"As the sun sinks in the west . . ." This evocative photograph, by Geoff Woodworth, shows the author's *Elmira* high over the west face of Ivinghoe Beacon. When the conditions are perfect, it is always a temptation to continue flying, literally until the sun goes down.

Radio Control
SOARING

Compiled and Edited by
DAVE HUGHES

with contributions by:
Ken Binks, Pat Teakle, Tony Ells, Chris Foss,
Geoff Dallimer, Dave Dyer, George Bushell,
Fred Deudney, John Beer, Norman Armstrong,
Geoff Meakin, J. Robertson and I. Barr.

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INTRODUCTION

INTEREST in radio controlled gliders has shown a marked increase during the past few years, and "soaring" must now be one of the largest and healthiest branches of the many-faceted hobby of aeromodelling. Many modellers of long-standing will have tried free-flight soaring, but it has been with the application of radio control that the model glider has really come into its own.

In addition to what might be called the "natural" attraction of soaring in its own right, there is also the fact that, with power flying becoming restricted in many areas because of the ever-present noise problem, many r/c fliers are turning to gliders and finding them a pleasant change, requiring the perfecting of new skills and techniques and giving a hitherto untasted variety to otherwise potentially jaded modelling appetites.

Not only are there no noise problems, the absence of an engine brings other advantages that have to be experienced to be fully appreciated. There is no fuel to be paid for, and no gooey mess of oil to be cleaned off the model after use. With no engines to start, there is no heavy accumulator to carry around, no burnt-out plugs—and no bitten fingers!

One becomes more conscious of the Great Outdoors, and soaring—especially slope soaring—is much more appreciated, as a rule, by the rest of the family. A day in the hills amidst beautiful scenery is, for them, far more enjoyable than spending it in the car on a flat and dreary aerodrome. They, too, appreciate the peace and quiet of soaring flight, and getting far away from the raucous power models which "have no business but dispensing round their magnanimities of sound." One can even find new side-interests, as many fascinating ancient earthworks and fortifications are to be found on and around many of the best soaring sites, as well as those intriguing chalk figures which so often share the slopes with the silent fliers.

Despite the current popularity of r/c soaring, however, there are still many existing, or would-be, model fliers who have only the vaguest idea of what it is all about. It is mainly for them, rather than for the soaring "buffs," that this book has been compiled.

Through the medium of the "Strictly for Soarers" column (a regular monthly feature of *Radio Modeller* magazine since 1966) I am continually hearing from people who, having read there a little about the many joys and delights of silent flight, are eager to start, but are really not quite sure how to go about it. I hope that, in the following chapters, enough background information has been imparted to enable them to embark on their soaring careers with some confidence and the knowledge, at least, of the paths that have already been trodden and the pitfalls to be avoided.

Like Topsy, this book has "growed" from what was originally envisaged as a modest booklet on very basic lines, to a more comprehensive treatise. And, just as r/c soaring is only one branch of aeromodelling, so even this branch has grown its numerous specialised off-shoots. On some of these, therefore (more especially on the theoretical design side, and again on thermal soaring) the appropriate exponents have been called in, for their specialised knowledge and individual views.

For my own part, I have endeavoured to adhere, in the main, to practical "go out and do it" advice, without probing too much into the whys and wherefores. For those with more questing intellects, however, the theory is also there—in a section of its own—for the reading.

DAVE HUGHES

CHAPTER 1

THE MECHANICS OF SLOPE SOARING

MANY modellers who have not actually experienced, or seen, slope soaring, erroneously imagine that it is just a case of carrying a model glider to the top of any old hill, flinging it off . . . steering it down to the foot of the slope . . . dashing down and carrying it up the hill again . . . flinging it off . . . and so on, the model staying airborne for perhaps a minute or two, with a lot of luck.

If this were the case, slope soaring would hardly have anything like the following it enjoys today. In fact, nothing could be further from the truth and, whilst this sort of thing *can* happen, if the would-be soarer chooses the wrong type of hill, or persists in trying to fly a certain type of model when there is insufficient lift (or he is insufficiently skilled in using what lift there may be), it is far more usual to find that, once launched, the average model can be kept up as long as the wind strength, daylight and receiver batteries, will allow!

It is quite usual for the flights made by weekend sports fliers, on their home slopes, to be in the region of half an hour—depending on whether or not there are others waiting to fly on the same radio frequency. World records for this class of model flying are in excess of 19 hours! However, conditions, and sites, have to be carefully chosen, as some give much better soaring than others, as we shall see.

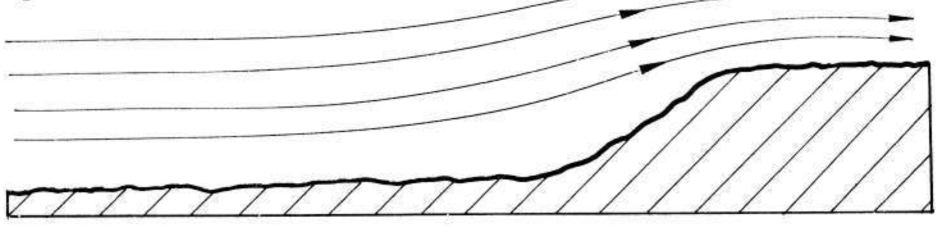
How does it all work?

Seeing the models floating silently out over the slopes—the large ones soaring to a great height with a graceful majesty, and the smaller ones busily flitting through precise aerobatics near to the hillside—newcomers always ask "What keeps them up?"

In the words of the folk ballad—"The answer, my friend, is blowin' in the wind." Or, more correctly, perhaps, and not so specifically, the answer is—"rising air." Air rises either by virtue of its temperature, or by its movement over rising ground. Slope soaring is concerned mainly with the latter, and "thermal" soaring, as its name implies, with the former—though one can often find some thermal lift when launching soarers from the slope on almost windless days. We will see the niceties of this discussed in a later chapter, and thermal soaring, from flat ground, is dealt with in its own section of this book but, for the moment, let us talk about slope soaring in the strictest meaning of the term—using wind that is rising because it is blowing uphill.

As will be seen in Fig. 1, the air rises to follow, more or less, the contours of the ground

Fig. 1



and so, in front of a hill, ridge or bluff, it is rising quite steeply. More steeply, in fact, than the gliding angle of the model. Put another way, the air is going up faster than the model is trying to come down. So the model ascends.

What seems to puzzle many onlookers, however, is the motive power. "With no engine," they say, "how do you make it go forwards into that wind, as well as going up?"

The only "motive power" our glider has is—gravity. The earth is constantly trying to pull our model down, but we have designed it in such a way that, like a dinner plate placed in water, it does not drop vertically down but slides along sideways, descending only gradually compared with, say, a knife or fork, immersed at the same time. Air is a form of fluid, less dense than water, of course, but behaving rather similarly in many ways. And our models—we hope—are rather more sophisticated than the humble piece of crockery. But gravity is always trying to pull them down—so they go forwards. This is something of an over-simplification, but it serves to illustrate the point.

Our glider, then, *is* only gliding, all the time and despite the fact that it may be getting further from the ground it is, in fact, gliding down its own downward path in the air, so to say. Like trying to run down the up-going side of an escalator. The up-going air may be carrying our model upwards quite fast, but it is, itself, continually gliding downhill, drawn by the force of gravity.

We have, in our slope, a marvellous sort of natural wind tunnel. One in which we can match our model's speed with that of the wind, so that it appears to hover, relative to the ground. Or we can make it move forwards (that is to say, more quickly downwards!) and the extra lift generated by this increased forward speed can be seen to cause our model to soar higher, as soon as we relax our downward, forward, pressure upon it.

We can, too, fly our model slower and slower, until it appears to be moving backwards, relative to the ground. And, taken a stage further, we see it lose that certain minimum forward speed it needs to maintain flight at all—and we see it literally drop out of the air. All these things can be seen to happen, quite dramatically, with a glider, on our hillside "wind tunnel," in a way that one could never hope to approach when flying powered models.

This, then, is the basic mechanics of slope soaring, put in its simplest terms. We need a hill, with a wind blowing onto its sloping face, so that it rises, to provide "slope lift" and bear our models (and the birds) up into the skies with seemingly effortless grace.

But there are many kinds of hill, and some are more suitable than others, for our purpose. Some provide magnificent lift in a variety of conditions; others are much better at certain wind velocities, while still other, perhaps innocent-looking hills, are treacherous in the extreme, with vicious down-currents and turbulence to throw our flimsy models about and smash at them like some giant invisible fist from the sky!

CHAPTER 2

TYPES OF HILL

LET us, in the light of the foregoing, take a look at some of the main hill configurations and their characteristics. Having said that we need a slope for the air to be forced to rise, let us see the different ways in which this can happen—the different configurations of slope. We will group these into main general types, which should be fairly easily recognisable.

The "Plateau" type

The best type of hill for model slope soaring is one with properties something like this: a fairly straight-faced slope, with an angle of about 45°, rising from an otherwise flat area of land, *with no other hills in front for several miles.* The length of the face should be as great as possible—obviously, the longer one's slope, the more area in which to soar. The top will be in the form of a plateau—that is to say, there is a flat area there, and that the land does not slope away too soon or too suddenly on the down-wind side. Fig. 2a shows this type of hill and Fig. 2b gives a closer view, showing the behaviour of the air over it.

Fig. 2a

As you will see, the air begins to rise gently quite some distance away, and tends to leave an area of more or less still, or "dead" air at the foot. There is an area of rising air, then, stretching some way upwards and outwards from the brow of the hill. The extent of this is dependent upon the angle of the hill and the velocity of the wind.

If the brow of our hill is fairly rounded, as in Fig. 2a, the air flows round the contours quite well and continues over our flat plateau top, just dropping a little, as will be seen from the diagram. This makes the plateau an ideal landing area—and we must always consider landing areas when we are looking at possible sites, or we may find ourselves in difficulties later! (We will be dealing with types of landing approach in a later chapter, when you will appreciate more fully the significance of the airflow patterns we are discussing here.)

If the edge of our hill is more sharply defined, however, as in Fig. 2c, then the air will

Fig. 2b

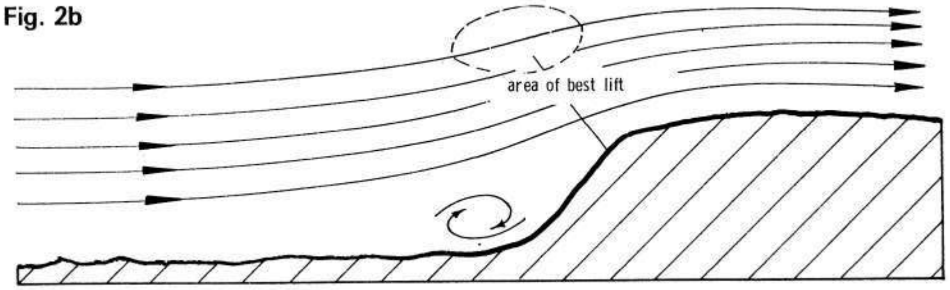
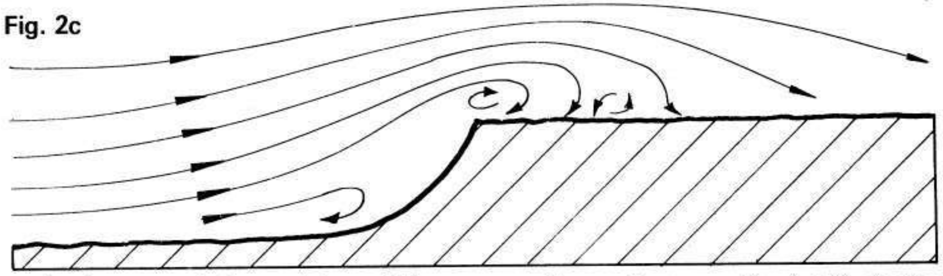
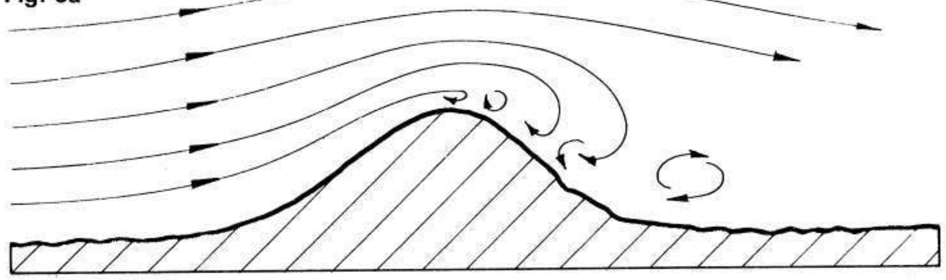


Fig. 2c



tend to become turbulent and there will be some very "bumpy" areas, or "pockets" with the air moving vertically downwards in places, and curling back upon itself in the manner shown. The higher the wind velocity, the more pronounced is this effect. The actual area of lift created, however, may be very good and, in any case, the turbulence formed in this way is behind, and not in front of, the slope from which we shall be getting our lift. Our difficulties will not be in getting the model aloft, therefore (one can launch it from a point part-way down the slope, in front of the turbulence) but in bringing it down smoothly.

Fig. 3a

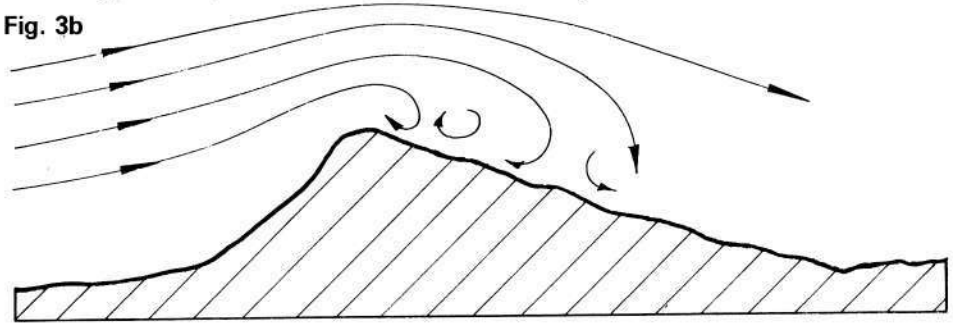


The ridge

Ridges often produce really fine lift areas, and can be much longer than most of the "plateau" type of hill face, which means that the models are not so confined to one area of sky—just in front of a short "face." However, landing on ridges can be tricky, especially for the beginner, as there is not much room for error. Figs 3a and 3b show typical ridge cross-sections and, once again, the air will be seen to be curling downwards over itself, on the windward side. Further down on the windward side, it becomes completely calm, in the lee or shelter of the ridge itself, even when there is a high wind blowing onto the top.

