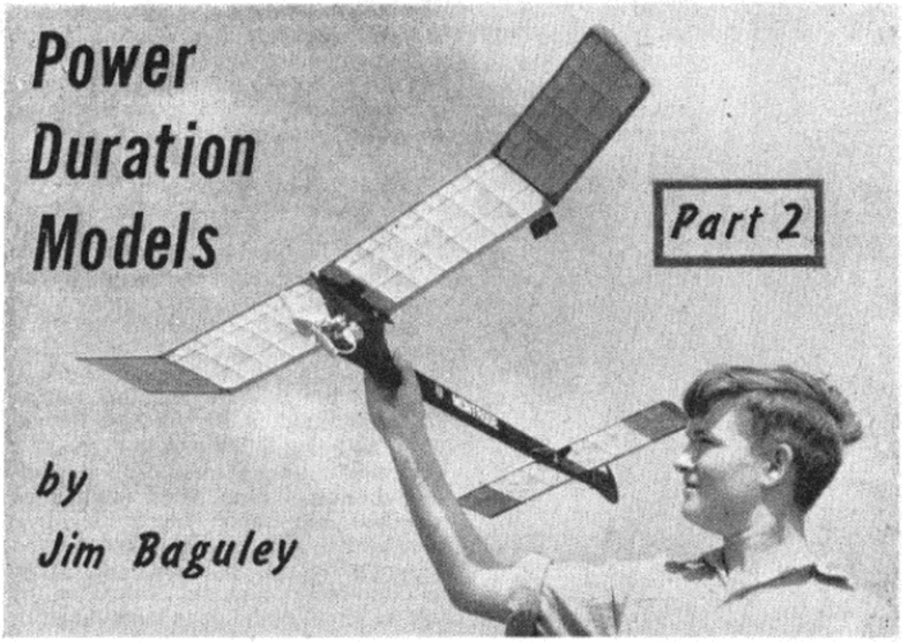


Aerodynamic Design Considerations

General:—

Firstly, let us consider the reason for using the pylon layout. If a model of any reasonably normal layout is made to increase its flying speed, above that of its normal gliding speed, it will tend to loop. This may be explained by saying that when gliding, the moments of wing and tail lift about the c.g. must be equal, if the model is to be stable.

As flying speed is increased, the moment of wing lift will increase at a greater rate than the moment of tail lift, provided the layout is not abnormal. We must therefore provide a nose down moment, as, unless we resort to an unusual layout, or use a layout which may have other vices (explained later), the loop diameter produced will be too small to be useful. The pylon layout solves this problem in two ways.

Slipstream

The wing is placed out of the slipstream and the tailplane directly in it to provide the best use of this layout. This means using only slight downthrust, otherwise the slipstream will be directed above the tailplane.

The slipstream impinging upon the tailplane will cause this nose down moment, the effect of which will depend upon the tailplane section, chord and moment arm as well as the strength of the slipstream. This effect is, I think, generally over-rated, but it does influence the flight pattern of the model to some extent. (See Fig. 8.)

Downwash

This effect depends upon the tailplane being located in the downwash from the wing during the glide, when the effective incidence of the tailplane will be reduced.

During "power on," the downwash from the wing will be diminished, as the wing will be operating at a lesser incidence relative to the airflow, and the slipstream will destroy any downwash. To counteract this reduced effective tailplane incidence during the glide, the tailplane should be rigged at a greater positive incidence. This will prevent a stall during the glide and also increase the tail lift moment during the power run.

In order to take full advantage of the above, the tailplane section should have similar characteristics to the wing section, which explains why many recent power models have fairly thick, even highly cambered, sections. This will also have a beneficial effect on the glide, when gusts and turning effects will increase the wing and tail lift proportionately, thus minimising any upsetting moments.

The tail moment should be long with a fairly large tailplane for obvious stability reasons. One can go too far with this, as it should be remembered that with very long moments, disturbances take a long time to damp out, due to the greater inertia. It is for this reason that extremities such as the tailplane, wing tips, etc., are kept light.

I would suggest a tailplane area of between 30 per cent. and 50 per cent. of the wing area regardless of other factors, and a moment arm (taken as wing trailing edge to tailplane leading edge) of between 2½ and 4 wing chords, the final choice obviously being a matter of experience. Remember, however, that as the product of area and moment increases power handling becomes easier, but pull-out and inertia are aggravated by the fact that if the model once achieves the vertical on pull-out, wing flow breakaway may cause the downwash on the tailplane to disappear, causing increased tailplane lift and no recovery! (This latter problem would not arise were the wing and tailplane so arranged that the downwash missed the tailplane, e.g. a typical high thrust line model.)

