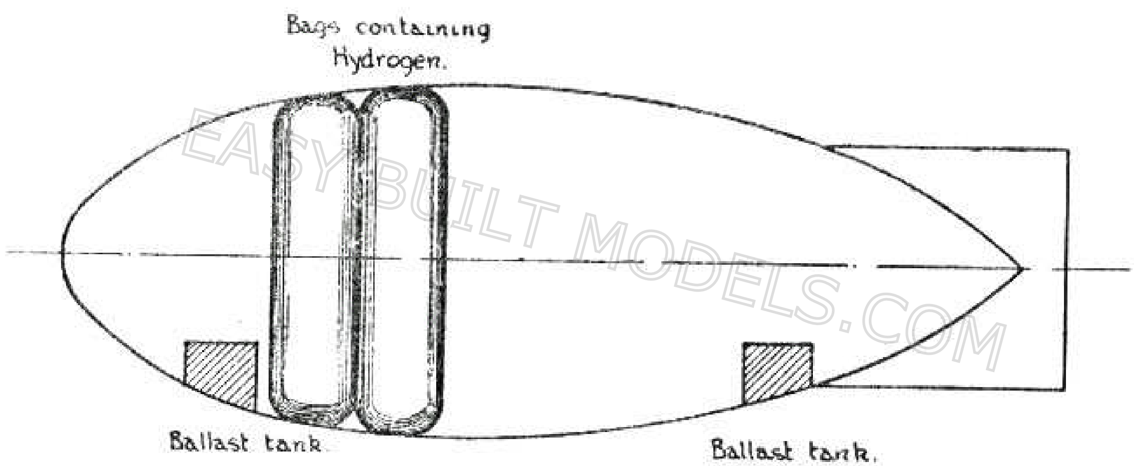

Fig. 5.

and stored in tanks as ballast. In the case of the Graf Zeppelin a gaseous fuel is used so that the change of weight of the ship is small when the fuel is burnt. This gaseous fuel called " Blaugas " is obtained from a heavy oil, is similar in many respects to the coal gas that was mentioned earlier, and is quite suitable for use instead of petrol in an airship engine.

Let us now see how an airship sets off on her voyage. All airships have to be taken into sheds to be refitted. They are brought out of the shed in very still weather, preferably a flat calm, as otherwise the wind makes it difficult to handle them. For large airships gangs of men are needed to hold on to ropes to keep the ship down and draw her to a mast (Fig. 6). This is called walking the ship. In America they have a short mast mounted on caterpillar wheels to which the airship's nose is tied before it is drawn out by a number of motor tractors. From the top of a large mast, such as that at Cardington in England, a rope is dropped which is then tied to another rope on the nose of the ship. This rope is hauled in by machinery until the nose fits into a small head at the top of the mast which can rotate freely, so that the airship will always face head to wind like a weathercock. From near the nose a platform is let down to the mast so that passengers can board the ship after ascending to the top by a lift. Pipe lines up the mast are used to supply gas, water, and petrol, or in the case of the Graf Zeppelin the special gaseous fuel.