In light breezes, the downwind turbulence of the ridge is not so in evidence and, in fact,

Fig. 3b



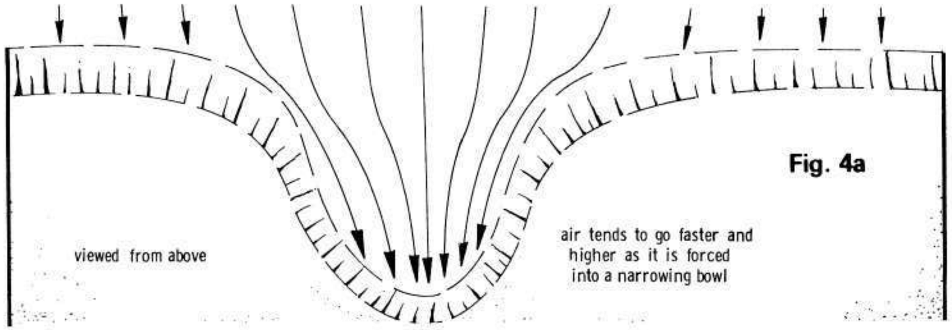


Fig. 4a

becomes simply an area of "sink" or "dead air," rather than anything more violent, and it is in these conditions that the beginner should begin to learn the technique of ridge landing. Actually landing on the crest of the ridge, or else letting the model settle down just at the back of it, in the naturally sinking air, are both methods that can be practised but, until one becomes adept—beware of the ridge in stronger winds. Again, we will talk about landing procedure fully at a later stage; it is mentioned here only to show that landing methods will depend upon not only the terrain but also the wind-speed over it.

It is not essential for the wind to be blowing exactly at right-angles to a ridge, or a "plateau" face, and lift is often present when the wind is at a very oblique angle (say 30°), though it will then usually be more localised.

Bowls

Some very fine soaring is to be enjoyed from "bowl" sites, and there are a surprisingly large proportion of soaring sites which have this configuration. The air tends to "funnel" up them and build up its speed by a sort of "venturi" effect, to give excellent lift to great heights.—See Fig. 4a. Bowls *do* tend to be very directional, however. That is to say, they require the wind to be blowing dead square on to the back of the bowl ("half-bowl" or even "horseshoe" might really be a better description). This is because, if the wind shifts to one side, so blowing over the "arm" of the horseshoe, as it were, the air at that side becomes very turbulent, and there may also be an area of dead air, as seen in Fig. 4b.

It is not uncommon to find that the lift area of a bowl site will extend a considerable way back from the crest, or launch-point, even though there may be a flat area of ground—or even one sloping away—behind it. If he does not want to have to force his model down into the strong lift, the beginner will often find that he has to fly his machine a very considerable distance downwind of a bowl site, before it will start to settle down. This means the bowl is "working" well, though it can often mean some extra exercise for our soaring enthusiast!

On other days, when the wind is not so strong, and does not go funnelling up the bowl,

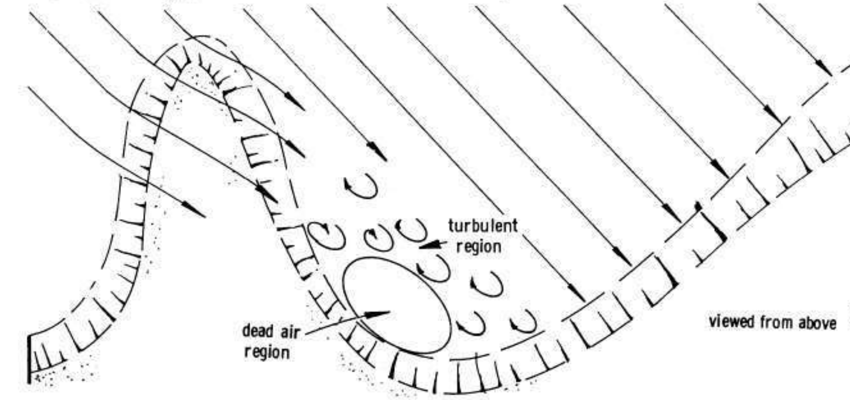
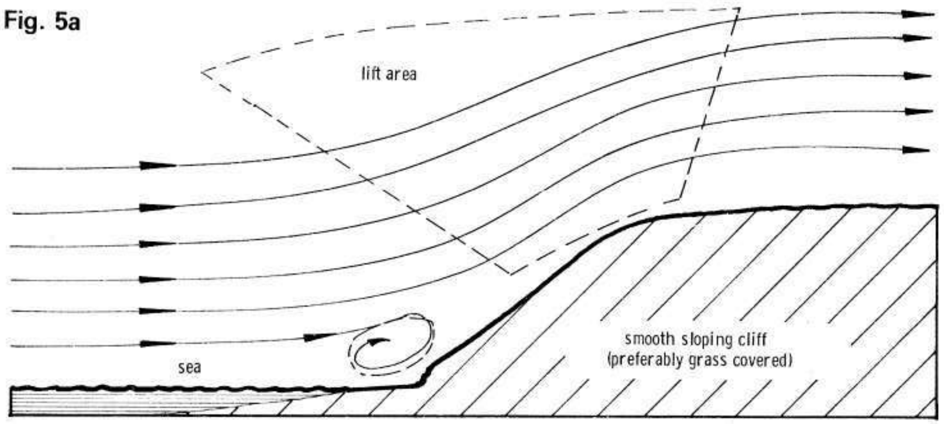


Fig. 4b

Fig. 5a



landings at the top will be easier—and the main area of lift will often be a long, long way out. Exploration and experience will show where to expect it for each particular site under different conditions.

Coastal sites and cliffs

Generally speaking, some of the best and smoothest soaring of all is to be had from coastal sites. The air flowing in from the sea is incredibly smooth and, as a result, when it does begin to rise over the land-mass, it starts doing so a long way out. The point at which it starts rising, as always, depends on its velocity and, on some days, one is not able to reach the forward limit of the lift—one starts to worry about losing sight of the model before this can happen!

The shape of our coastal hill, or cliff, of course, affects the airflow in the same way as does our inland hill, so that steep cliffs—especially those with sharp edges—are best avoided by the beginner. Good soaring can be had from them by the experienced flier, but it will probably be necessary to fly the model through considerable areas of quite frighteningly strong turbulence during the initial stages of the flight, and also very often having to land through very bumpy air. Figs. 5a, b and c show some typical cliff effects. Fig. 5a shows the best type to look for—in effect a "hill by the seashore" rather than an actual cliff.

Fig. 5b

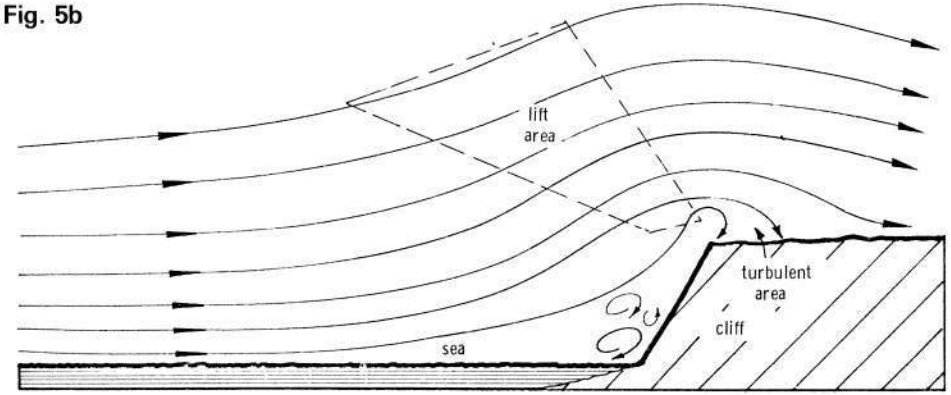
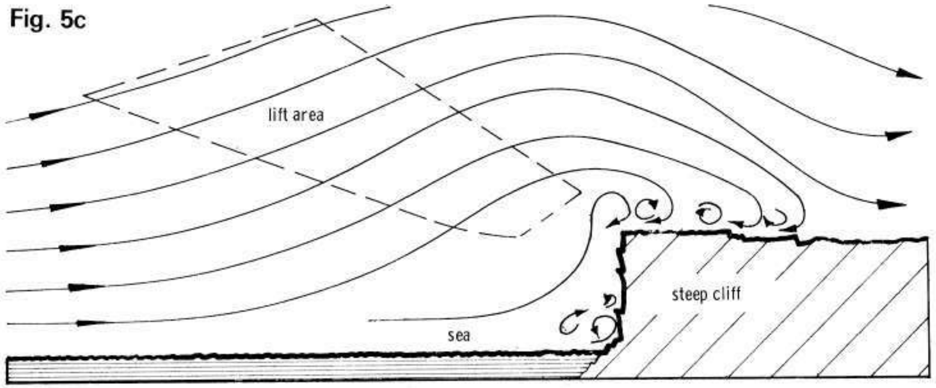


Fig. 5c



One does not, of course, have to fly over the sea, unless one wants to, to enjoy the benefits of the coastal site. As long as our hill "sweeps down to the sea"—with no obstructions to spoil the smooth airflow, then we can actually be flying on a hill a mile or so away from the tide-line, with whatever added confidence it may give us to have solid earth all those hundreds of feet below our model, instead of the briny!

It does, however, give some added zest, to the seasoned flier, to lead his model out over the waves, with the seagulls for company, and to try and match his recently acquired skills, with their inborn instinct for soaring up on every available current of rising air.

The sharper edged type of slope, but still with a reasonable face-angle (Fig. 5b) can be very worthwhile, but the vertical, or near-vertical cliff, with a sharp edge (Fig. 5c), can be very treacherous, as there is a definite and clearly defined (but unfortunately invisible!) point at which the lift ends and the turbulence begins, with no transition areas to give a warning to the pilot.

It is surprising how much of our holiday-resort coastline has coastal slopes, or "sloping cliffs" suitable for slope soaring, and how many of these, too, have flat fields at the back of them, suitable for landing.

Another type of "sea-soaring," for those who do not have nice high slopes near their seashores, is "dune soaring," much favoured on the French and Belgian coasts. An efficient model can be coaxed to considerable heights from the upcurrents of off-sea air from quite small sand dunes, and learning the in's and outs—or rather the ups and downs!—of your particular stretch of dunes can be quite a challenge in itself.

The standing wave

This is nothing to do with "sea-soaring," despite its name, but is a phenomenon that occurs in front of most slopes when the conditions are just right.

Air tends to behave rather differently at low speeds, from the way it does at higher speeds. At fairly low speeds, it flows over our hills in the manner shown in the diagrams, in a fairly comfortable way, with the surrounding air adjusting to accommodate it. In higher wind velocities, however, the surrounding air itself tends to resist. Consider Fig. 6a. Our layers of air at (X), in rising over the hill, are becoming compressed and are, in turn, preventing the air following (Y) from getting near to the contour. This follows the line of

Fig. 6a

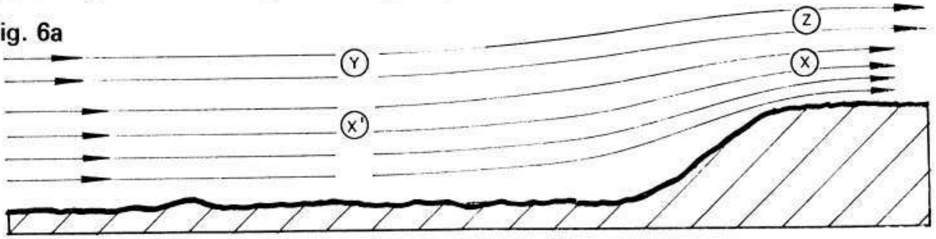
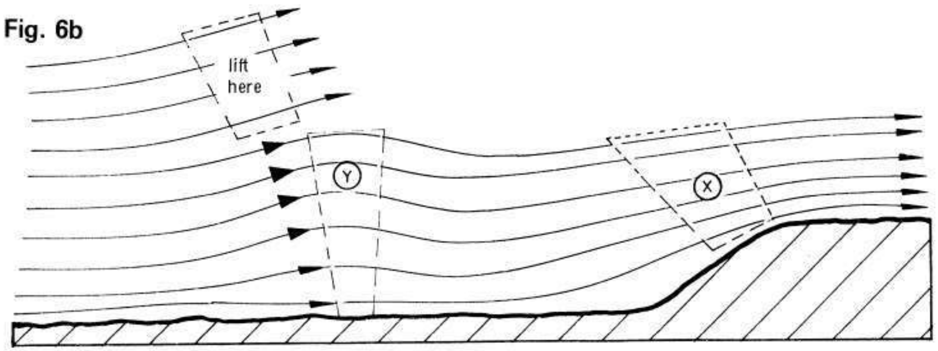


Fig. 6b



least resistance and rides upwards, also becoming somewhat compressed, and causing a further area of lift (Z).

Now, the wind following along behind (X) (call it X^1) is restricted from going forwards as fast as it would like, by the slope at (X) and from going upwards at this point by the already compressed layer at (Z), so it starts to ride up further out, at (Y), where the top layer (Z) has not yet formed.

The picture is now as seen in Fig. 6b, with the main area of lift at (X) and a further one at (Y). In favourable conditions, this secondary bump of air will induce yet a further lift area, acting just like a slope itself! This is what is known—to model fliers, at any rate—as a standing wave, and it can form a considerable distance in front of the hillside—anything up to half a mile.

