A Variable Drag Parachute for Glide Path Control of a Sailplane

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Introduction
Generally the shorter the distance to touch-down after the perimeter obstacles have been crossed and the shorter the distance the aircraft takes to stop after touch-down then the safer is that aircraft. This is particularly true of sailplanes which do not as a rule land on prepared airfields and are much more likely to terminate a flight in some unfamiliar field.
An aircraft with efficient glide control on the landing approach has a distinct advantage and the object of this paper is to describe a decive which will provide such a precision variable control for the final glide path. This is effected by modifying the currently used 'single shot' uncontrolled drag parachute to provide a continuously variable drag.
A consequence of using this method is that it eliminates the need for dive brakes with resultant improvement in the performance of the aircraft.

The Necessity for a Change
Glide control devices operate by using one or a combination of the following methods, (1) reduction of the lift produced by the wing, and (2) increasing the total drag of the aircraft.
Presently used glide control devices on sailplanes are
(a) **Spoilers:** – Now normally found only on the older types of aircraft; these are not particularly effective in either manner.
(b) **Dive Brakes:** – These are used on the majority of sailplanes and are quite effective. Dive brakes suffer from the necessary aerofoil discontinuity where the brake blade folds into the wing and more particularly they suffer from the leakage of air between the lower and upper aerofoil surfaces, resulting in loss of performance through loss of lift. From the structural point of view brakes require elaborate construction of brake boxes to house them and to attempt to seal them. They must be mounted to substantial members, e. g. spars. The effects of using wing mounted dive brakes are,
(1) diminished performance,
(2) increased problems in wing design, and
(3) increased wing weight,
all of which lead to increased cost.
(c) **Spade Brakes:** – These are brakes the blades of which are mounted on the fuselage; they are not in general use. Because they are not acting to destroy lift on the wing they are less effective than dive brakes and because of the size limitation they cannot be made big enough to provide large amounts of drag.
(d) **Drag Parachutes:** – These devices are commonly installed as part of the equipment of the modern high performance sailplane. While highly effective in terms of drag production their great drawback is that at a given speed the drag produced is constant.
Drag parachutes were used when it was realised that larger drag loads could be taken through the fuselage than through the wings. This benefit, and others, were first noted during World War II and trials were carried out on both powered and unpowered aircraft by German, British and American Air Forces (Refs. 1 and 2).
The German Ribbon Parachute has survived the test of time and in sailplanes is the drag parachute exclusively used. The Ribbon Parachute, first developed by T. Knache and R. Iserman (Ref. 2), can be made very strong, is very stable and is not subject to oscillation. In addition the opening shock is very low so that the parachute may be deployed at high speed.
The great potential benefits to be gained from the use of drag parachutes for sailplane operation are not being fully realised only because, to date, no system has been developed to obtain a variable drag from the parachute.
The author has devised and tested a method of obtaining the required variable drag that will make the drag parachute a most useful glide control device which may supersede the wing mounted dive brake.
Theoretical work, wind tunnel tests on a model parachute and ground runs with a full sized parachute show that, after some small modifications, the existing parachutes supplied with modern sailplanes can be used to achieve this 'new' type of control.

Methods of Altering a Parachute's Drag
A number of different methods of altering the drag produced by a parachute can be devised. Of these the most practical ones appear to be
(a) by use of a variable central rigging line (Ref. 1)
(b) by use of adjustable Taschengurts (Ref. 1)
(c) by altering the rigging line length (Ref. 1)
and (d) by using a parachute reefing method (Ref. 2).
Because of mechanical reasons (a) and (d) are the most practical solutions to the problem. Of these, (a) is the more attractive because it has fewer wearing parts, requires lower operating forces and requires only small modifications to existing parachutes.
The basis of the variable central rigging line idea is that as the crown of the parachute is pulled toward the store the drag will increase to a maximum when the centre line length is equal to the rigging line length. Further shortening of the line produces a rapid fall in drag. As the centre line is pulled in, the frontal area of the parachute decreases and, in the case of a ribbon parachute, the main drag producing area becomes more porous. The shape assumed by the canopy under test conditions is shown in Figure 1.