When everything is aboard, the captain trims the ship so that

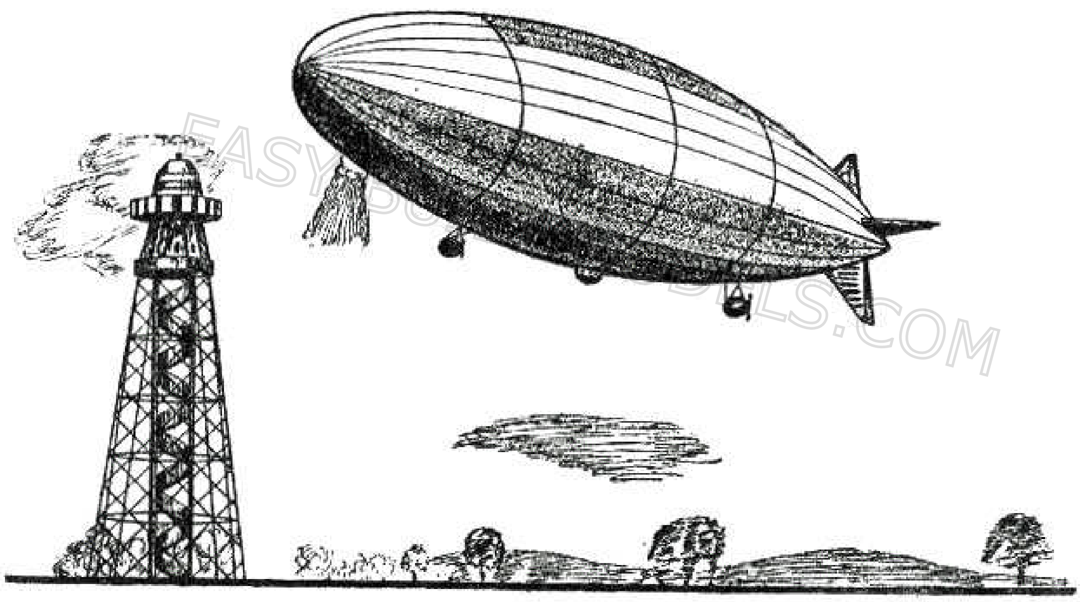

Fig. 6.

she lies on an even keel and is just buoyant, and for this purpose he can move water ballast from the one end of the ship to the other or drop some overboard. When trimmed and in the steady air conditions most often found either early in the morning or late at night he casts off from the mast by releasing perhaps as much as half a ton of water. The ship ascends, the motors already ticking over are run ahead, and the ship starts on her voyage. The pilot governs his height by his elevators, but he has to use his water ballast or to valve gas if he meets violent currents.

When she comes back to land care is taken in the same way as when starting to ensure that the airship is of the correct weight at ground level. Whenever the Graf Zeppelin has come to Hanworth near London it has flown along a valley where the air is steadiest. At Friedrichshafen its voyage commences over Lake Constance, where again steady conditions are to be found. If the air is very unstable, as over a flat district on a hot sunny day, then the airship would wait until the evening to land, just as a ship will ride out a storm before entering harbour. She will then fly down to the mast by putting the elevators down and so to speak driving the ship down on to the mast.

A large airship needs a crew of at least 20 to handle it and large bases with masts to operate from. The expenses of running it are consequently very great. The Graf Zeppelin, however, pays its way, and the fares are less over the longest distances than any other form of transport, partly because the time taken to travel is much

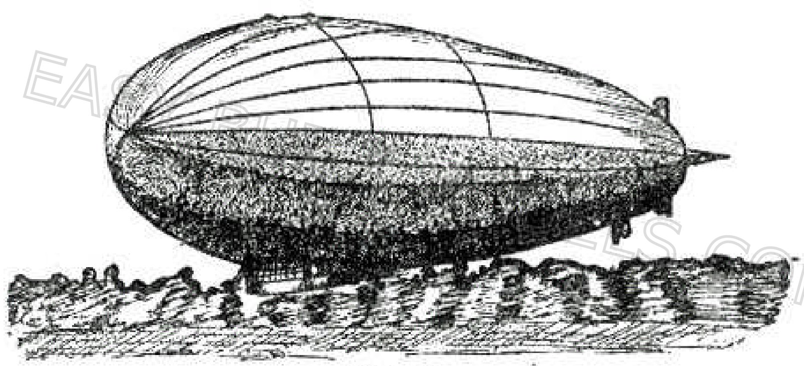

Fig. 7.

less and so the passengers need less in the way of food, amusements, etc. The fare is £20 to £30 for a 24-hour trip round Great Britain covering about 1,600 miles. It costs the passenger £200 to fly to New York from Friedrichshafen and back, and £300 for the return trip to South America. A trip round the Mediterranean and Palestine occupying four to five days costs £80–£100, so that it is more costly than the luxury liner fortnightly trips that have become so popular in the last few years.

The Graf Zeppelin (Fig. 7) with a total lift of over 100 tons makes seven or eight scheduled trips to South America and back each year taking about seventy-two hours for each journey. She flew round the world in the summer of 1929 and has flown the Atlantic fifty times.

The United States of America has built larger airships, weighing about 180 tons, but the Graf Zeppelin remains the world's most famous airship.