WASP MARKINGS FOR PROPELLERS AND ROTOR CONSPICUITY

by T.C.D.Whiteside, Argyll, Scotland and L. Smrcek, University of Glascow, Scotland

Presented at the XXIII OSTIV Congress, Borlänge, Sweden (1993)

INTRODUCTION

The introduction of new categories such as very light aircraft, motor gliders and microlight aircraft has caused a sharp increase in the number of propeller aircraft – especially in the past 15 years. During this period, CAA records show 9 fatalities and 4 cases of serious injury. However it should be noted that this record may well not include injuries which are associated with the propellers of microlights where such injuries are reported to BMAA and not directly to CAA.

The year 1973 saw the introduction of flickering blade markings which attract users' attention to the potential danger (1). That design certainly attracted the attention of anyone in the vicinity, but unfortunately it also produced an illusion that the propeller was turning eccentrically. Naturally, these markings were not very popular with ground crews. The aim of the present investigation has therefore been to examine the physiological and psychological factors involved to produce a design of markings which will ensure that turning propellers are more visible at all RPMs and to attract attention to the hazard without also producing the illusion that the propeller is turning eccentrically (2).

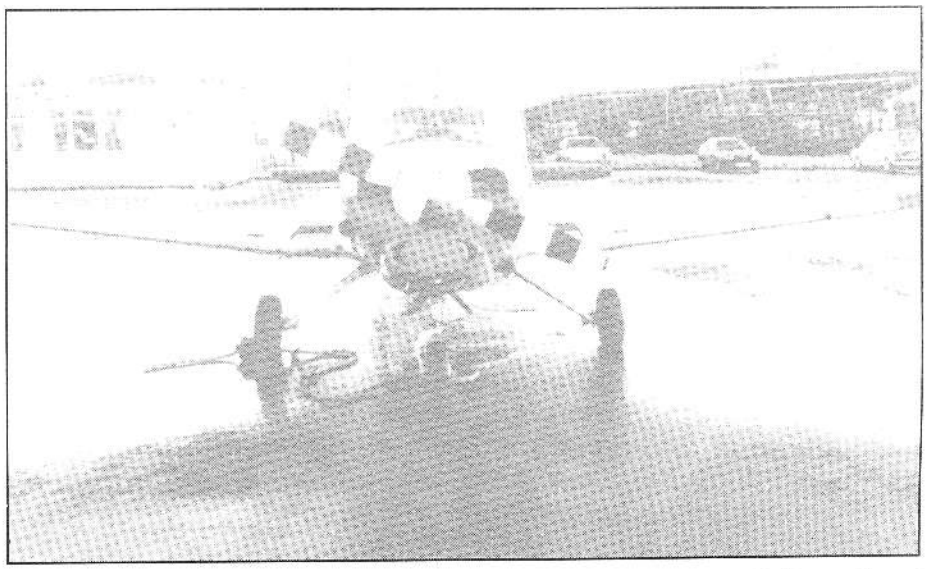

FIGURE 1. "Wasp" ,markings temporarily appli9oed to a Bulldog aircraft. (Reproduced from CAA Paper 91002, "Propeller and Tail Rotor Markings", by permission of Civil Aviation Authority.)

THE INVESTIGATION:

1. Testing the new design.

Experimental markings in black and in white were compared with the 1973 markings in the laboratory by means of two 30 cm diameter propellers turning simultaneously side by side at 1000 rpm. Thirty subjects took part in assessing the attention-getting quality, the annoyance, the flicker, and the eccentric effects. Light levels were controlled. The detail of the preferred designs