Oddly, perhaps, there are two kinds of standing wave—the one just described, which we can call the "modeller's type"—and that used by full-size glider pilots, which they would call (rightly) the true standing wave. This occurs when a torrent of stable air flows over a line of hills or range of mountains, and the standing wave is formed on the *downwind* side.

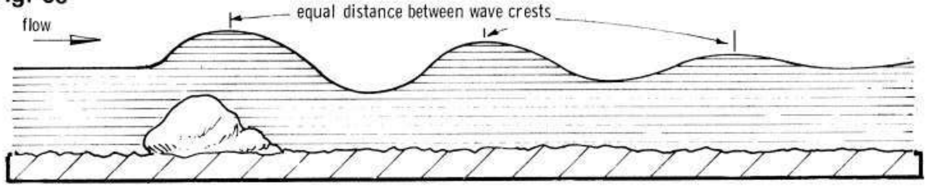
Thinking, once more, of the air as a fluid, we can draw a parallel with a submerged boulder in a fast-flowing river. This will cause a hump in the surface of the water above it, as one might expect. However, down-stream of this, the water forms itself up again into a secondary wave—with, perhaps, a further one still beyond—which maintain their positions relative to one another and the river bank. Fig. 6c shows this effect.

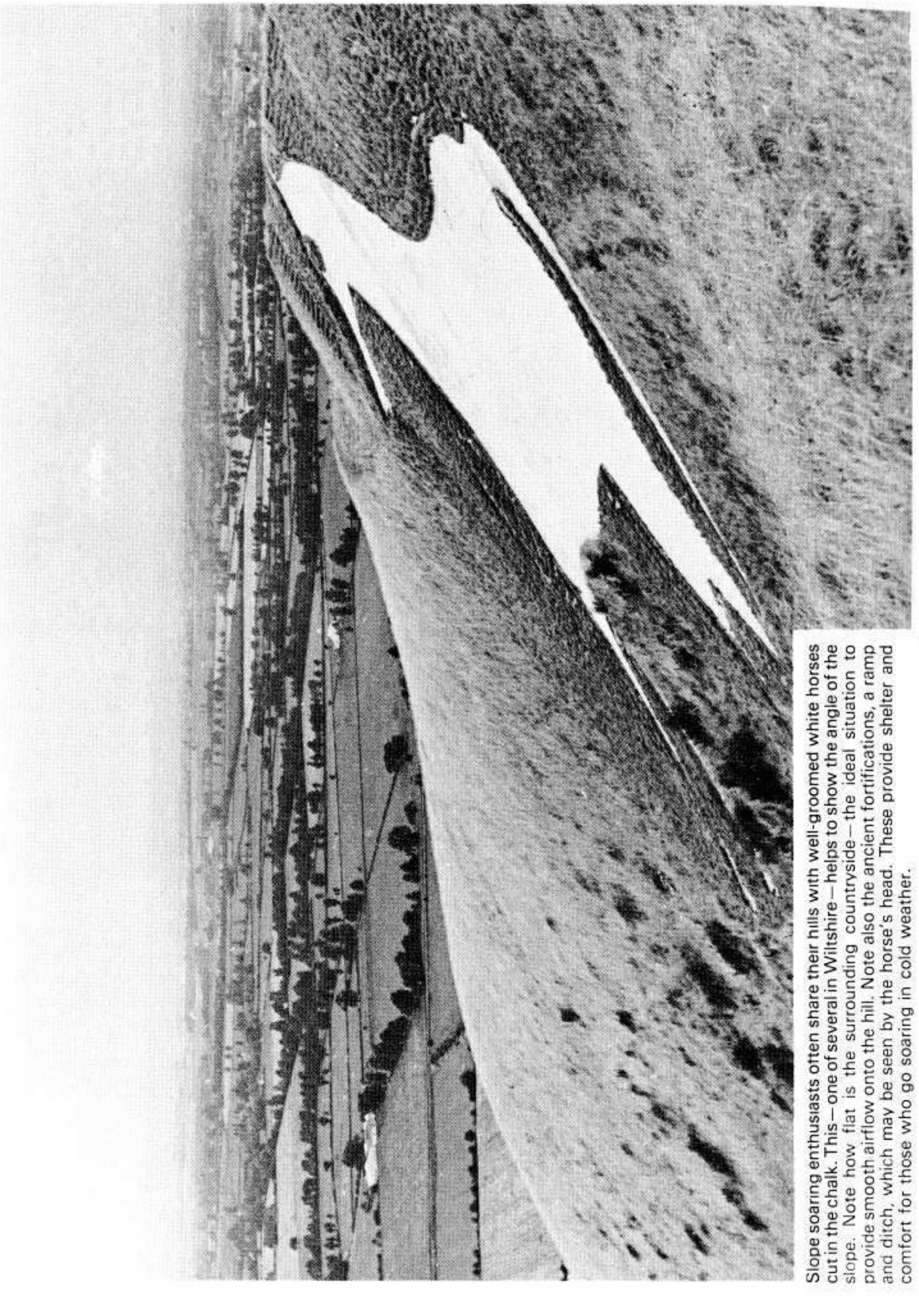
Not only is the phenomenon, over a large range of mountains, on a vastly grander scale than our river-bed boulder, but the air is so much less dense than the water that these waves can propagate at tremendous heights, and altitudes in excess of 44,000ft have been reached by full-size gliders using them. However, it is rare for our models to be caught up in genuine wave lift—which is probably just as well, for we can usually say "goodbye" to those that do!

Types of hill to be avoided

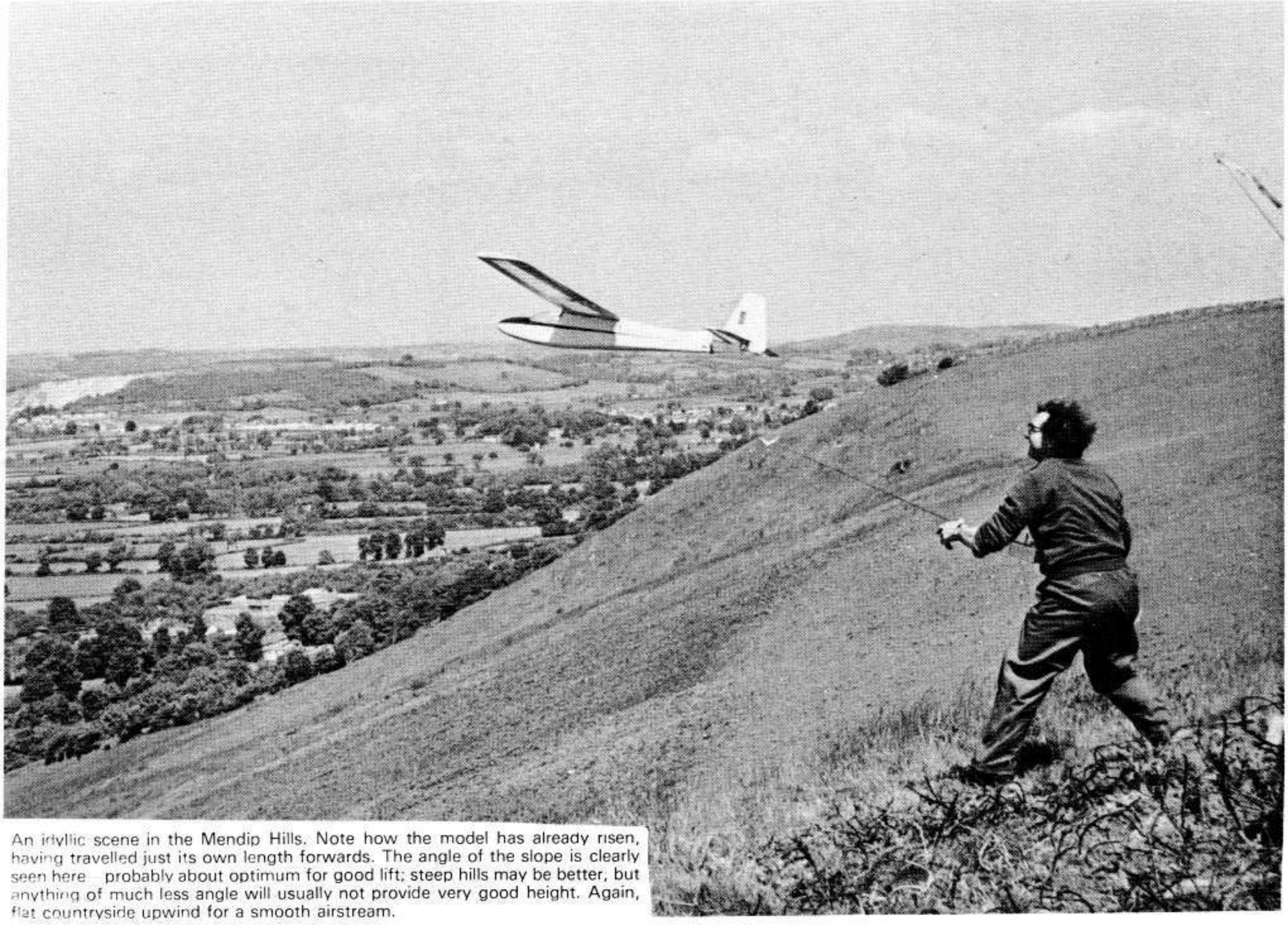
We have seen the various kinds of hill that can be useful to us and, of course, there are innumerable variations with regard to general scale, surroundings and type of ground. Now a few words about the types of hill which will be best avoided, at least until we have

Fig. 6c



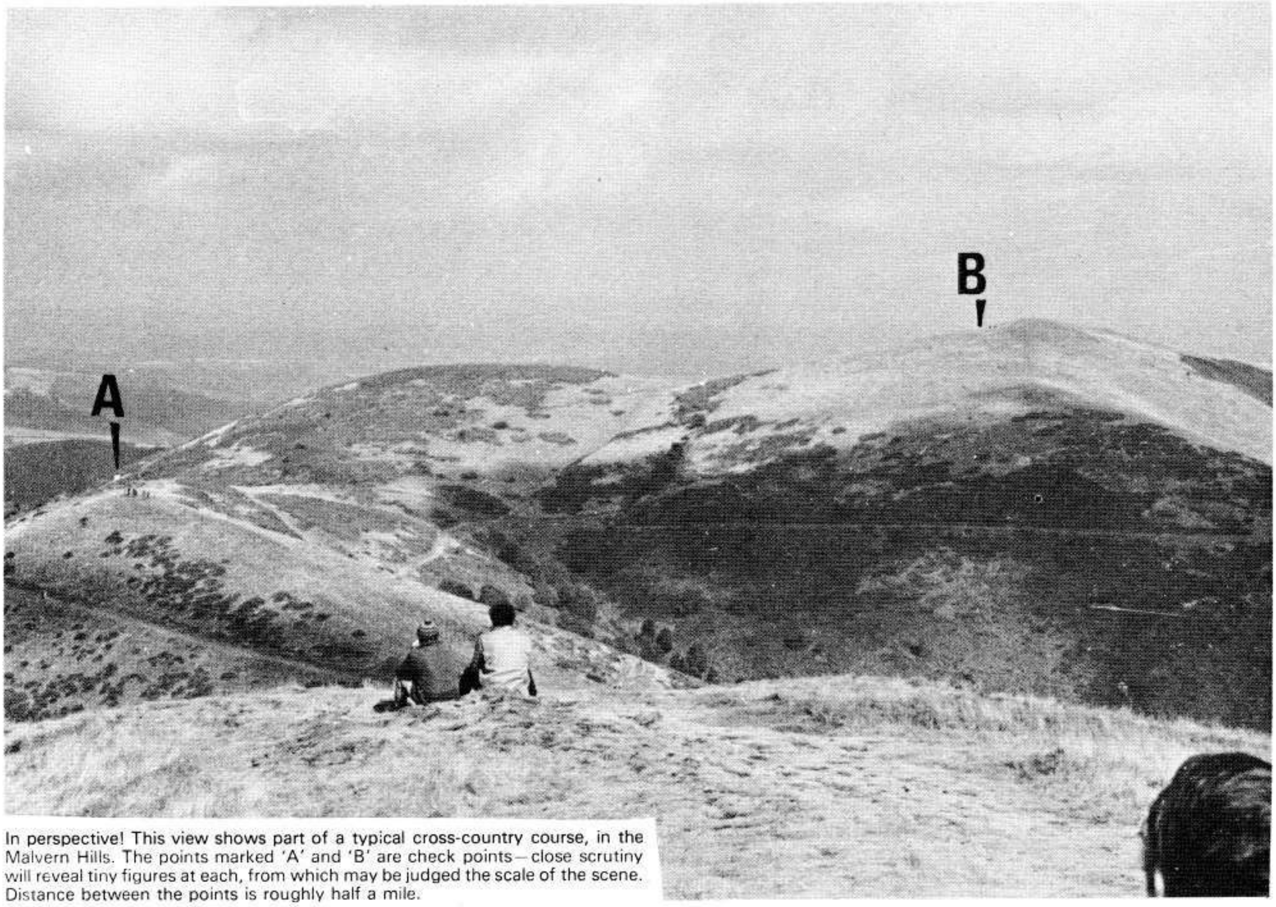


Slope soaring enthusiasts often share their hills with well-groomed white horses cut in the chalk. This—one of several in Wiltshire—helps to show the angle of the slope. Note how flat is the surrounding countryside—the ideal situation to provide smooth airflow onto the hill. Note also the ancient fortifications, a ramp and ditch, which may be seen by the horse's head. These provide shelter and comfort for those who go soaring in cold weather.