Preliminary Testing with a Parachute
The initial study was conducted by observing in a purely qualitative fashion the behaviour of a hand-held parachute

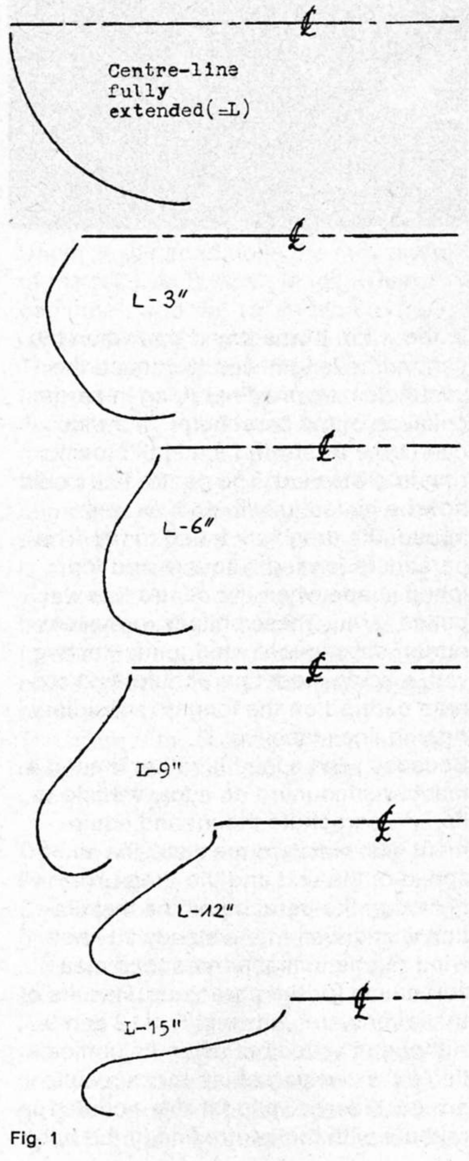


Fig. 1

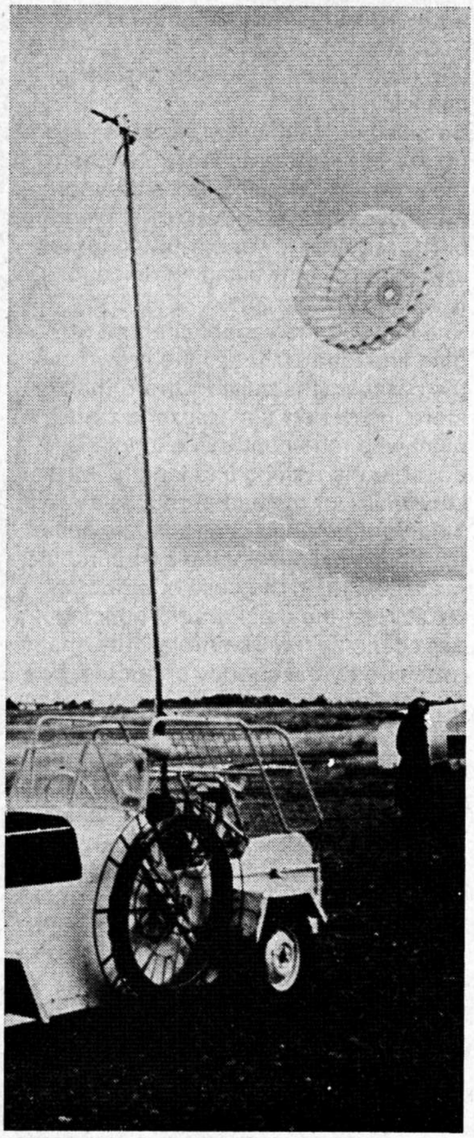


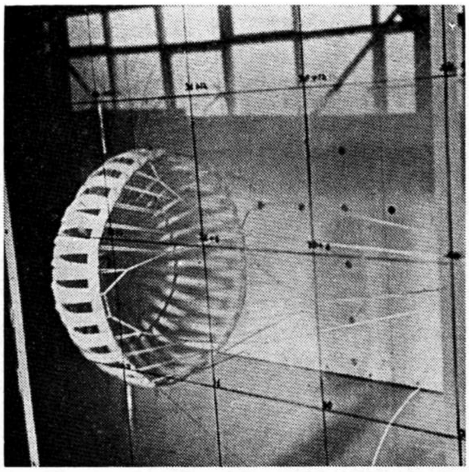
Fig. 2

in the wind. It was found that when the centre line length was shortened the vent hole deformed resulting in partial collapse of the parachute. This was overcome by sewing a metal 'crown' ring into the vent. The centre line could now be pulled fully in and, as was hoped, the drag was found to fall. The parachute formed a square and four lobed shape when the centre line was pulled far in. These shapes, prevalent during subsequent wind tunnel testing with a scale model parachute, had corners centred on the longest subsidiary rigging lines (see Fig. 7).
Because wind speed is rather limited a mast was mounted on a tow vehicle to carry a parachute mount and equipment with which to measure the air speed of the unit and the drag produced by the parachute. The installation was driven into a steady 20 knot wind to obtain higher air speed measurements for the parachute. Results of these runs are shown in Figs. 2 and 9. Although carried out using an unmodified full sized parachute these results are considered valid for the modified parachute with the centre line in the fully extended position and provide a valuable basis for further work and testing of a model parachute in a wind tunnel. Errors in the experimental results occur from inaccuracies of low airspeeds and from difficulties in reading the Airspeed Indicator and drag balance.

Testing A Model Drag Parachute
Quantitative results require that the drag parachute should be tested in a controllable wind source such as a wind tunnel. However, the test section of the only wind tunnel available was too small to contain the full sized parachute so a 2.83:1 scale model parachute was constructed. This scale was decided on the bases of the ribbon size available and on the requirements to prevent shoking of the wind tunnel.
With the parachute mounted on the drag balance the drag produced by the model parachute could be measured directly. The airspeed in the tunnel was found using standard methods.
Opening and closing characteristics of the parachute were studied and it was found that the model parachute performed well.
Measurements of drag and centre line length were made for various wind speeds and the centre line force was also measured. These results are shown in Figs. 10 and 11.
Analysis shows
$Drag_{(Max)} \doteq 4.16\ Drag_{(Min)}$.
The Drag Coefficient versus centre line length is shown in Fig. 12. Figs. 3 to 8 show the model parachute under test in the wind tunnel for differing centre line lengths.

Errors in the Experiment
(1) Spinning and associated instability: – The parachute, being made of commercial nylon ribbon, had a fairly stiff centre portion or crown. This inflexibility, on occasions, caused the crown vent to be 'off square' with the air flow resulting in a jet of air being deflected to one side of the parachute axis driving the parachute to the opposite side. Spinning of the parachute accentuated this instability problem. Use of a restraining line to prevent spinning and 'aiming' the jet produced by the centre portion eliminated this problem, and the effect on the results is considered negligible.