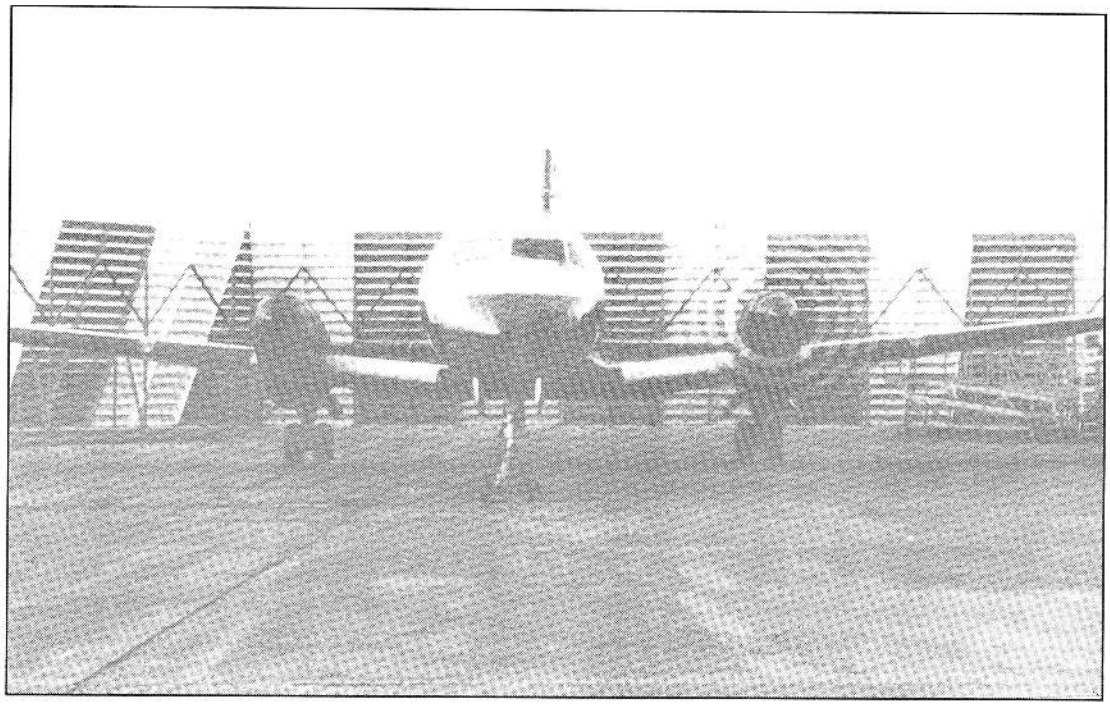

FIGURE 2. British Aerospace ATP with usual tipmarks on the starboard propeller and "Wasp" markings on the port propeller. (Reproduced by permission of Aerospace magazine, Royal Aeronautical Society.)

was then reassessed using propellers of 1.5 meter diameter rotated at 700 rpm by an electric motor to which one, two or three such propellers could be attached simultaneously so as to make propellers of 2, 4, or 6 blades. Similar markings were then applied (temporarily) to the propellers of 3 Bulldog aircraft and the test was repeated but, for practical reasons, with a different group of subjects.

2. Visibility by night airfield lighting.

The effect on visibility of the experimental markings. of low level illumination (such as that found on the more isolated dispersal areas of an airfield), was assessed both in the laboratory using 30 cm. model propellers and on an airfield at night on the parked Bulldog aircraft whose propeller had been temporarily marked with the experimental markings.

3. Black and white vs colored markings.

To give some tolerance limits to the specification of black and white markings, tests were carried out to assess the effect on visibility of a reduction in the maximum contrast of black and white. The results showed that a small reduction entailed only a slight loss of visibility. Accordingly, tests were carried out on combinations of light colors and of dark colors whose brightness difference (as measured by the diffuse reflection factors) was within the range of brightness contrast reduction found for the black and white markings.

THE MARKINGS:

In certain specified environments such as snow covered terrain, black and fluorescent red or yellow can appear to be slightly more visible. Black and white markings however are not only the simplest to apply but also give the best contrast and the best visibility against most backgrounds. When the propeller is stationary, the blade looks rather like a wasp (hence 'WASP' markings). When it is turning, the marks form concentric circles: the bright ones being more visible against a dark background while the dark ones are more easily seen against a bright background. If colors are used, they should lie within the permitted specification for good visibility.

In addition to the concentric circles, the design also produces a small amount of flicker near the blade tip, and near where the propeller would normally go under the spinner, and on the spinner itself. These refinements are aimed at ensuring that anyone near the propeller will be alerted to the presence of the rotating hazard, even if it is only seen edge-on when the flicker created by the differently painted halves of the painted spinner should ensure visibility even from the side.

It cannot be too strongly emphasized that although the principle looks simple – and in a sense it is – you should be warned of the possible dangers of trying a do-it-yourself modification of the design on the basis of this communication alone which summarizes work done over a two year period. You are therefore most strongly urged to see a copy of CAA's Pink 45 (3), in which considerable effort has been expended to make quite clear just how to apply the design according to the size of propeller, colors, etc..

CONTRASTS AND COLORS:

For a given background brightness, at any point in the turning blade, the visibility of the circle formed by a marking depends on the mark/space ratio: the higher the ratio, the better the visibility. Since the mark/space ratio increases towards the center of rotation, the circle visibility is best near the spinner and worst at the blade tip. Furthermore, for the same reason, the greater the number of blades, the better is the visibility of the circles produced by the markings.

