

## DISCUSSION.

MAJOR D. C. M. HUME: I thank the lecturer very much for a highly instructive and illuminating paper, and should like to say a few words on one or two points.

There is no question of the unsuitability of rubber shock absorbers for the tropics, for in dry hot climates the rubber goes hard, and in moist hot climates it goes gummy. Certainly, the first endeavour of the designers of undercarriages should be to eliminate rubber, the need for which is almost entirely confined to taxi-ing.

I am particularly interested in the lecturer's remarks because of the possible application of Oleo gears for seaplanes. When an Avro Viper is used as a seaplane, is the Oleo gear employed? In that case, do they use rubber as well?

I am impressed with the ingenuity of the taper needle design, but more particularly with the difficulties of that pattern. For that reason it does not seem to me advisable to use it if the open port central valve type will do equally well. It seems rather too delicate a mechanism to employ, and expensive from a manufacturing point of view, as well as stores deterioration.

With regard to oils, I believe rape seed oil has been used for this apparatus. I should like to know what are the relative advantages of the different types of oil that may be used. I have heard of a non-freezing oil for hydraulic gears, that is, liquid down to  $42^{\circ}$ .

In conclusion, I thank Mr. Dowty very much indeed for the instruction he has given me this evening.

COL. BELAIEV: My remarks are from the gunner's point of view.

When I first heard about this paper I wondered whether the question of our recoil buffers would be mentioned at all. I was more or less connected with them about fifteen or twenty years ago.

I must confess I was very much interested to hear that it is quite possible to apply the same methods as we were applying in the gears you have mentioned. The first thing I would like to ask, however, is—how is it possible to use Oleo gear for an undercarriage, and yet have it of such a low weight?

For our different types of guns we always thought that for each particular type only one quality of oil was quite suitable. You have always more or less to change the viscosity of your oil when you go from a small calibre to a high one. The main point is that it is inadvisable always to use the same kind of oil.

About twenty years ago, when we first introduced the recoil cradles in our field guns, we used a kind of rubber in the buffer which after one or two years of experience we had to throw away, and had recourse to steel springs instead. For at least five years we had many difficulties at our works

in getting the right kind of steel for the spring, but after that time the trouble was removed. The sooner you are able to say definitely what kind of steel you require, the sooner the problem will be solved.

I should like to say in conclusion that I have found this lecture exceedingly instructive.

MR. P. SALMON: I congratulate Mr. Dowty on his interesting paper. He seems to have gone a good way into his subject.

We at Farnborough are interested in the undercarriages, and the type which he has himself backed (i.e., the type in which the legs do not return to their original position until the aeroplane leaves the ground) is by far the most satisfactory.

There is one point he has not touched upon—the relative deflection required in taxi-ing. Before the war it was usual in Oleo undercarriages to allow about three and a-half to four inches for spring movement in taxi-ing. The weight of these springs relative to the undercarriage seems very heavy, but I think we have gone astray on our data as to the necessity of large deflection in taxi-ing. We are trying to find out whether we can reduce this deflection.

It does not seem impossible in small machines to do away with the rubber V springs altogether, and let the tyres and axles do the work. Can Mr. Dowty tell us whether he has had similar ideas to this, and, if so, has he any data on this point?

With regard to hollow springs, we cannot find anyone to make these. They would give us a large reduction of weight. A spring of 56 lbs. construction in the usual way could be reduced to about 7 or 10 lbs. It is desirable, if we do away with rubber, to have these hollow springs, if we have to use springs.

I am interested to note the difficulties which have cropped up in manufacturing the needle type. We are now confining ourselves particularly to the types where we have a series of holes which are gradually covered up as the legs deflect, having the same effect as the needle type, but possibly less sensitive than a needle which facilitates the passage of oil rather than resists it.

If we rely on the valve regulating the oil flow, the members of the undercarriage have to stand the full shock on every landing, but if you can control leakage by the holes, the stress on the legs will vary according to the rate of landing.

I certainly think the undercarriage of the future will be the Oleo type, and that the ordinary rubber wound type is bound to disappear. It is certain that when we land we do not want to bounce. Rubber is not generally used for absorbing energy, but for storing it and sending it out again.

There have been experiments carried out in the past to ascertain the absorbing power of the axles themselves, and the tyres, as well as that of the shock absorber, and the ordinary undercarriage rubber shock absorber, roughly speaking, absorbs one-third of the energy, and the axles and tyres the other two-thirds, so for taxi-ing it might be possible to do away with the springs altogether, and rely on the tyres and axles to absorb the shocks.