(2) Crown inflexibility: – This resulted in the model parachute not assuming the least-resistance shape that would be obtained from the very supple full sized parachute. Thus the model always presented a more bluff end to the air stream than would be the case with the actual drag parachute.
(3) Porosity: – It is implied above that the porosity of the ribbon is not the same for the 'parent' as for the model parachute. The effect of this inequality of porosity is not believed to be of concern because the **porosity gradient** of the full sized parachute has been very accurately simulated and it is this quantity which determines the shape of the canopy at any stage and it is the change of shape which is of prime importance in this exercise.
Of these error sources only (2) is of great importance. It is seen that we would expect the actual drag parachute to produce less drag than is predicted by the model results. Hence a greater glide angle could be achieved when the parachute was in its minimum drag configuration. It is estimated that the minimum drag produced by the actual parachute in operation will be about 75% of the drag predicted from the experiment. Consideration of the above will show that the error is 'in the right direction', i. e. it gives worse results than we would actually get in practice.
As a method of predicting drag at any airspeed mathematical analysis of the parachute shapes has been made. Results correspond quite well with the model results.
The drag results from the wind tunnel tests can be converted into those for a full sized parachute by applying the appropriate scaling factor. These results for the model parachute, centre line fully extended, the results for the full size parachute under preliminary testing do correspond with reasonable accuracy (Fig. 13).

The Effect of the Drag Parachute upon Aircraft Performance
Assume that the airspeed of a sailplane is held constant throughout deployment and inflation of the parachute. The lift is constant throughout the operation and any drag produced by the parachute adds to that produced by the sailplane. Thus the performance of a sailplane can be found, knowing the drag and lift produced by the glider and the additional drag produced by a parachute for any given speed.
Consider a Schempp-Hirth Open Class Cirrus sailplane flying at a constant 50 knots (26 m/sec) with All Up Weight of 460 kg. From the polar for this aircraft the sink speed is 1.19 knots (0.6 m/s), so that the glide angle at this speed is 42.0:1. Hence the aircraft alone develops 460 kg lift and produces drag of 10.95 kg.
The drag measured on the model parachute can be scaled to give the values that would be expected to act on the aircraft.
At 50 knots the additional drag on the aircraft would become
(a) 15.9 kg when the parachute is in the minimum drag configuration, and
(b) 66.0 kg when in maximum drag configuration.
Thus the aircraft has the following characteristics:



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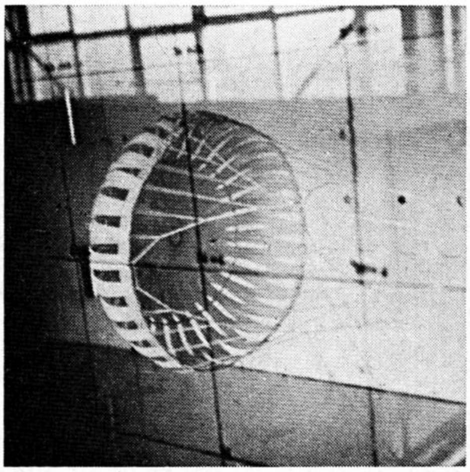

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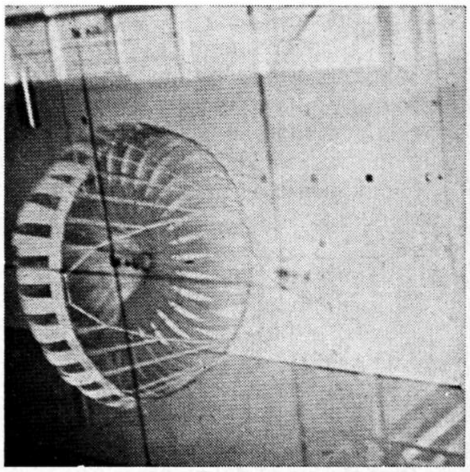

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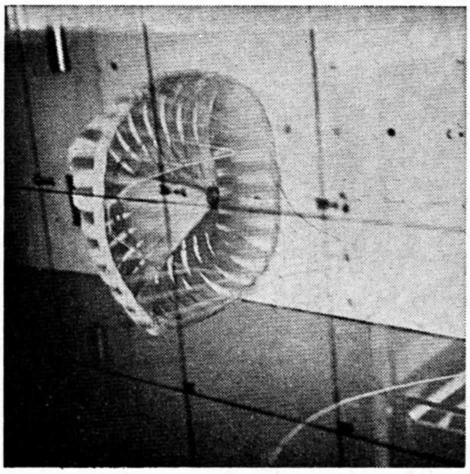

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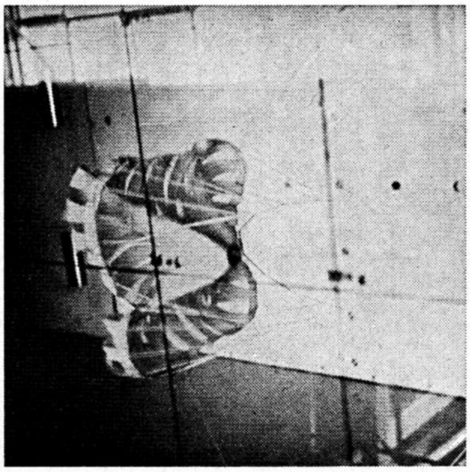

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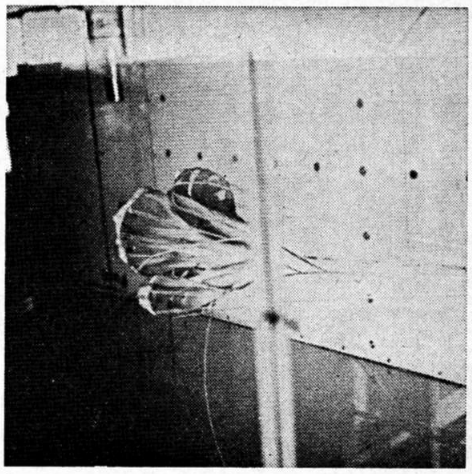

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(1) Aircraft alone: Drag is 10.95 kg, hence Glide Ratio is 42.0:1,
(2) Aircraft plus minimum drag produced by parachute: Drag is 26.85 kg, hence Glide Ratio is 17.1:1,
(3) Aircraft plus maximum drag produced by parachute: Drag is 76.95 kg, hence Glide Ratio is 5.97:1.

