to draw your attention. The first is Major Goodden's method of starting a spin. He started it by putting on the rudder and pulling the control-stick over to the opposite side. We know now that the most effective way of starting a spin is to pull back the control-stick first and to stall the aeroplane. The second point is the way he emphasises the fact that the spin is the result of bad flying, and is to be avoided. In those days the spin had not become a general manœuvre of all pilots.

A little later there was a further series of accidents on another aeroplane, due mainly to engine failure when getting off the ground. When the engine failed it started turning, due to the turning tendency and increased by errors of judgment of the pilot, and the aeroplane developed a spin. By that time, pilots knew how to get out of a spin. There was no danger, but for the fact that the aeroplane was too close to the ground, and thus at an insufficient height to enable it to recover from the spin. I think it was this series of accidents that really started the proper investigation of the spin. All the earliest experiments were carried out by Dr. Lindemann on a B.E.2E aeroplane, and since that date the examination of the characteristics of an aeroplane in a spin has become almost a routine job in testing any new type.

The characteristics that are common to the spin of nearly all aeroplanes are first, that the speed is only about 60 m.p.h. The second easy point which can be settled about the spin is the rate at which the aeroplane is turning round. This, of course, varies for different types, but for a small scout or fighting aeroplane, such as the Camel or S.E.5, the period is about 2 secs. For a two-seater B.E.2E it is about double—$3\frac{1}{2}$ to 4 secs.; and between those two limits we have the Avro with 3 secs., and the Bristol Fighter and F.E.2B with $2\frac{1}{2}$ secs. The last is the most surprising, for we should expect a small fast aeroplane to turn quicker than a slow and larger one, and yet the F.E.2B rotates nearly as fast as the S.E.5. There is apparently no direct connection between the size of the aeroplane and the rate of the spin, or it is obscured by other factors. Still, a good many of these possible factors have been investigated. Take first of all the shape of the wings. We have tried a Bristol Fighter with wings of three different aspect ratios. With the ordinary aspect ratio of $7\frac{1}{2}$, the rate of spin was $2\frac{1}{2}$ secs. When the aspect ratio was increased to $9\frac{1}{2}$, the period went up from $2\frac{1}{2}$ to $3\frac{1}{2}$ secs. When it was cut down to $4\frac{1}{2}$, the period dropped to $2\frac{1}{4}$ secs. This change in rate of spin with aspect ratio agrees with the type of thing we should expect. I shall return to that later.

Now, as to the controls and the best position in which they should be for a spin. First of all, I will take the *ailerons*, because there is probably more controversy about them than others. It is impossible to get a definite conclusion as to how the *ailerons* should be held in a spin. Some pilots prefer to have them crossed, that is, right rudder, left *aileron*; others prefer them the same way, but one thing is certain, that the spin cannot be started in some aeroplanes unless the controls are crossed. Crossing the controls certainly helps to start an aeroplane spinning; whether the aeroplane spins better with them crossed or with them both in the same direction is uncertain. I believe the French did not allow crossed controls in a spin on the plea that it caused greater stresses and a jerky spin. We can see a little in a general way how the *ailerons* affect the problem. Suppose you are spinning to the right with the left *ailerons* pulled down, you will get a rolling moment tending to turn the aeroplane round in the proper direction, but you get a bigger drag force on the outer wing, and so another moment trying to pull the aeroplane round the other way. In different cases, these two effects may balance out in different ways. On the whole, I think it is safe to say that the *ailerons* are relatively unimportant in a spin though they may be important in starting spins. Let us next consider the effect of the fin and rudder. The rudder is used to start the aeroplane turning, and there is no doubt that as the power of the rudder is increased the rate of the spin is increased. For example, we took a Camel aeroplane, the rates of spin being 2 secs., and fitted it with a larger rudder. The spin then took 1·8 secs. Another example was a Vickers aeroplane, which was rather peculiar. It would not spin at all. Several attempts were made by different pilots, but whenever a spin was started, they found they could not hold it, and always ended in a rather violent spiral. Well, we thought it might be the fin, so we started stripping the fabric from it. We stripped the whole of the fabric, and then the aeroplane was at last made to spin, but it was a very unsatisfactory spin, and the method of coming out was rather too startling for the experiment to be repeated. It proves that the fin had been the cause of the initial difficulty of spinning this aeroplane. The remaining control is the elevator, and this is undoubtedly the most important in the spin. The elevators must be held right up, and there is no way of getting a spin with the stick forward. To start the spin, Major Goodden did a flat turn, and then eventually pulled back the stick. The flat turn started a banking movement and speed was lost. Now the standard way of starting a spin is to pull back the stick, thus losing flying speed, and kick over the rudder. You start the turn in the direction required, and occasionally it is necessary to cross the *ailerons* as well, but if you had a larger rudder, it would not matter what you did with the *ailerons*. It is the usual way of starting a spin, but it is by no means the only one. It is quite possible to turn an ordinary spiral or helical glide into a spin, by pulling back the stick, and by putting on full rudder. This is shown very clearly in some of the experiments with a B.E.2E aeroplane by Dr. Lindemann. He started a spin with a period of about 4 secs. He turned from this spin into a spiral, and then turned back to a spin, rotating all the time. He was never in a straight dive at any time. But it is a very delicate manœuvre, and not to be recommended. It causes far higher stresses on the aeroplane than the ordinary method.

