CORRESPONDENCE

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY,
7, Albemarle Street, London, W.1, England.

Dear Sir,—The excellent report by J. J. Green and G. J. Klein on the "Aerodynamic Characteristics of Aircraft Skis and the Development of an Improved Design," published in the August number of the Journal terminates with an appendix which prompts a little discussion.

At the outset let me say that the four recommendations made by the authors, viz., that

1. The ski pedestal should be of the rigid type and not of the shock absorbing (oildraulic) type;
2. The ski with its rigid pedestal should be used in conjunction with a specially designed ski undercarriage instead of attempting to fit the ski to an existing wheel undercarriage;
3. If a special ski undercarriage is not possible, the wheel undercarriage shock absorbing unit should be capable of a double range adjustment—one range for use with wheels and the other range for use when wheels are replaced by skis (the ski pedestal being of the rigid type);
4. The ski trimming gear should be enclosed in the ski itself and should operate on the axle. External trimming cables, due to their very high resistance, should be avoided;

represent a counsel of perfection and as such are unassailable. There are, however, certain practical considerations which render the ideal solution too difficult or too costly to be attained.

Take, for example, the military aeroplanes of the fighter, army co-operation and day bomber classes belonging to any power in the temperate zone. These aircraft spend their lives as wheeled landplanes, but should, at a moment's notice, be capable of preparation for operation on snow. In order to maintain a high state of preparedness and mobility and at the same time observe the dictates of economy, it is desirable to reduce to the smallest possible the number of operations required to convert from landplane to skiplane, and also to reduce the quantity of special components that have to be held in stock. This is a strong argument in favour of a ski which can be used as a direct and simple replacement of a wheel without a change of undercarriage.

Recommendation number 3 has much merit and would probably be the correct solution in the more northern countries where ski operation represents a substantial proportion of the aircraft life. In the matter of expense, it is admitted that the capital cost of a shock absorbing ski pedestal is probably a little greater than that of the necessary modification to the standard shock absorbing unit, but it seems a pity to carry the extra weight of the latter about in the air all the time on account of a mere possibility that it might be useful sometime. The ski pedestal stays in storage until required and demands no more than ordinary storage maintenance. Another argument against the double range shock absorbing unit for a temperate zone Air Force is that only a certain proportion of the effective aircraft strength would ever be employed on skis, and consequently it is better to concentrate the conversion parts into one com-

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ponent which can be stocked in the quantities deemed necessary without affecting the standardisation of the entire landplane equipment on the strength.

In enumerating the advantages of a rigid pedestal over a flexible pedestal, the authors of the report make the following statement:—

> "With a rigid pedestal the problem of internal trimming can be solved easily. In the case of a flexible pedestal this problem is very difficult."

With this statement I disagree entirely because the simplest solution of the trimming problem that has yet been achieved has been rendered possible by virtue of the deflection of a shock absorbing pedestal. When the National Research Council had evolved a desirable ski shape, it was decided to have a practical full-scale trial on a "Hawker Audax" and a pair of skis of suitable size was constructed to the recommended lines. Calculations showed that the trimming force, even with the much improved pitching moment characteristics of the new skis, would reach a magnitude in a high speed dive which, with the ordinary elastic type of restraining device, would necessitate a heavy and complicated system of springs. The trouble is that for taxying the restraint should be as little as possible whereas in flight it should, under the worst conditions definitely overrule the upsetting moments. The answer obviously was to produce a device which would only come into effect in flight and would lock the ski rigidly in the desired position. Furthermore, the operation had to be automatic, to relieve the pilot of any responsibility, and had to be simple. The idea of using the extension of the elastic leg of the pedestal as the weight of the aeroplane becomes airborne was hit upon, and this is how it is put into effect. A strong lever carrying a hardened steel roller on a horizontal axis at its lower end is mounted nearly upright on the brake flange and secured against rotation relative to the airframe by means of the brake torque strut used with the ordinary wheel undercarriage. To the base of the ski are securely attached a pair of rigid brackets joined across their tops by a flat piece of steel on edge and lying longitudinally with the ski. This piece, which is called the trimming quadrant, has for its under edge a special profile based on a true circle described from the axle as centre. The roller on the trimming lever engages with the bottom profile of the trimming quadrant and at the position corresponding to the desired attitude in flight, the profile takes a sharp drop of such a depth that, as long as the roller is bearing on the profile, it cannot pass the "step." For approximately fifteen degrees ahead of the step, the profile follows a true circle about the axle and then begins to withdraw with increasing rapidity. Behind the step the profile again withdraws like a cam in relation to the axle. When one quarter of the weight of the aeroplane is acting on the two skis, the rollers on the trimming levers are depressed away from the profile, and there is complete freedom of rotation within the wide limits of the trimming quadrant brackets except for the mild restraint of an anti-chatter spring. As soon as the aeroplane becomes airborne, the trimming roller, which with the tail of the fuselage slightly depressed for take-off, is a few degrees in advance of the step, comes to bear against the quadrant profile, and as the pitching moment on the ski is positive at all angles upwards from 12½ degrees negative incidence, the step of the quadrant is forced against the roller and remains there. In the unlikely event of the ski nose becoming sufficiently depressed to produce negative pitching moments, the roller will bear against the rising cam forward of the step, and any increasing depression of the ski nose will be forced to produce a compression of the pedestal leg. Thus any shock on the limit stops is averted.

During an ordinary tail down landing, the quadrant is free to move about the roller over the fifteen degrees of circular profile, and this is sufficient to let the tail well down, with a reasonable allowance for irregularities of the ground, by which time the weight of the aeroplane will disengage the "lock." If, by

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any chance, the nose of the ski should strike a bump when the aeroplane is just about to be airborne, the impact will be enough to compress the pedestal leg to a sufficient extent to allow the roller to override the step. The fast rising cam behind the step will absorb any further shock and will return the quadrant to its proper position as soon as the aircraft is properly airborne.

The position of the roller relative to the airframe, and consequently the attitude of the ski, can be accurately adjusted by means of the adjustable brake torque strut. As a first trial, the angle chosen was plus 3° relative to the thrust line of the airscrew, as this corresponded to the angle of minimum drag in the wind tunnel.

It is true that the arrangement described above necessitated a flexible helmet of approximately streamline shape to house the brake flange and the tops of the trimming lever and pedestal. This helmet requires development and refinement, but it is felt that its drag is a small price to pay for the generally good compromise achieved.

The preliminary trials were made with external steel safety cables attached to the nose and tail of the skis and reefed with a thin copper wire. After a period of aerobatics the copper wire was completely unaffected, so the safety cables were removed for all subsequent flights. The speed with the streamline skis was about 162 m.p.h. as compared with 154 m.p.h. with ordinary skis.

The reader should bear in mind that all the foregoing discussion applies only to aircraft with a fixed type of undercarriage. In my opinion the problem of ski equipment for retractable undercarriages has two distinct sides. On those undercarriages which retract about a thwartships axis the crudest type of ski and trimming gear will probably be the best, as in flight it can all be tucked up out of the way against the bottom of the wing in simple fashion and during landing the drag will probably be advantageous. Weight will be the primary consideration. On undercarriages which retract about a longitudinal axis the problem is very difficult indeed and I hesitate to venture any predictions beyond the weak admission that for a time at least it may prove the wisest policy to forego retraction in winter and fit a good streamline ski and shroud the legs as well as possible a la Northrop.

Yours truly,

A. FERRIER, *Squadron Leader.*

Ottawa, Canada,
September 7th, 1935.