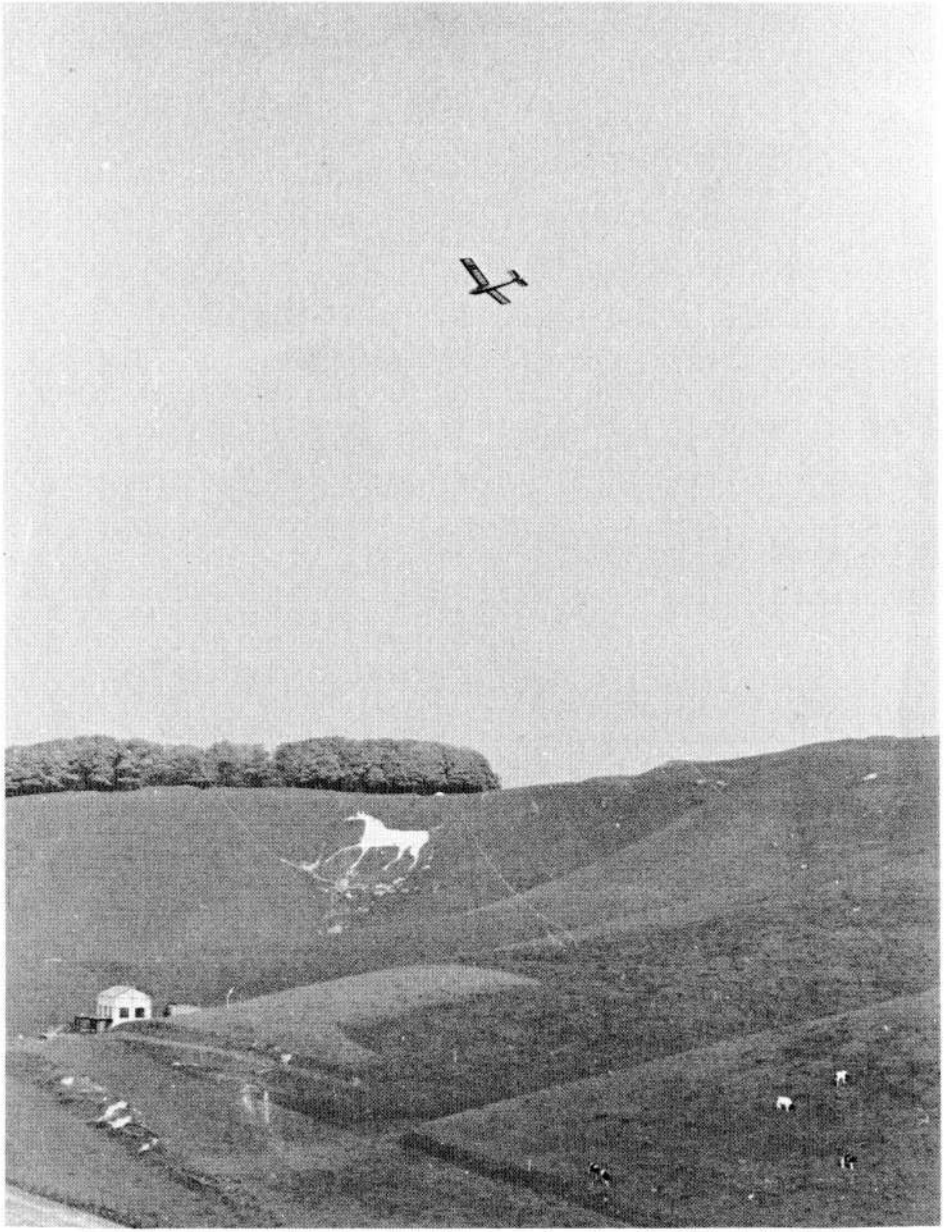
An idyllic scene in the Mendip Hills. Note how the model has already risen, having travelled just its own length forwards. The angle of the slope is clearly seen here – probably about optimum for good lift; steep hills may be better, but anything of much less angle will usually not provide very good height. Again, flat countryside upwind for a smooth airstream.

Two miles of ideal soaring hills, overlooking golden sands and foaming surf. One of the finest "sea soaring" sites one could wish for, at Rhossili Bay in the Gower Peninsula (S.Wales), for westerly winds. With really smooth air off the Atlantic, it is interesting here to be able to relate the outward extent of the lift to the wind velocity.



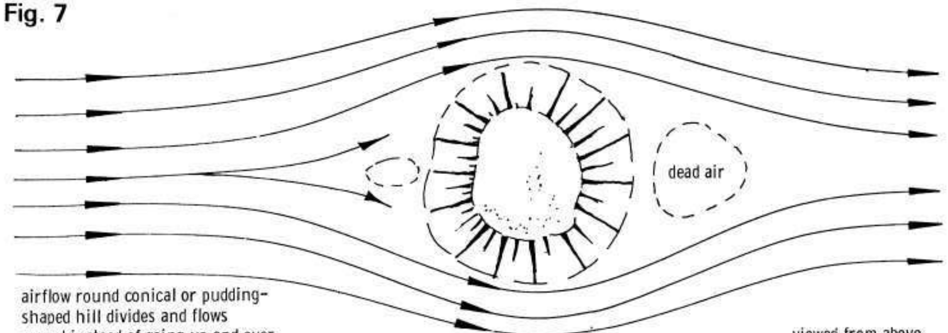
In perspective! This view shows part of a typical cross-country course, in the Malvern Hills. The points marked 'A' and 'B' are check points—close scrutiny will reveal tiny figures at each, from which may be judged the scale of the scene. Distance between the points is roughly half a mile.

This picture, taken during a soaring meeting, shows a really fine ridge giving a considerable length of slope face, a change of direction at the near end also providing a bowl effect. Note the narrow top area, then the steep drop away of the slope. Landings, for other than the most adept, are made in the field behind the wall (left). Even so, care is necessary, as the ground slopes away that side and there is an area of turbulence.



Another Wiltshire white horse, this time in one of a series of bowls, themselves forming a larger bowl. One may fly each in turn to find the best lift, or move round as the wind veers. When the wind is on the "horse" bowl, however, landing can be tricky because of the trees growing right up to the edge.

Fig. 7



airflow round conical or pudding-shaped hill divides and flows round instead of going up and over

viewed from above

considerable experience and can cope happily with turbulent and rapidly changing conditions.

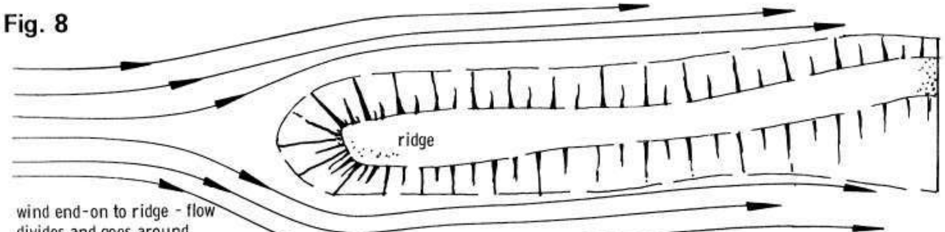
The classically "useless" hill is the "sandcastle" or conical one. This is because, instead of climbing up over it, the air finds it easier to split up and flow *around* it. On small conical, or pudding-shaped hills, there will usually be no slope lift effect at all and, on the larger ones, what lift is produced is only found in a very narrow "straight ahead" area. If one is daring (or foolish) enough to launch a model into this, one is faced with either "hovering" it in virtually the same spot for hours on end, or else having it simply carried "round the corner" and right away by the air rushing past the sides—a fate which it will meet sooner or later in any case! Fig. 7 shows how the air divides in front of a conical hill, and then rushes round to join up with itself on the other side.

The same sort of effect is often to be found on a ridge site, when the wind swings to blow parallel with the ridge. (If the wind had been end-on to the ridge all the time, one assumes that you would not have been there in the first place!) Chasing the wind, one wanders over to the end of the ridge (Fig. 8) only to find that, though there may be just an inkling of upward-going air, most of it is passing to either one side or the other, and not going up at all.

Similarly, there is often a partial effect of this kind at the *end* of any face, or ridge, where the wind ceases to flow upwards over the top and commences to flow round the side (Fig. 9). This is always a treacherous area, to be wary of—more especially when the wind is fairly strong, because we have then the strength of the wind to fight against, without the upward component enabling our model to fly faster without losing height. The result, unless we are very lucky or very skilful, is that we find our model sinking downwards while making little or no progress forwards. If we are less fortunate, it may disappear around that corner, out of our sight—and so out of control.

Another type of hill to avoid, or at any rate treat with a great deal of reserve, is the one *with other hills upwind of it*. Within a couple of miles, that is—although, of course, this does depend on their size. In light breezes, these sites may prove very good (Fig. 10a) but, when

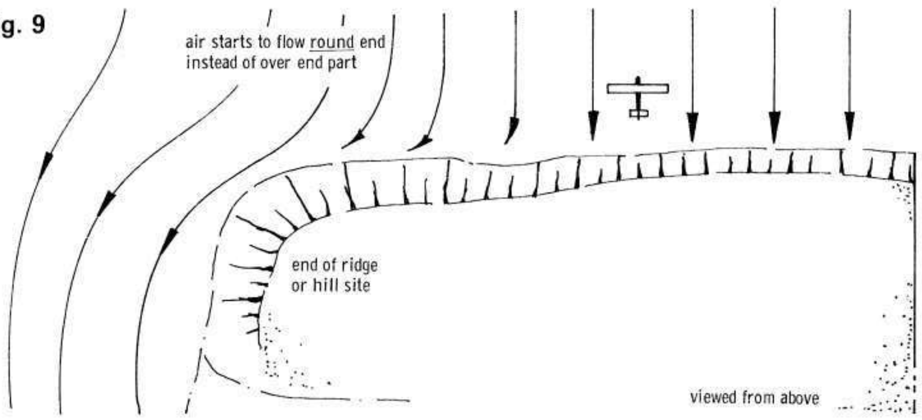
Fig. 8



wind end-on to ridge - flow divides and goes around, rather than up and over.

(viewed from above)

Fig. 9



the wind freshens, severe turbulence is often caused by the hills to windward. Fig. 10b shows the sort of thing that happens to the airflow.

The air may seem smooth enough at the launch point of our main slope but, as the model begins to move outwards—perhaps as little as fifty feet, perhaps as much as fifty yards—it can be severely buffeted and even find itself in air that is moving very fast in a *downward* direction.

In less strong winds, however, it is often to be found that these "advance guard" hills, when they are considerably smaller than the main hill, can produce a fair amount of lift in their own right, which can be used to great advantage by the more experienced and adventurous fliers, who are not daunted by the possibility of "running out of lift" from the base hill before reaching the outer "staging post," as it were. In general, however, the soaring to be had from hills with clear space in front of them will always be more reliable.

Thickly wooded slopes, it should go without saying, are also to be shunned. Firstly for the obvious reason that, should the lift fail, the model could well be lost in a treetop, and secondly because the trees themselves are likely to cause turbulence and make flying the model both difficult and hazardous.

Slopes that have areas of woods at the very foot, however, can often be quite efficient, provided they are high enough, as the woods could well lie in the region of "dead air" that is, as we have seen, generally to be found in this area. Again, one would be prudent only to launch a model from this sort of slope if one were reasonably certain that there would be enough lift to enable it to be landed back at the launch point, rather than somewhere down the slope.

Fig. 10a

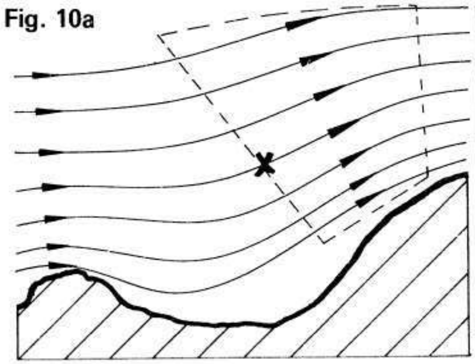
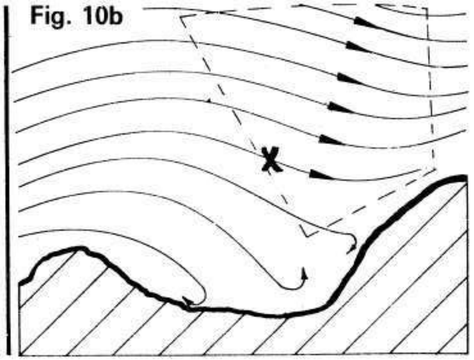


Fig. 10b



Hills with trees at the *top* do not usually create any problems with soaring, as such—only with landing, but this is simply a matter of technique, and is covered in our discussion of landing methods later on. In all things, one does well to start with as few problems as possible, and apply specialised techniques as one learns them so, for the moment, the beginner should find himself a slope of the first type we described, on which to make his first sorties.

Looking for sites

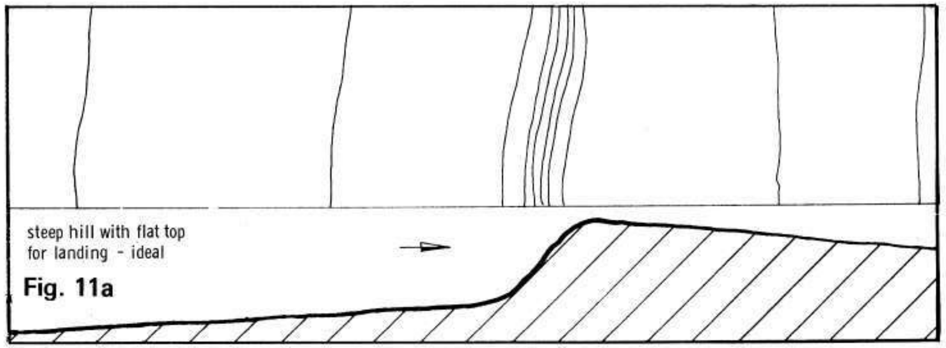
Although by now most of the sites frequented by groups of slope soarers—especially those where competitions are held—are well-known, there must be many other places around the country which have not been tried, or about which the users prefer to keep quiet. (For this latter reason, incidentally, it is not possible for us to give a *detailed* list of slope soaring sites here. We would not wish to be accused of "spoiling" sites for the local fliers, by precipitating an influx of scores of soarers from many miles around!)