In addition, the higher the contrast between the con-

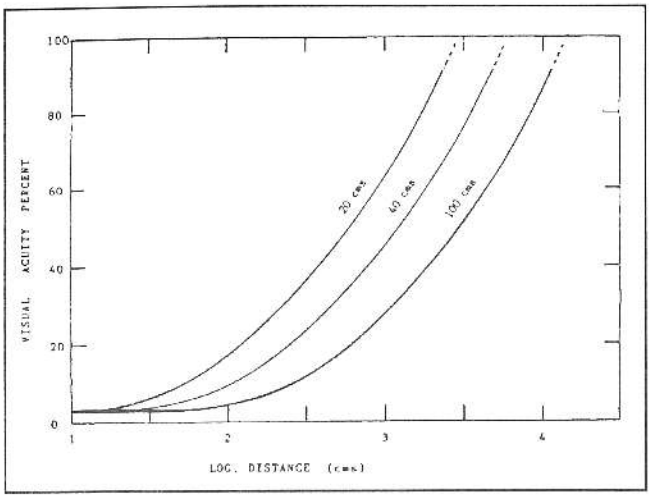

FIGURE 3. Reduced visual acuity as an object goes away from your direct line of sight. (Reproduced from CAA Paper 91002, "Propeller and Tail Roto Markings", by permission of Civil Aviation Authority.)

centric circles formed by the markings and the background, the better is the visibility. In this connection, note that "contrast" can be one of brightness or of color or of both. However, since background colors vary so much, it is better to concentrate on brightness contrast which can be tackled with more consistent rules – hence the recommendation for white and black in the WASP markings. The black used should be gloss black since, in sunlight, matte black can look quite gray compared with gloss black. With white paint however, the apparent brightness in sunlight is less dependent on whether the surface is matte or gloss .

Either the dark circles can be seen against a light background, or the light circles against a dark ground, or both can be seen against a background which is neither too bright nor too dark. Even with colored backgrounds the same applies since different colors can have the same brightness (hetero-chromatic matching).

In experiments referred to in CAA Paper 91002, it was possible to increase the tolerance limits by permitting a slightly reduced brightness contrast between the bright and the dark markings. In turn this meant that it was possible to use certain colors instead of the best contrast of black and white. But again, the darker color should have a gloss finish.

DESIGN PHILOSOPHY:

The main advance in this design however, is that it presents what is believed to be a radically new philosophy of design. You mark the whole propeller – not just the tip – because otherwise, unless you happen to be walking directly towards the marked tip, the closer you go to the propeller, the less you see the tip marks as they go more and more into the periphery of your visual field. So with tip marks alone. If you are unfortunately very near a rotating propeller, the chances are that you will see nothing to alert you to the hazard.

On the other hand, the closer you go to WASP markings, the more you see them and are able to make a judgment on how far they are from you, because with WASP markings you have something to focus on – the concentric circles. With the smaller propellers of microlights and powered gliders, maybe it is not a life that's at stake – just a hand or an arm but the same principle applies as for tail rotors, for helicopter main rotors (marking the underside for the safety of passengers, or the upper surface to enhance air-to-air visibility) or for the many-bladed props of an ATP. Unlike most markings, WASP markings are designed so that any part of the propeller can be seen not only from a safe viewing distance but by people who are already dangerously close.

Finally, the AIC is at present not mandatory but you don't need to be a lawyer to see the possible implications of not marking the propeller, especially if the same principle applies as is stated in page 4 of the Highway Code for road users issued by the Department of Transport (UK). That message, here paraphrased in our own words is: You don't have to follow these recommendations, but if you fail to do so and someone is injured, you might, in a private prosecution, be liable for damages for not having implemented a safety recommendation. However as microlights are not mentioned in the AIC, a case might be argued for smaller markings for the smaller propellers of microlight aircraft or of powered gliders.

It would be scientifically reasonable, for example, to suggest for small propellers, the size of markings should be adjusted so as to show no less than 4 sectors per blade (two black, two white). This proposal would require discussion with the relevant authorities.

References:

(1). Whiteside, T.C.D., (1973): Markings for Propeller and Tail Rotor Conspicuity. AGARD-NATO Advisory Report No. 56, ASMP.

(2). Whiteside, T.C.D., and O'Donnell, P.J., (1991): Propeller and Tail Rotor Markings. CAA Paper 91002. Civil Aviation Authority, London.

(3). CAA UK Aeronautical Information Circular (AIC 62/1992 25th June), Propeller and Rotor Markings.

See also in *Aerospace*, (Royal Aeronautical Society):

Whiteside, T.C.D., (1992): "Clear Prop!", *Aerospace*, Dec. 1992, pp. 15-17.

Eshelby, M. and Whiteside, T.C.D., (1993): "'WASP' Propellers", *Aerospace*, May 1993, pp. 8-9.