It was previously noted that the bluff end of the model may cause the minimum drag value to be 125% of its correct value. Allowing for this the minimum drag of the combined aircraft and parachute would be about 22.85 kg, which gives a Glide Ratio of 20.1:1 as the maximum obtainable once the parachute has been released.

The sailplane can have a glide ratio continuously variable between 6.0:1 and about 20:1. Thus the pilot has a wide range of control and if necessary he could soar his aircraft although the glide angle is increased.

Experiment has verified the proposition that a variable parachute can be designed and has confirmed the effectiveness of such a device.

Control of the Parachute

The OSTIV Airworthiness Requirements (September 1971) Regulation 2.72 reads: 'It shall be possible to extend the drag increasing device at any speed throughout the speed range up to V_{NE} without causing any structural damage and to retract the device at any speed up to 75% of V_{NE} by applying a force not greater than 20 kg.'

The maximum speed for fibre glass sailplanes is at present 135 knots so that $0.75\ V_{NE} = 105$ knots (54 m/sec). At 54 m/sec the maximum force in the centre line of the full size parachute would be, from the model measurements, 61.7 kg, much in excess of the allowable limit. Thus some load cancelling device is required if operation of the parachute is to meet the requirements of the OSTIV Regulations.

To achieve this the drag force produced by the parachute is made use of in the form of the feed-back system shown in Fig. 14.

It has been noted previously that maximum drag is obtained when the centre line is of the same length as the rigging line: any foreshortening of the centre line causes a fall in drag. Thus if the centre line is varied within this range the full range of drag can be produced by the parachute and control is easier.

To meet the conditions of 15″ movement of the cockpit control from minimum to maximum drag and the net required movement of 21¼″ of the centre line length means
(a) $A_2/A_1 = 0.494$, and
(b) the control cable must be directly coupled into the compensating ram.

Under these conditions the movement of the rail ram is 7.55″ which, when combined with the 15″ motion of the control gives the required total.

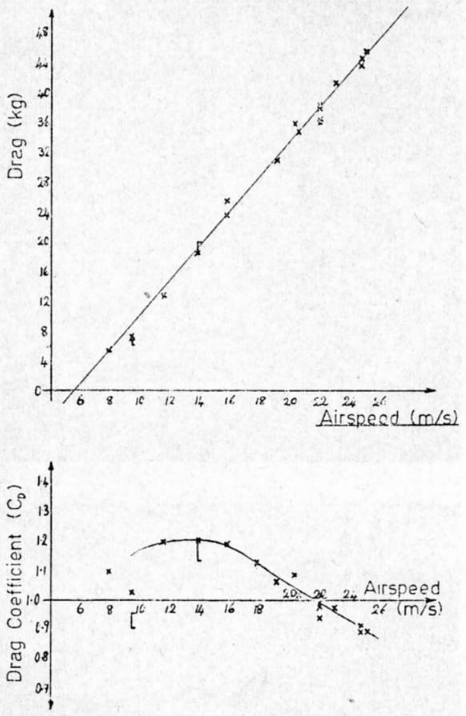
The control loadings for these conditions are shown in Fig. 15 and 16 for the maximum air speed and are thus the maximum loadings which the pilot would encounter when using the new control device. Further, the «feel» of the control, although much lighter than, is of the same sense as, present devices: that is the control handle must be held by a (light) force towards the front of the cockpit to prevent the parachute opening to the maximum drag configuration.

The control mechanism which is to be used with the modified system is shown in Fig. 17.

Operational Characteristics of the Parachute

Because the canopy of the parachute has not been altered the opening and closing characteristics of the parachute should not be affected.

Packing of the parachute: – Because the modified parachute uses a centre line whose length is equal to the rigging line length the parachute cannot be packed using present methods. Ex-



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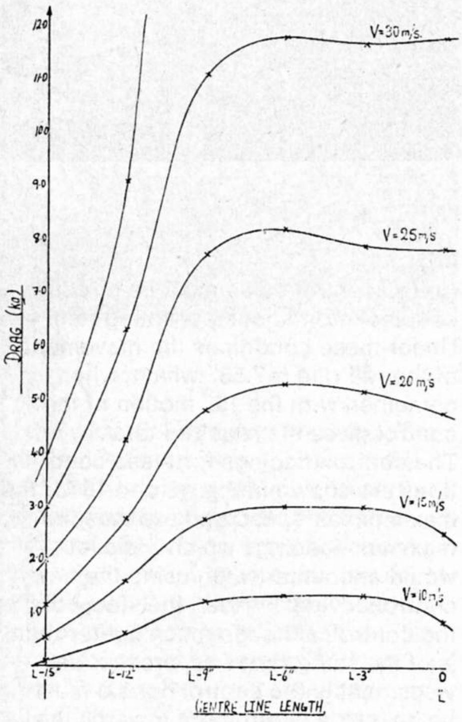