If you live in a hilly area, then you should not have too much trouble finding a suitable site. Talking only in the most general terms, there are many suitable slopes, for instance, on the South Downs, also in Hampshire, Dorset and, further west, in Somerset (the Mendip Hills). Cornwall has many coastal sites. Going further north, there are the Cotswold Hills, and the Malvern Hills. North of the Severn we have the mountainous regions of Wales (starting with the Gower Peninsula, with its magnificent coastal soaring). In the midlands, the Peak District of Derbyshire offers its rugged grandeur, while, in the north-east, the North Yorkshire Moors abound with tempting sites, and the east coast has a number of inviting cliff areas, if you are prepared to face the bitter east winds. Scotland, one hardly needs to add, must be a soaring paradise, though the only named sites that have become known south of the border, are the East and West Lomonds. If, however, you live in the flatter lands of, say, south-east England, then perhaps you would be wise to consider taking up thermal soaring! Even so, there may well be small hills and possibly coastal sites, that are worth investigating for their slope-lift possibilities. It is really for those who live in "marginal" areas—neither very hilly nor very flat—that the question of searching out suitable slope sites becomes more of a task. There are many soaring enthusiasts who regularly make journeys of 50 or 60 miles to their slope sites, because there simply is nothing available nearer home.

How best, then, to go about finding a slope soaring site? First and foremost, one should make enquiries locally. Your local model shop proprietor may be able to tell you where the nearest site is. If not, he should at least be able to put you in touch with the secretary of the local club. If that worthy says they have no slope soaring members, then you will, in all probability, have to start looking further afield than you might expect to have to go for power flying.

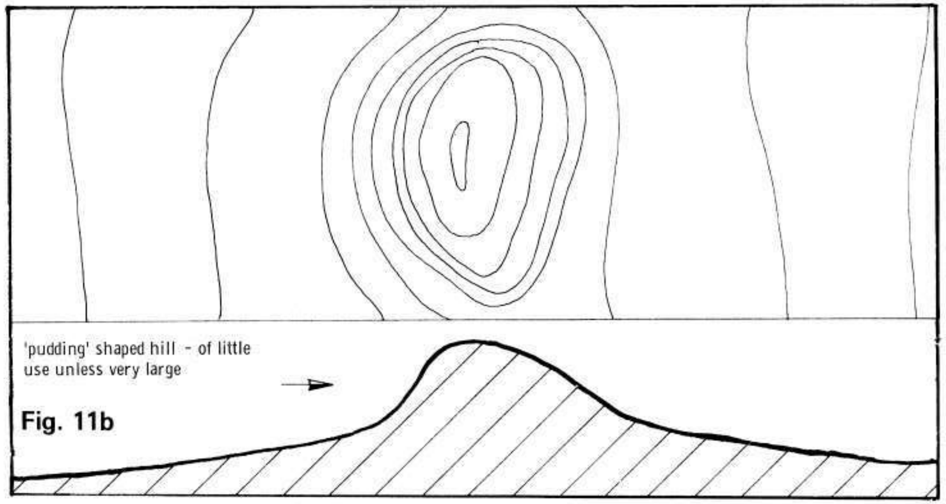
If there *is* a club, or group of people who regularly soar in a certain locality, then you should first make contact with them. It is only courtesy to do this, apart from being commonsense, to avoid possible radio interference with one another. You do not want to find yourself launching your model "just around the next hill" from the established site, or you may find that it is "shot down" by someone on the same frequency—not to mention your doing the same to someone else. For this same reason, of course, when you go to an established site, you should always make yourself known, and fly from the same area as the others. In this way you will be able to ascertain what frequencies are being used, and make sure that the other fliers are aware of yours. You will also make new friends, and learn "the ropes" much quicker.

If all your efforts to contact fellow soarers fail, and you feel you would like to see some slope soaring going on before you actually tackle it yourself, then your best plan is to arrange to go to one of the numerous contests that are held throughout the summer, the dates and venues of which are listed in the "For Your Diary" feature in *Radio Modeller.* You will also



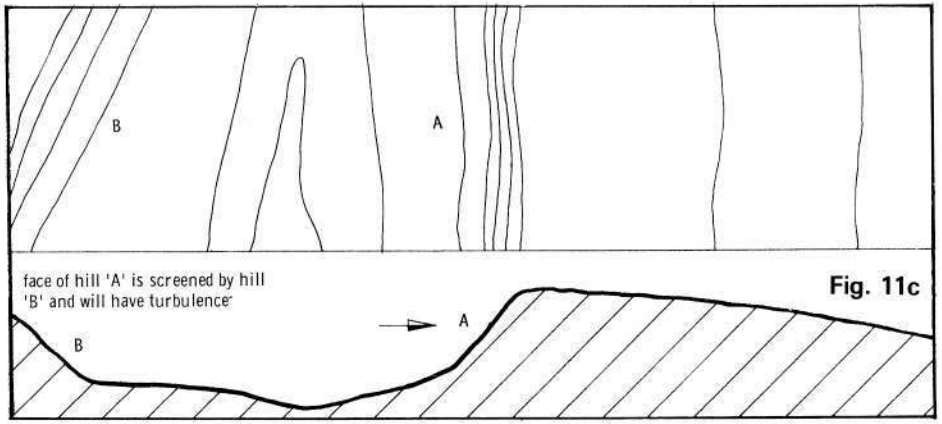
steep hill with flat top for landing - ideal

Fig. 11a



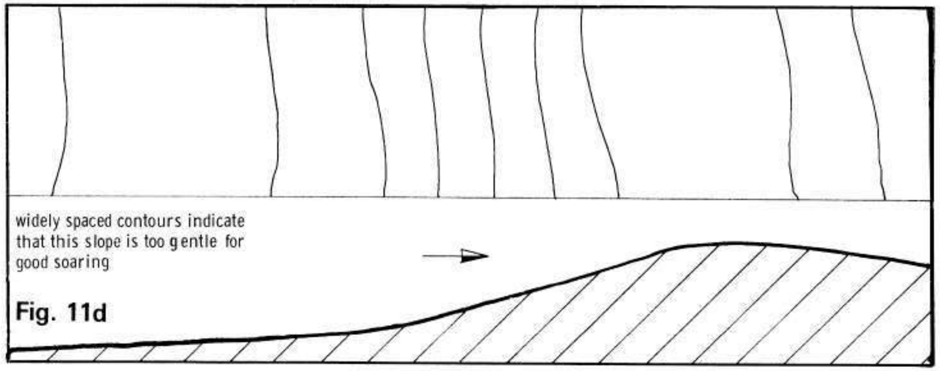
'pudding' shaped hill - of little use unless very large

Fig. 11b



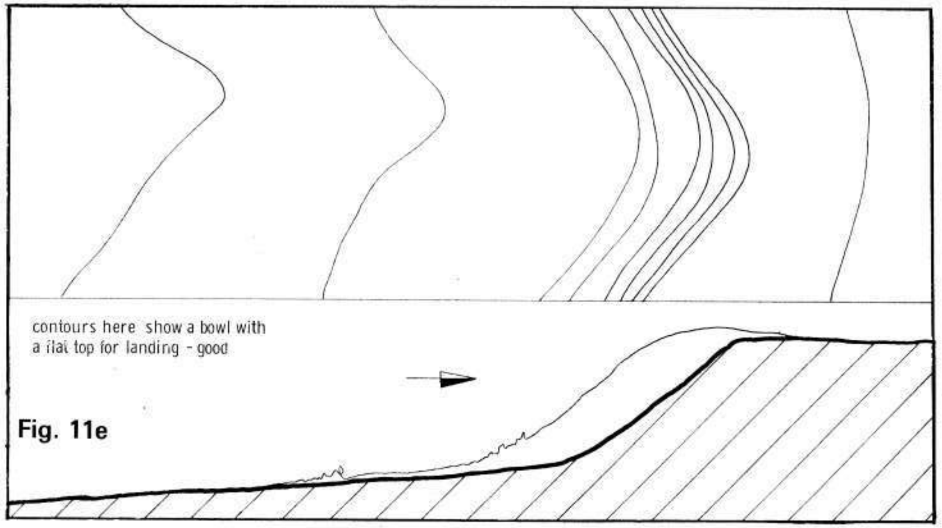
face of hill 'A' is screened by hill 'B' and will have turbulence

Fig. 11c



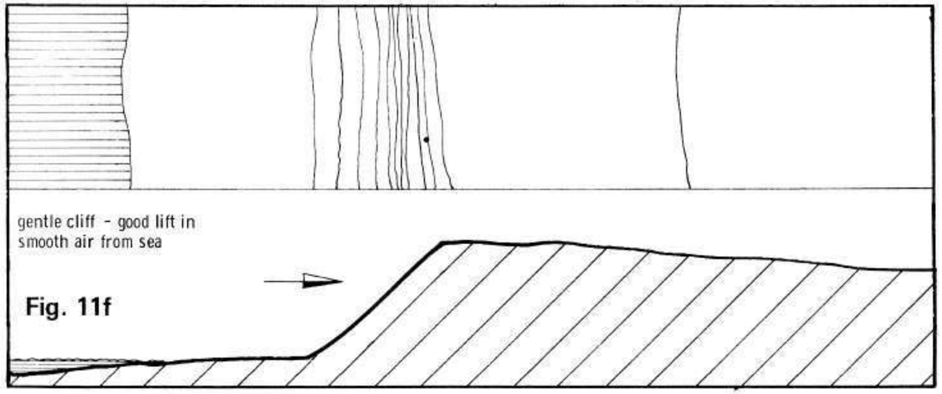
widely spaced contours indicate that this slope is too gentle for good soaring

Fig. 11d



contours here show a bowl with a flat top for landing - good

Fig. 11e



gentle cliff - good lift in smooth air from sea

Fig. 11f

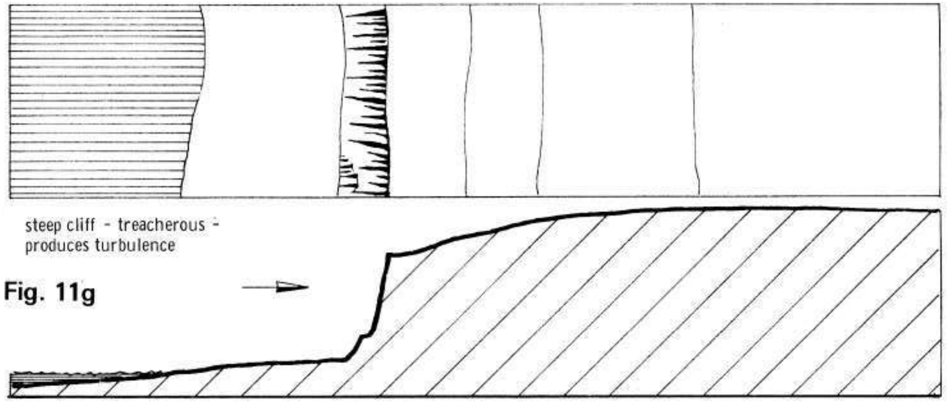


Fig. 11g

then have the opportunity of chatting to some of the participants—and perhaps finding out by this means where your nearest established site is.

However, if you live too far away from *any* of the contest sites, but still feel there ought to be some soarable slopes within a more reasonable distance, then the best plan is to obtain an Ordnance Survey map of the likely area and study the contour lines on this. Remember that you are looking for either a ridge, a hill with a more or less "flat" front face, or a bowl—and that there should not be other hills close by to windward. The contour lines should give you the general picture of the topography, and our sketches (Fig. 11a-g) show some typical formations of contour lines, together with cross-section drawings showing the sort of thing that they represent. Fig. 12 represents an imaginary hilly area, on which are shown slopes of varying steepness and direction. With reference to the Key letters on it, you will soon be able to see how to "read" your own particular Ordnance Survey map for the location of possible sites.

From the map, too, you will be able to see which direction the wind should be coming from, to make the hill "work," and if there is road or track access. Wooded areas are shown on the maps, but it is often not possible to tell from the map whether or not these will

SEARCHING FOR SITES. This is a map of a purely imaginary area, which has been drawn to include as many interesting features as possible. These would not, of course, be crammed so close together in "real life". The contours are arranged so as to show various configurations of terrain – some suitable, others unsuitable for slope soaring. The various locations indicated are as follows.