On a pylon model one must consider at what longitudinal dihedral this phenomenon is likely to occur and try to avoid it, although it is usually only discovered the hard way! A long moment arm will enable a greater longitudinal dihedral to be used, but will be subject to long moment arm limitations, and we are once more faced with a compromise. I have found with my designs, that 1½ deg. would seem to be a minimum, but models with different proportions may well be safe with closer rigging angles.

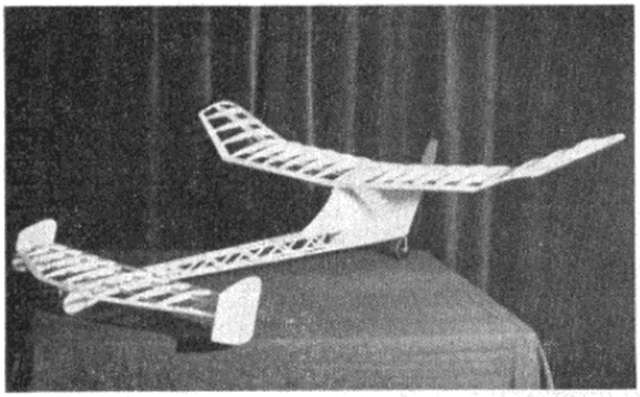
The main argument for a low aspect ratio tailplane is that a greater area will be in the slipstream. I have frequently been told, by people who should know, that my tailplanes have too high an aspect ratio, but I believe that although other factors have to be adjusted to suit the climb, it is justified by the effect on the glide.

The actual angle of the thrust line relative to the tailplane would seem to be fairly non-critical—I use 2½ deg. but most people use rather more.

The nose length of any power model should be kept short, if only in the interests of reducing inertia; this is also allied with keeping the tail and fuselage rear end light, as the nose will then *have* to be short to achieve balance.

The pylon should be high enough for the wing to be just out of the main slipstream, as trouble may be experienced in the form of an under-elevated sweep round before climbing away, if the rotating slipstream (which is greatest at launch) causes the model to bank sharply due to its effect on the wing. The small distance between the wing and thrust line would also contribute towards this, as if the model were side slipping to the right, the correcting left rolling moment, due to side area above the c.g. and thrust line, would be less than if the pylon were high. This was

George Fuller is here seen adjusting the engine of one of his typical, functional square wing tip models.



A beautifully constructed high thrust line model. Although featuring twin fins (which Jim Baguley does not recommend), the simple structure and Warren girder fuselage are worth noting.

probably the reason for John Thompson's old low pylon F.A.I. models nearly coming in to the right before climbing away, and would also account for the peculiar " round and up " climb some *Creeps* have when built with the shallow dihedralled long centre panels and sharply dihedralled short outer panels. It would also be a good reason for keeping side area to a minimum at the front of the fuselage and above the thrust line, although designs which do not use cut-away or shaped pylons do not appear to suffer.

Contrary to widely held opinions, I believe that the rear fin area should be large in order to achieve a more consistent rate of turn on the climb. The stability reserve, built into pylon models by the use of dihedral and a high-mounted wing, can more than adequately cope with this. By making pylons and fins of a symmetrical section similar to that of a combat or stunt model, the unpleasant effect of side areas partially stalling is minimised.

Concerning the vertical location of fin areas it should be remembered that any trim tab adjustment on an underslung fin will give roll and turn in the same direction, which becomes an immediate potential danger. An underslung fin can also be effectively a top fin if the arrangement of incidences is such that the model flies nose down, i.e. very large wing and tail incidences. This mainly affects the glide, and would also cause the tailplane, in effect, to be mounted high and possibly out of the downwash. I think that the fin is best placed behind the tailplane, as, although it will partly be blanketed by the tailplane wash, the fin will be fairly clear of the airscrew slipstream.