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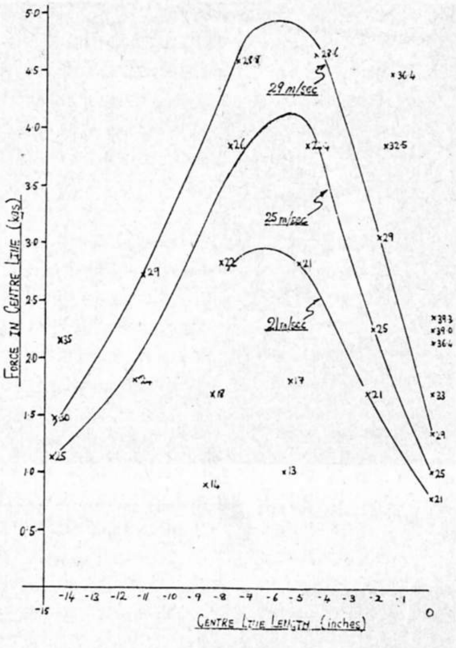

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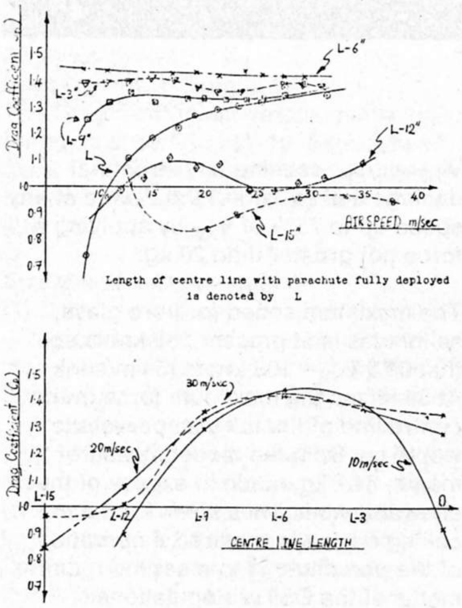

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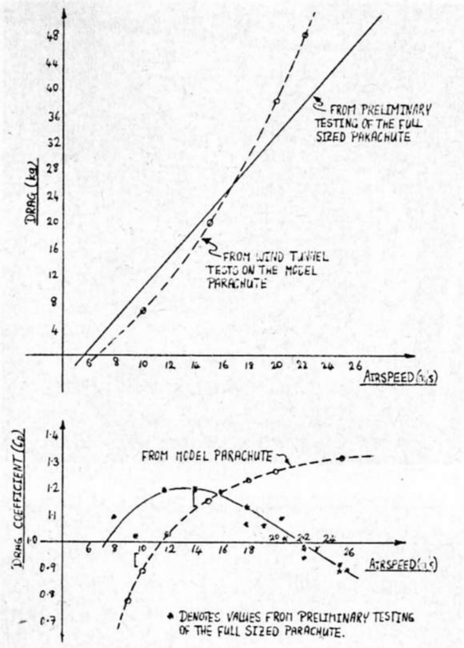

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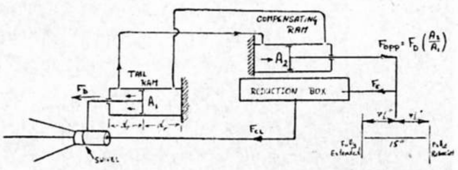

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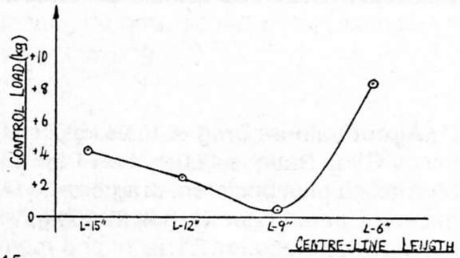