A. Sloping cliffs, with gently sloping back area. Excellent for smooth airflow from the sea. **B.** Quarry, if large, can produce lift, but often has turbulent areas which can be treacherous. If lift dies, you may have to land on the rocks! **C.** This ridge should work well, but could be tricky for landing, being rather narrow at the top. **D.** This ridge is too close, downwind, to C and will suffer from turbulence. **E.** This is an almost conical hill, so the airstream would separate and go round it. There may be a very narrow area of lift directly in front. **F.** Again, this ridge is too close to E. **G.** This area, though shown wooded, will bear investigation, as this may mean "trees" rather than "a wood". **H.** Here is a steep bowl, facing offshore winds. Should be ideal, and has only gently sloping back area. **J.** An interesting escarpment which could work well, as models should reach further wave of lift if flown high out over D and C. Landings, however, must be made well away from the road. If this is a main road, then do not risk accidents – find somewhere else. **K.** Contour lines show that this bowl is much too shallow to be worthwhile. **L.** Ridge end is no use, as airflow separates. **M.** Valley head – sharp cleft – wind has to be dead-on, otherwise severe turbulence likely. **N.** This type of ridge end will only afford limited lift. **Conclusion:** the best areas to find good lift would be **A** and **H.**

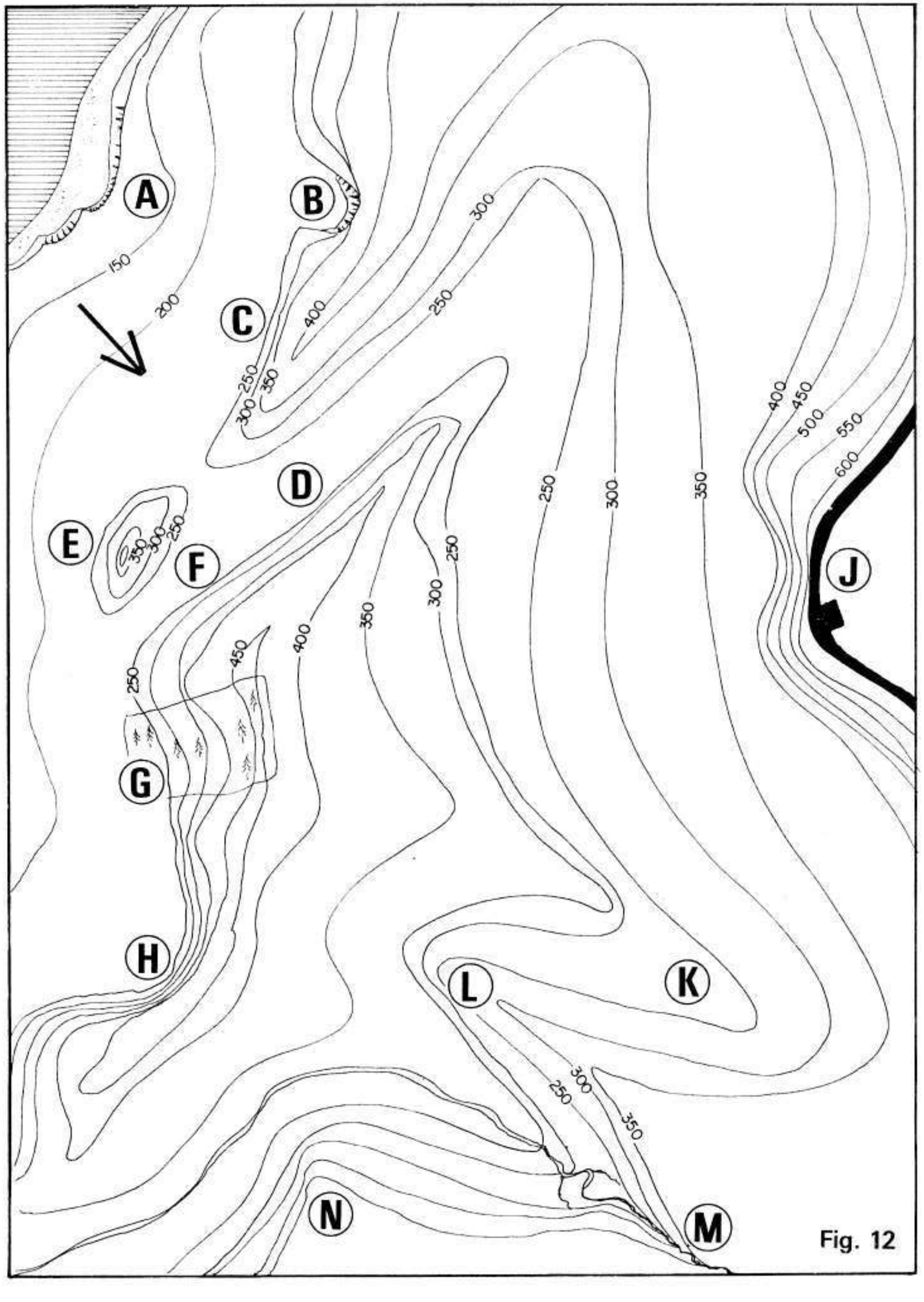


Fig. 12

interfere with flying. The map will not tell you if the area is private property, either, and these things can only be decided by a visit to the proposed site. On the other hand, a very large number of suitable sites are on National Trust land—and these areas are marked "N.T." on the map.

We have only been able, so far, to get an indication of the likelihood of a site's possibilities. The next step, having visited it and *ensured that one is not trespassing*, is to try it out for oneself. Testing out an "uncharted" site, however, can be hazardous and, strictly speaking, the beginner should learn to soar on sites that are known to produce the right conditions. With too many unknown factors, the novice will find his early days frustrating, as he will not know if—when all does not go well—it was his choice of hill, wind speed, or model that was wrong, or whether he simply made an error in flying the model. However, if everyone had soaring friends to help them and "safe" sites to learn on, there would be no need for this book! The lone hand beginners must start somewhere, so the next item to look at will be the choice of model type, and the various types of models are discussed in the next chapter.

You will be spending many enjoyable days in the countryside, and it therefore behoves you to obey the country code. Close the gates behind you. Do not leave litter—especially plastic bags, which can kill animals. Do not climb dry stone walls—use the stiles or gates. Do not let dogs chase sheep. And, if your model does crash—don't leave the wreckage all over the hillside just to prove you were there!

Having arrived at your proposed launch point, it is a good idea to spend a few minutes observing the conditions, instead of flinging your model into the air with gay abandon. See what the birds are doing. They will often be soaring from one area rather than another and, by watching them closely, you may even be able to get an idea of where the areas of strong lift—or violent turbulence—occur. If those ungainly birds, crows, are managing to soar, then the lift *must* be good; on the other hand, do not be deceived by the wily seagulls as they are past masters in the art of soaring and will be making the most of perhaps only slight lift. Nevertheless, watching *any* birds will give you some clues in helping to decide where to launch and fly your model.

CHAPTER 3

TYPES OF MODEL

THE array of different designs from which the newcomer to slope soaring has to choose may seem quite bewildering, so we will look at the main categories and their functions. It is convenient to classify radio control model types in terms of the number of controls available. Each of these categories can then be subdivided into "type" from a shape and size point of view.

We can group the types, controlwise, into *Single Channel,* (or, more correctly, *Rudder-only), Intermediate* (rudder and elevator) and *"Full House"* (ailerons, elevator and rudder). As will be seen, "full house" with soarers comprises only three functions—that is, all the controls of a full house power model except, of course, throttle. The fourth function, however, is sometimes used for such refinements as flaps, "flaperons" (variable camber aerofoils), airbrakes or spoilers.

Before we go on to look at each of these basic categories of model, it will be as well to give some attention to a consideration which is of considerable importance to both designers and fliers of slope soaring gliders—the *wing loading.*

Wing loading

Soaring enthusiasts, of both slope and thermal categories, are usually very conscious of the wing-loadings of their models. This is the relationship between the weight of a model and its wing area, and it is expressed either in ounces per square foot or, metric fashion, in grams per square decimetre. *(See the wing loading Nomogram on page 32).*

It is natural to think of large models as being heavier than small ones and, of course, this is nearly always the case, but it is not the absolute weight alone that affects the model's performance; it is the weight per unit of wing area. Thus it will be seen that we can have a small model that is highly loaded (relatively heavy for its size) or a large model that, despite a seemingly high overall weight, is really quite lightly loaded, when one considers the area of the wings that will be supporting it. Also, models can be small *and* light, or big *and* heavy.

Wing loading decides the speed at which the model will fly—and so, in turn, the speeds of wind in which it will perform best. The higher the loading, the higher the speed. Slope soarers have, in general, much higher wing loadings than thermal soarers since, as they depend on air *blowing* up a hill for their lift, rather than simply on warmer air rising, they are designed to fly in quite strong winds. For instance, a reasonable wing loading for a medium-sized slope soarer will be 14 to 16oz./sq.ft. whereas a thermal soarer of the same size will have a wing loading of only about half this.

This is, perhaps, somewhat of an over-simplification, but it will serve us well enough when thinking about sizes and weights of models generally. The subject is delved into much more deeply in a more technical, aerodynamic manner, by Fred Deudney, in his chapter, "Speed and Efficiency" later on. Suffice it to say, here, then, that the "middle of the road" figure, for our slope soarer, is 14 to 16oz./sq.ft. A slope soarer of 8oz./sq.ft. wing loading would be considered lightly loaded, and only suitable for light breezes and, at the other end of the scale, a model of 24oz./sq.ft. loading is heavily loaded, and will need "strong to gale" force winds!

Aspect-ratio

The other "technical term" which you will often see mentioned in descriptions of models—and full-size machines—is *aspect-ratio.* This is simply a way of defining whether

WING LOADING NOMOGRAM

EXAMPLE

Your 700 sq. in. model weighs 6¾ lbs. To find the loading, lay a ruler, or better still draw a line, from the 700 sq. in. point on the right-hand scale to the 6¾ lb. point on the left-hand scale. Where the ruler or line crosses the centre scale, read off the loading (in this case 22 oz. /sq. ft.).

The nomogram can also be used to find the required total weight for ballasting, by laying the ruler across the area and loading scale and reading the required weight off the left-hand scale.

In addition, each scale can be used as a conversion scale for oz. to lbs., grammes per sq. decimetre to oz. per sq. ft. and sq. in. to sq. feet respectively.

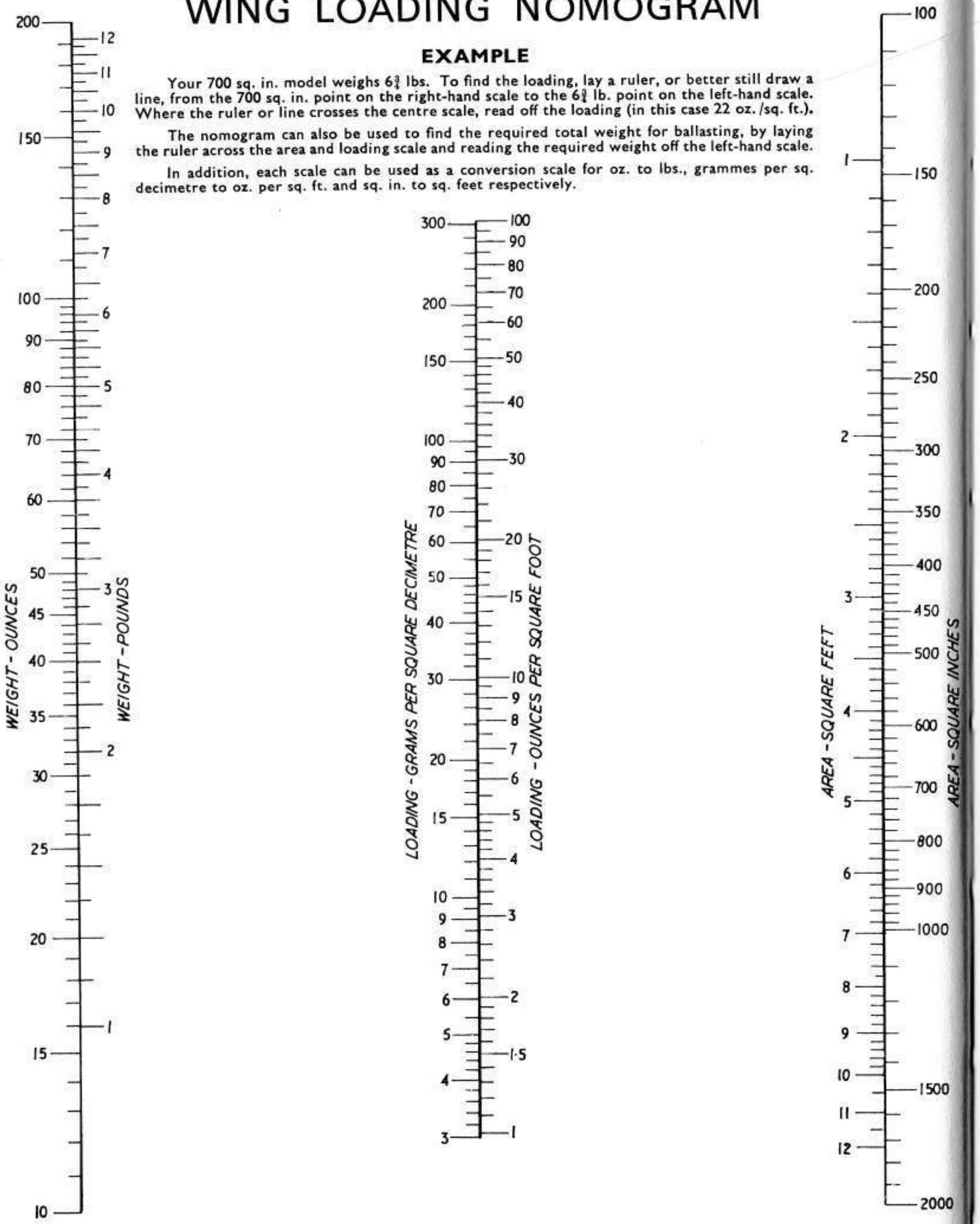
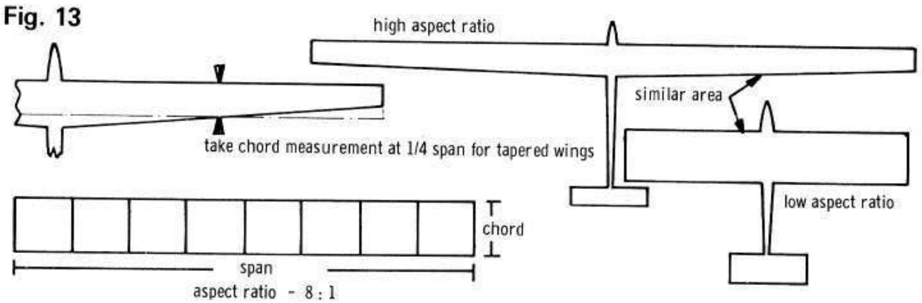


Fig. 13



the aircraft has short stubby wings or long slender ones. Arithmetically, it is the wingspan divided by the mean chord. For instance, if your model has a span of 80in. and a chord (width of the wing, from leading edge to trailing edge) of 10in., then its aspect-ratio is 8:1 ("eight to one"). We say the "mean" chord to take into account tapered wings. The diagram, Fig. 13, shows the whole thing at a glance.

Let us now take a look at each of the basic categories of model that we mentioned earlier. We will take them in turn, and see the kind of soaring of which they are capable, and the advantages and disadvantages of one type as compared to another.