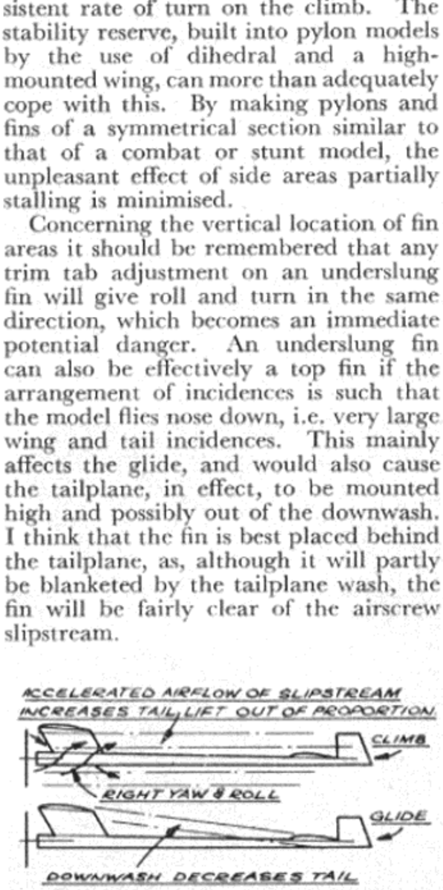
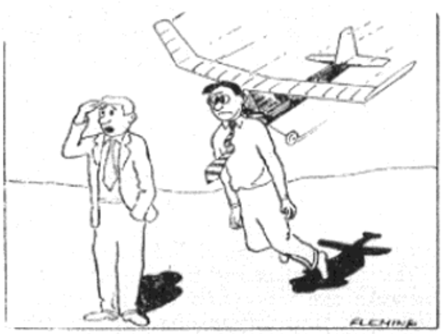


FIG.8. DOWNWASH AND SLIPSTREAM EFFECTS.

These considerations will be influenced by the type of model, and the trim employed. Dihedral form has been found to be quite critical; polyhedral is the most satisfactory, the actual proportions depending upon various factors but a general guide may be given.

A dihedral form with low resistance to roll, such as a polyhedral form of equal panel length and equal dihedral angle to each panel, when used on a model with any roll of appreciable magnitude would tend to cause the model to " barrel roll " in the dihedral rather than roll about the fuselage axis.



Cor, what a climb ! It's out of sight already.

A marked dihedral on short tips with shallow centre panel dihedral would give the opposite effect and the model would prove rather difficult to trim for a consistent rate of roll.

The most desirable characteristic is a compromise between the two, and the general practical form, arrived at by experience, would seem to be polyhedral with the centre panels about $1\frac{1}{2}$ times the length of the tip panels. The dihedral angle of the outer panels, in relation to the inner panels, should be at least twice the dihedral angle of the inner panels from flat. The total dihedral measurement at the wing tip is dependent upon layout, etc., but is usually in the region of 1 per 4 units of semi span. Straight dihedral, and tip dihedral (outer panels only raised) *can* also be successful.

Tips should always be washed-out and tapered in some way to prevent tip stalling, especially when a washed-in inner panel is used for trim, although a very good contradiction of the use of tapered tips may be seen in George Fuller's models !

The vertical c.g. position can be quite important, for while a low c.g. can be desirable from the point of view of pendulum stability, it should be noted that when a model is turning, centrifugal force will throw it outwards, acting at the c.g., thus, if the c.g. is low, the model will be rolled into the turn. While this effect is very difficult to achieve with normal building weights, it can be produced by placing ballast in the wrong place. In a misguided moment I ballasted a 350 sq. in. open model to new rule weight ($26\frac{1}{2}$ oz.) by putting $10\frac{1}{2}$ oz. of lead in the fuselage instead of in the pylon at the original c.g. !

Streamlining can be a most unrewarding business, especially when one considers the small effect the drag produced by a stationary propeller and a motor-cylinder has on the glide. The propeller may be dealt with by folding (but make sure the hinge is strong enough) and the motor may be faired, in which case it must be mounted upright to achieve a beneficial result. However, any *general* streamlining is to be encouraged, as every little helps.

It has been said that the objection to an upright motor mounting is that the direction of the reciprocal out of balance force due to piston inertia is in the direction of the line of stroke, thus causing extra wing drag by the vibration produced. This, however, depends upon how the motor has been balanced, as it is possible for the total out of balance force to be at 90 deg. to this direction if the total reciprocating mass is wholly balanced. Most motors are designed so that half the reciprocating mass has been balanced, giving forces of half the previous maximum in both directions. This is the best arrangement and makes the motor mounting non-critical.

Aspect ratio is best kept on the low side for highly powered models, as a low aspect ratio can be persuaded to have a higher safe rate of roll, although a high aspect ratio, within reasonable limits, usually produces a better glide for a given weight and area. The usual aspect ratio is between 6 and 8 for power models. I prefer the higher figure and make up for this by using a longer tail moment arm.

I can see no use on power models for anhedralled tailplanes, which were the fashion a short while ago, or for tip fins on wings which will prevent " roll in the dihedral." Sweepforward may be useful in increasing the rate of roll but may be subject to structural limitations, although it will bring the motor closer to the c.g. which is a desirable feature.

Tailplane tip fins are not recommended, solely because any side area attached to a tailplane on a power model is bad even if the tail is keyed in position, unless, of course, the keys and the flier are infallible (remember Mike Gaster's fourth flight in the '56 World Champs ?).

To be continued next month