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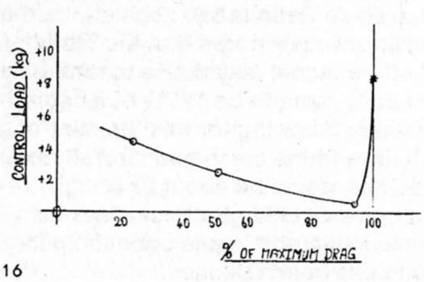

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tending the canopy to the limit allowed by the centre line leaves the rigging lines slack. To ensure that the parachute opens with taut rigging lines the slack in the rigging lines during packing is taken up by using elastic stowage loops that are mounted on the aircraft, as shown in Figs. 18 and 19. The parachute will then deploy with all lines taut and the inflation of the canopy will pull the stowed rigging lines from the loops. These lines will feed out under tension until the parachute is in its maximum drag configuration at which point the pilot can vary the drag by appropriate movement of the cockpit handle.

It will be apparent that the initial position of the cockpit control must be in the maximum drag position, with the centre line extended as far as possible, during packing and when the parachute is stowed.

The initially large drag following deployment of the parachute is thought to be necessary and acceptable if the parachute is to be expected to perform with few malfunctions.

The extra drag, and hence a lowered performance, that is obtained when the parachute is in its minimum drag configuration after deployment is believed to be a small price to pay for the overall advantages of controllable drag offered by the system proposed.

Conclusion

Glide control of a sailplane is vital for safe operational procedure. This re-

Schematic Diagram of Control Mechanism.

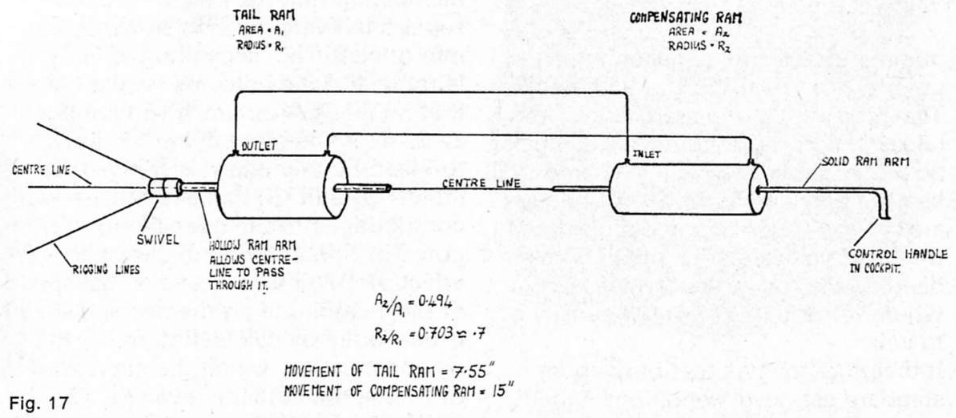

Fig. 17

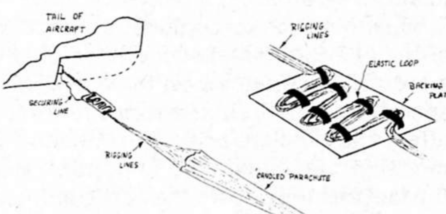

Fig. 18

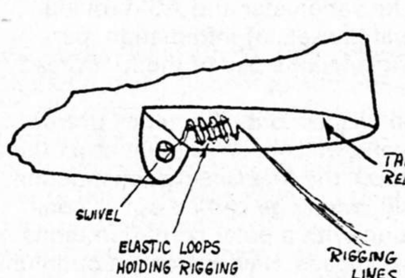

Fig. 19

quires a variable drag producing device in order to be effective.
The work done has established the possibility of converting the present «single shot» drag parachute to a variable drag parachute by the addition of a centre line that can be drawn in and out to change the configuration of the parachute canopy.
Results of experiments performed mainly on a scale model of the proposed parachute show conclusively that a variable drag parachute can be achieved by using this method of control. Further is has been shown that such a parachute can conform to OSTIV Airworthiness Requirements, therefore the postulated system is a practical proposition.
Flight testing is needed to verify the predicted control and to confirm the handling characteristics of the parachute. It is hoped to run these tests in the near future.

References
1. W. D. Brown: Parachutes. Published by Pitman & Sons, 1951.
2. T. Knacke and R. Iserman: The First Ribbon Brake Parachute: Headquarters Air Material Command, Wright Field, Dayton, Ohio. 1946.