Rudder-only

As with power models, the single-channel, or rudder-only models are the type that many people still choose to start with, due to the relatively low cost of the equipment. Paradoxically, however, they are, in fact, choosing one of the most difficult types of flying, since all the work of manoeuvring the model has to be done with the rudder alone. In addition, generally speaking, the conditions in which one can fly a rudder-only model are much more restricted, because trimming cannot be done in flight. When conditions change, the model can be brought down and re-trimmed—but only to a certain extent, or we upset its natural stability. Multi function models (i.e. the other two categories) can be trimmed *in flight* to cope with a very wide variety of conditions. Nevertheless, it is possible to derive a great deal of pleasure from simple rudder-only slope soarers if one is prepared to accept their limitations and wait for the right weather.

The question of size now arises. One generally thinks of rudder-only soarers as being fairly small, but this isn't necessarily the case. The larger any model, the more efficient it will be, and it is, therefore, because of practical considerations that we more often see small models being used for this purpose. This is, first of all, because single-channel radio, with its rubber driven escapements, lends itself to the smaller, lighter, types of model and, secondly, that "the larger they come, the harder they fall"—and one must expect more crashes, initially at any rate, with a rudder-only model, simply because one does not have at hand the necessary degree of control to cope with all conditions. The smaller models, too, are more agile, and responsive to the movement of the rudder, while the larger craft have more momentum and will be more sluggish in response.

The rudder-only model must be "auto-stable," and hence will need to be rigged and trimmed very much like a free-flight model. It will have a pronounced dihedral, too—and this fulfils not only the purpose of providing built-in lateral stability (as it does on the free-flight model), but also enables the model to perform a banked turn, when rudder is applied, instead of simply skidding sideways. Fig. 14 shows how the dihedral produces the banked turn effect on a typical rudder-only model.

The important point to bear in mind, with the rudder-only model, is that there is no external means of altering the pitch attitude of the model in flight. It must be rigged, therefore, to have built-in longitudinal stability of a high order. This can be adjusted, for each flight, to suit the wind velocity at the time of launch but, as we shall see in the following

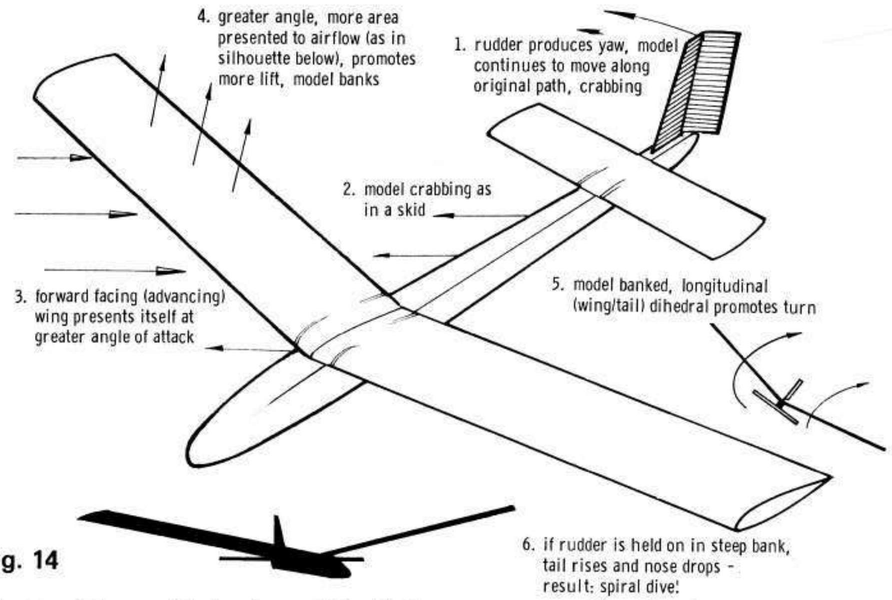


Fig. 14

chapter, this can only be done within limits or we are courting disaster.

Generally speaking*, the ideal conditions for light or medium weight rudder-only soaring are a gentle breeze of between 5 and 15 m.p.h.—steady, without gusts or turbulence, and preferably accompanied by thermal activity. If you are prepared to wait for the weather conditions to be just right, then you will be able to enjoy your rudder-only soaring, even when the heavier models are grounded through lack of wind. If you would prefer to be able to soar in a wide variety of conditions, as well as being able to manoeuvre the model much more precisely, and land in more restricted areas, then you should choose a multi-control model—either two-function (rudder/elevator) or full-house.

Intermediate

The addition of elevator control opens up a whole new world of soaring. Instead of having to re-trim his model, not only every time he goes out, but often during the course of the day, as well, the flier with elevator control—control in the *pitch* axis—can cheerfully forget most of the problems he faced with the rudder-only models' limitations. If the wind increases while he is flying, he can "feed in" a little down-trim or, if it drops, a little up-trim. (This means, aerodynamically speaking, that by the use of elevator trim, he can effectively decrease or increase the angle of attack of the model's wing, thus enabling it to fly faster or slower, as necessary). Again, of course, this is only the case within limits, and here the wing-loading of the model plays a vital part.

At the moment, however, we are concerned simply with our added elevator control. Not only does this extend the range of conditions in which the models can be flown, but the whole technique of soaring takes on a different aspect. The model can be really made to go where its pilot intends, and not just nudged in roughly the right direction. And aerobatics, of a certain kind, too, can be performed, with precision. Landings become more accurate and more satisfying. We will discuss the technique of flying intermediate models in a later chapter, however. Here we are concerned with the different types of model within this category.

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*One can only generalise here, since there are exceptions—certain rudder-only models being specifically designed for flying in high winds, but these are beyond the scope of our theme here.

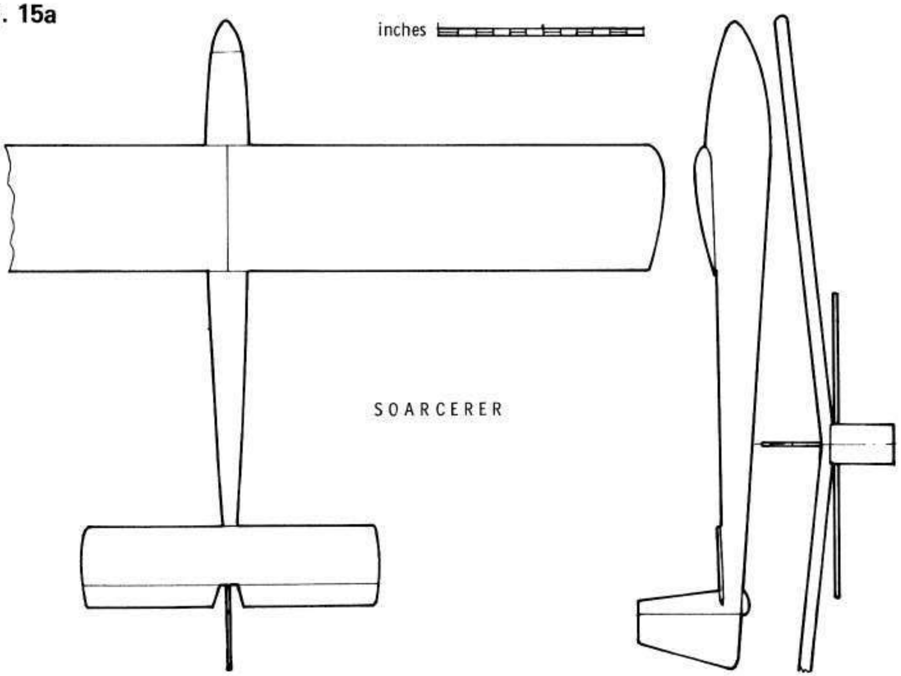
The intermediate class probably sees the widest variety of design of all, and we can roughly classify them, firstly simply into "small," "medium" and "large." Each of these can again be subdivided into "light," "medium" and "heavy," from the weight point of view, relative to size. We can then classify all these into either "functional" or "semi-scale."

The "functional" types are more compact, with relatively low aspect-ratio wings. They make the best trainers, as their very compactness enables them to withstand rough treatment better. The small and medium sizes in this class (up to, say 60in. wingspan) having less mass-inertia, are generally more responsive to the controls, and so are more manoeuvrable than the larger sizes. This means, apart from other considerations, that they can be landed in more confined spaces. The larger types, say of 7 or 8ft. span, which have considerable mass, tend to be more sluggish. Things happen more slowly: This, in a sense, makes them suited for learning with, but one has to remember that learners often "freeze" on the controls when they have done something wrong—and that any corrective action will also be slow in taking effect. Also, the landing speeds of these larger models are usually rather high, and they will need more space in which to be lined up and landed. Figs. 15a and 15b show typical small and large intermediate models.

Many of the medium and small intermediate models in the "functional" class are very like rudder-only models, in configuration. In fact, it is quite common to see rudder-only designs with elevators added. One of the best trainers has turned out to be the (originally) single-channel *Impala*, with the addition of elevator control, and it is probably safe to say that more of these models are flown as intermediate than as rudder-only machines!

The other intermediate category is the "Semi-scale" type. These are either "free-lance" designs which look something like full size sailplanes, or else "near scale" types based on a definite full-size prototype. Some of these are *very* near to scale, only departing from true scale outline, perhaps, in tail areas, and the lack of ailerons (which means they have to have more dihedral, to make the rudder turn them, as we have seen). They are thus, in nearly all

Fig. 15a



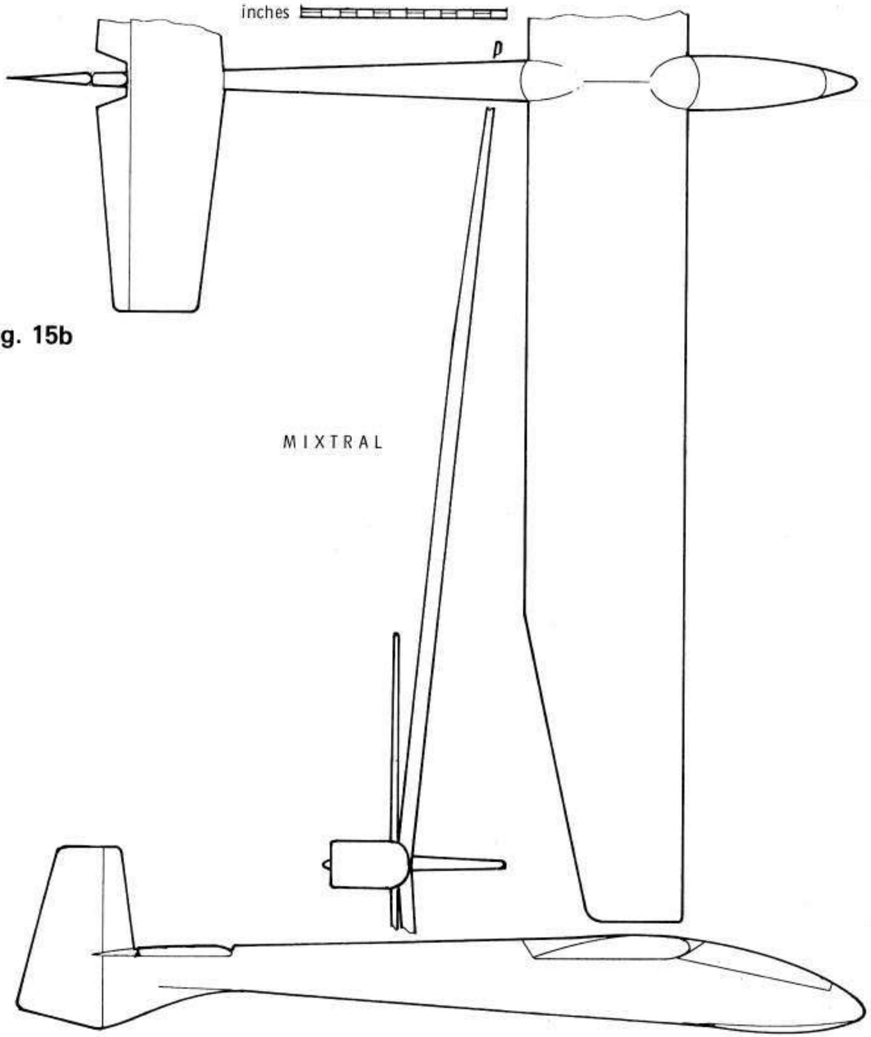


Fig. 15b

cases, elegant creations with slender, high aspect-ratio, tapering wings, and of generally pleasing line and graceful appearance in the air. Wingspans are relatively greater in this class—usually between 7ft. and 12ft. Fig. 16 shows two models typical of the breed.

Problems can, and do, arise, however, where, for the sake of appearance, the dihedral of the wings has been kept down to an "aesthetic" minimum—which often means that the rudder authority is not as great, especially when flown slowly, as one could wish. The slender, tapered wing, too, has a tendency to tip-stall if sufficient "washout" is not built in. This can result in dropping a wing very suddenly, when slowed down, so that care has to be exercised continuously to keep the flying speed up in turns and when landing—just as in full-size practice.

These, therefore, are definitely *not* models on which to attempt to learn—no matter

how appealing their appearance! However, in the hands of experienced pilots (who are used to anticipating control requirements in order to obtain the desired response at the right moment), they make very pleasant models, and are usually very efficient, soaring to great heights with ease, and are a joy to watch in the air. Many of these models would be much improved, from the control point of view, by the addition of ailerons—but that, of course, takes them into the "Full House" category, which we are now about to consider.