To start a spin, you pull the stick back, and put the rudder over; to stop it you do the reverse. You push the stick forward, and put the rudder in the centre, and that is obviously one of the difficulties pilots must have experienced in the early days. As the aeroplane was pointing steeply downwards, the natural tendency must have been to pull the stick back. What they ought to have done was to push the stick forward in order to stop the rotation. It is easy to understand now, but until it had been successfully accomplished, the spin was always a fatal accident. With a stable aeroplane, it is often sufficient merely to abandon the controls and the aeroplane will come out. It is true, for example, that in the S.E.5 it is not necessary for the pilot to make a definite motion of pushing the stick forward. He lets go and the aeroplane comes out. Of course it will take much longer than if he directs it in the proper manner, but it will come out. With an unstable aeroplane this is not the case, and there the correct motions must be made to stop the spin. In general, simply pushing the stick forward and putting the rudder central is the simplest and best way, but other methods have been attempted with success. First of all, if you put the rudder opposite instead of merely central, you will obviously apply greater force, and if that is done until the rotation ceases, you will gain a little in the recovery. Again, if you have the stick right forward, you will come out in a very steep dive. At times it is sufficient to push the stick central instead of right forward. But the question has to be studied for each particular aeroplane. In some cases, for instance, on the Camel, if you put the rudder opposite, it does not even stop the spin; it goes on spinning against the rudder. There the stick must be forward. In the S.E.5, on the other hand, the rudder will stop the spin, even if the stick is back. The rudder must be used to stop rotation, and the aeroplane will come out as soon as the rotation is stopped. The most important thing is the height required to get out of the spin, and as an average figure 500 ft. seems to meet the case. Occasionally you get a recovery at as low a figure as 350 ft., and at times it rises much higher. In fact, there were tests not so long ago on a certain single seater, which took over 2,000 ft. to come out. There is another difficulty about the unstable aeroplane in the spin—that is, when you come out from the dive, to avoid stalling the aeroplane again and so starting a second spin, the more so because after the rotation which the pilot has been undergoing, it is often very difficult for him to judge what is level. If you watch an aeroplane come out of a spin, you can generally see that the aeroplane is flying with one wing down, and if stalled in that condition, probably it would mean a second spin. That is a point of advantage on the side of the stable aeroplane.

I now pass to the more detailed analysis of the motion. Fig. 1 shows records of the speed and acceleration in a spin, that is, the force at right angles to the wings. The top record is from an S.E.5A. First comes the stall where the speed drops to about 40 m.p.h., next the steady spin at about 60 m.p.h., and finally the dive and recovery. The other two records are from a Bristol Fighter. The bottom one gives only the acceleration, and shows a remarkable oscillation about the steady motion with a period of about 1·5 secs. This shows quite clearly that the aeroplane is doing a small oscillation about its steady motion of spinning. The middle record gives both the speed and the acceleration, and the oscillation is again shown quite clearly.

Besides measuring the speed, acceleration and rate of rotation, we also obtained the rate of descent or vertical velocity, the radius of turn, and readings of lateral and longitudinal bubbles to give the direction of the resultant force. These results were more than sufficient to determine