MR. H. S. BELL: I had the pleasure of being associated with Mr. Dowty during the war, but since then have deserted the Aircraft Industry.

There is one point that I should like to mention: I understand that the Oleo Gear has a stroke of from 12 to 16 inches. Would it not be possible to utilise, say, 12 inches of that stroke for compressing elastic fluid, such as air, into a small cylinder and utilising the compressed air as a cushion against the remainder of the stroke, to take the place of rubber or springs, or to enable very much lighter springs to be used for absorbing the minor shocks of taxi-ing, etc.?

MR. HOWARD-FLANDERS asked Mr. Dowty whether he had investigated the use of compressed air as a spring in place of rubber or steel, and stated that he knew of several experimental chassis legs of this type which were used in 1915.

MR. DOWTY'S reply to the Discussion.

Major Hume has suggested the use of opposed Oleos for taxi-ing. I do not think that these could be successfully employed. Some form of springing, such as rubber or steel springs, should be used in order to allow the machine to ride over the ground as smoothly as possible.

The Avro "Viper" undercarriage was designed for a land machine, but when it is converted to a seaplane and floats fitted, the Oleo gear is not used. The very short movement of the floats of a seaplane when landing makes the advantage of fitting Oleo legs rather questionable.

I think that the difficulties experienced in making a taper needle are warranted by the advantages gained. With a plain orifice leg, high pressures occur on landing, with a great falling-off of pressure as the leg contracts. The pressure varying thus entails the undercarriage being stressed much higher than would otherwise be the case if a constant-pressure leg were used.

From tests it appears that the type of oil used is of no real consequence. Rape-seed oil has been substituted for Coly oil on several Avro machines. On the "Bat" machines B-B motor oil was used with success.

Col. Belaiew has asked why the Oleo gear can be made so light in comparison to gun-recoil work. The reason is that we are compelled to bring everything down to a minimum of weight on aircraft, but furthermore, the pressures we deal with are not as high as those used on guns, and the parts need not be made so heavy. The cylinders used are only 17 gauge, and this alone saves several hundred per cent. over the weight of gun-recoil cylinders.

I have replied to the question of oils in my reply to Major Hume.

With regard to hollow springs, we have found no firm who will manufacture them. It is quite a different proposition from ordinary spring manufacture, and I think it will necessitate special plant laid down for the purpose.

Mr. Salmon raises the question of deflection on the chassis. The "Viper" gear illustrated, has a six-inch movement on the oil, with a further possible six inches movement on the rubbers. I think this is on the large side, and possibly three inches is generally sufficient movement to allow for an aeroplane while taxi-ing. I have gone into the question of hollow steel springs and I have no doubt that they could be made as light as tension rubbers.

In making a taper needle no difficulty is experienced on large machines.

With aircraft, say, of 5,000 lbs. weight, it is possible to get a taper of 18-hundredths on a six-inch length, using a  $\frac{3}{4}$ -inch diameter needle. This is not a very difficult operation for an aircraft machine-shop. Regarding the suggested deterioration of the needle. It is running in oil and there is no reason why it should not keep its correct taper indefinitely. I think that the taper-needle leg is the best type in use to-day.

MR. BELL: I have not had experience of compressed air used as a medium for springing. Great difficulty has been experienced in keeping air pressures in gun-recoil cylinders.

In reply to Mr. Howard-Flanders' remarks, I was very interested in the Oleo leg described as I had not previously heard of such an arrangement. I think that the type of leg that does not rely on the keeping of air pressures for any considerable length of time is preferable, as under service conditions it may not be convenient to readily make good any loss of pressure through air leakage. I hope to have the opportunity of going thoroughly into this type of gear, for it certainly seems to have several excellent features.

MR. H. B. MOLESWORTH (Chairman): We all thank Mr. Dowty for a most useful and instructive paper. The subject is one which very few aeronautical engineers have had occasion to deal with, therefore the experience of an expert is particularly valuable. In 1910 I put spiral springs to an aeroplane I was building, simply to try and get rid of the rubber troubles. I put belting round the axle under a sheave below it and carried the springs along the skids—that answered very well.

MR. S. T. G. ANDREWS: I have much pleasure in seconding this vote of thanks. I have known Mr. Dowty for many years by correspondence, and am delighted to see him in the flesh and enjoy his entertaining lecture. I accord him a very hearty vote of thanks.

MAJOR HUME, in proposing a very hearty vote of thanks to Mr. Molesworth for taking the chair, remarked upon the fund of happy reminiscences their Chairman possessed, so that, no matter what the subject under discussion, he could always add something of value from his ripe experience.

A unanimous vote of thanks to the lecturer then brought the meeting to a close.

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