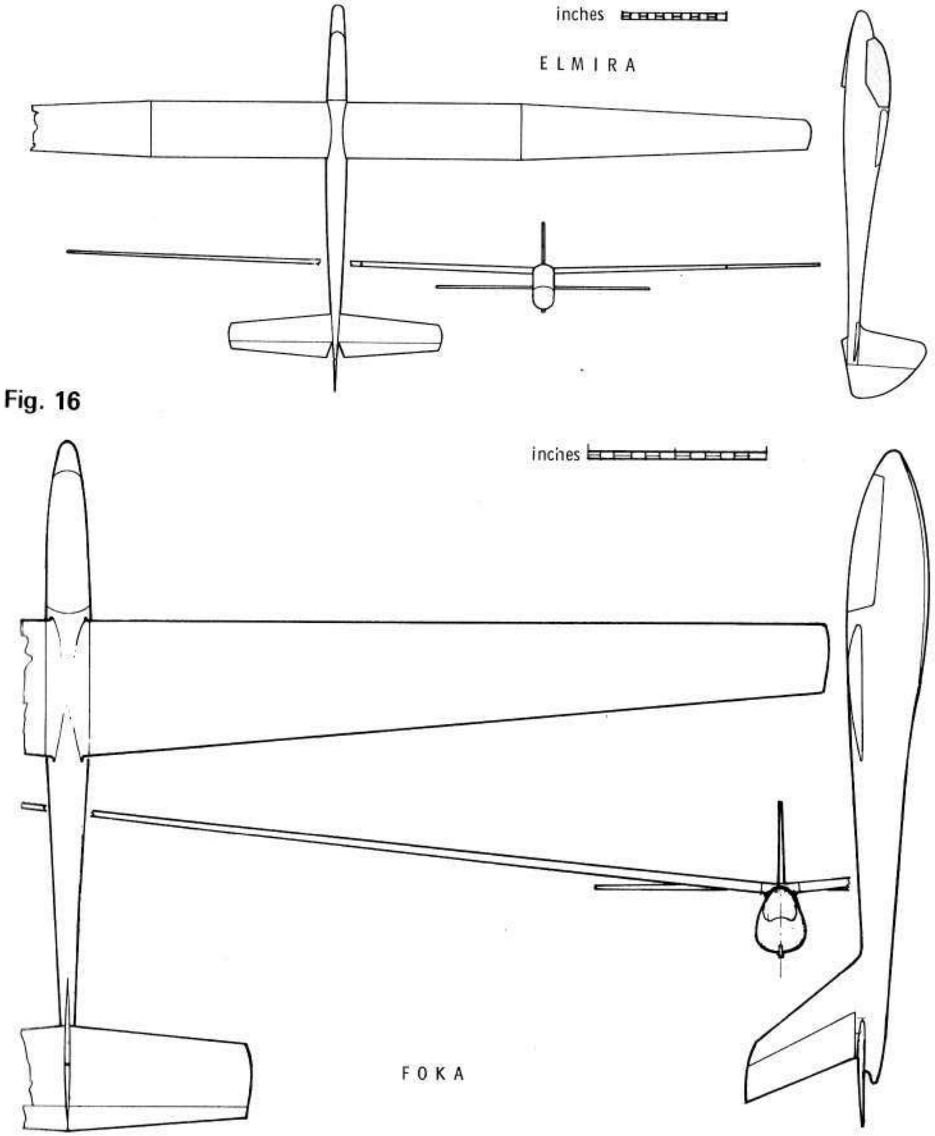
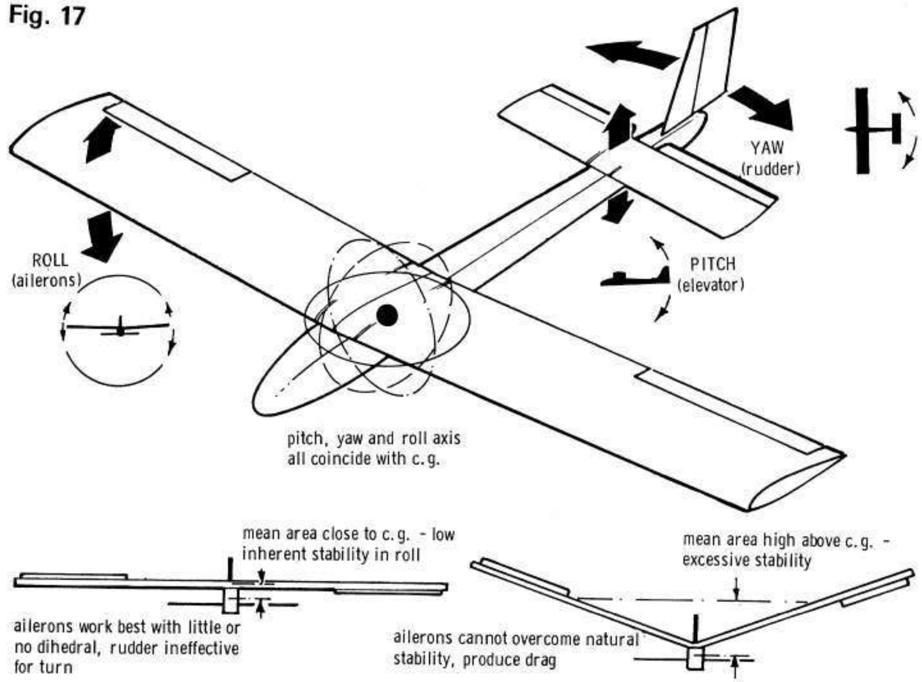


Fig. 16

Fig. 17

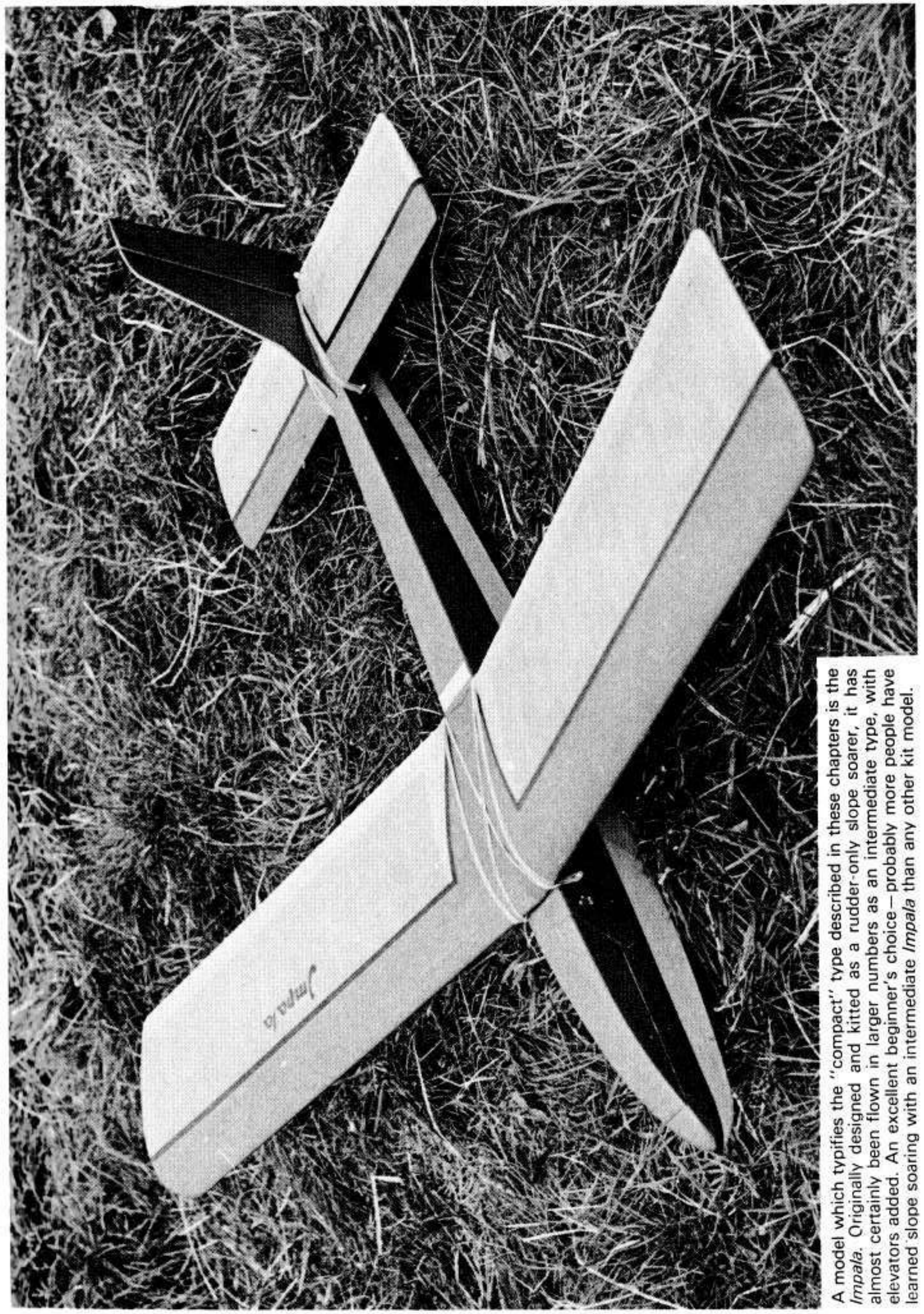


Full-house

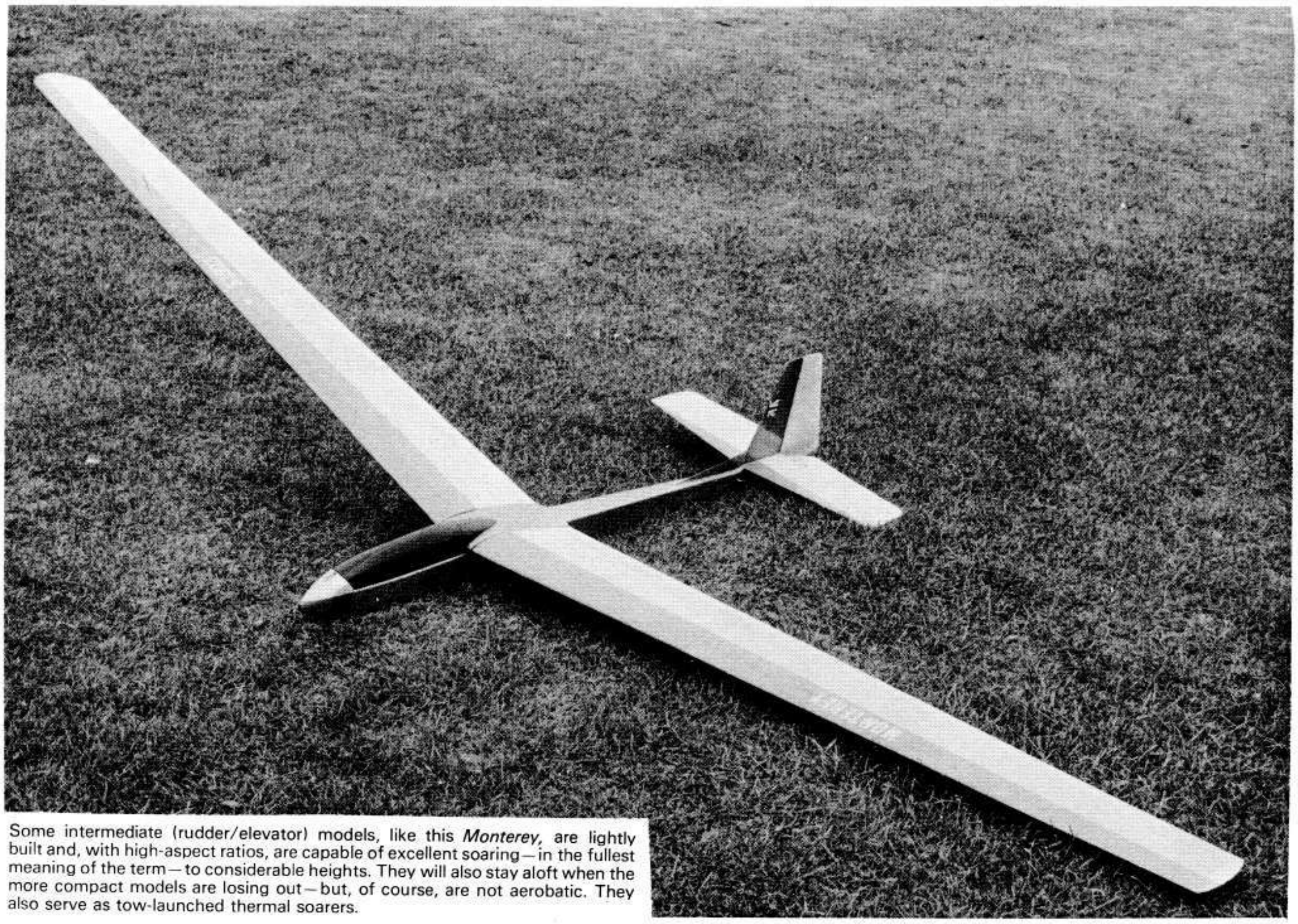
This is, of course, the *smoothest* form of flying, since the pilot has control of his model in all three axes—pitch, roll and yaw—with elevator, ailerons and rudder respectively (see Fig. 17). The ailerons enable axial rolls to be performed (as distinct from the "barrel" rolls of the intermediate model). and also really tight "pylon" turns with the model banked vertically. But, before discussing the actual flying any further, let us once again see the different types of model in this "full-house" category. These fall basically into two groups, the "aerobatic" and the "semi-scale or scale." (The latter are really two classes, of course, but can be grouped together here for our purpose, from the point of view of general attributes and the type of flying that is done with them).

Although we will deal with flying more fully in the appropriate chapter, we must discuss it to some extent in this connection, since it is the way that the models are flown, and what is demanded of them, that have produced our first sub-division—the "aerobatic" model. The fully aerobatic slope soarer is a type of glider which has been unique to Great Britain for some years, although other countries are now beginning to favour this sort of model to some degree. The reason for its development is, in all probability, the fact that there have been more contest days when the winds have been strong (20-40 m.p.h.) than otherwise. It is certainly contests that have dictated the requirements of the aerobatic model, which is, of course, in its element in conditions of strong slope lift.

Originally, once it was established that there was no longer any contest value in "pure duration," all slope contests became "speed" events, in which the fliers drove their models as fast as they could between two flags, or flagmen, stationed along the ridge. The model completing the greatest number of laps in a given time was the winner. This applied to both "single" and "multi" (the latter, in those days, being what we now call "intermediate"). Then someone added some loops, and so started the "aerobatic" class.



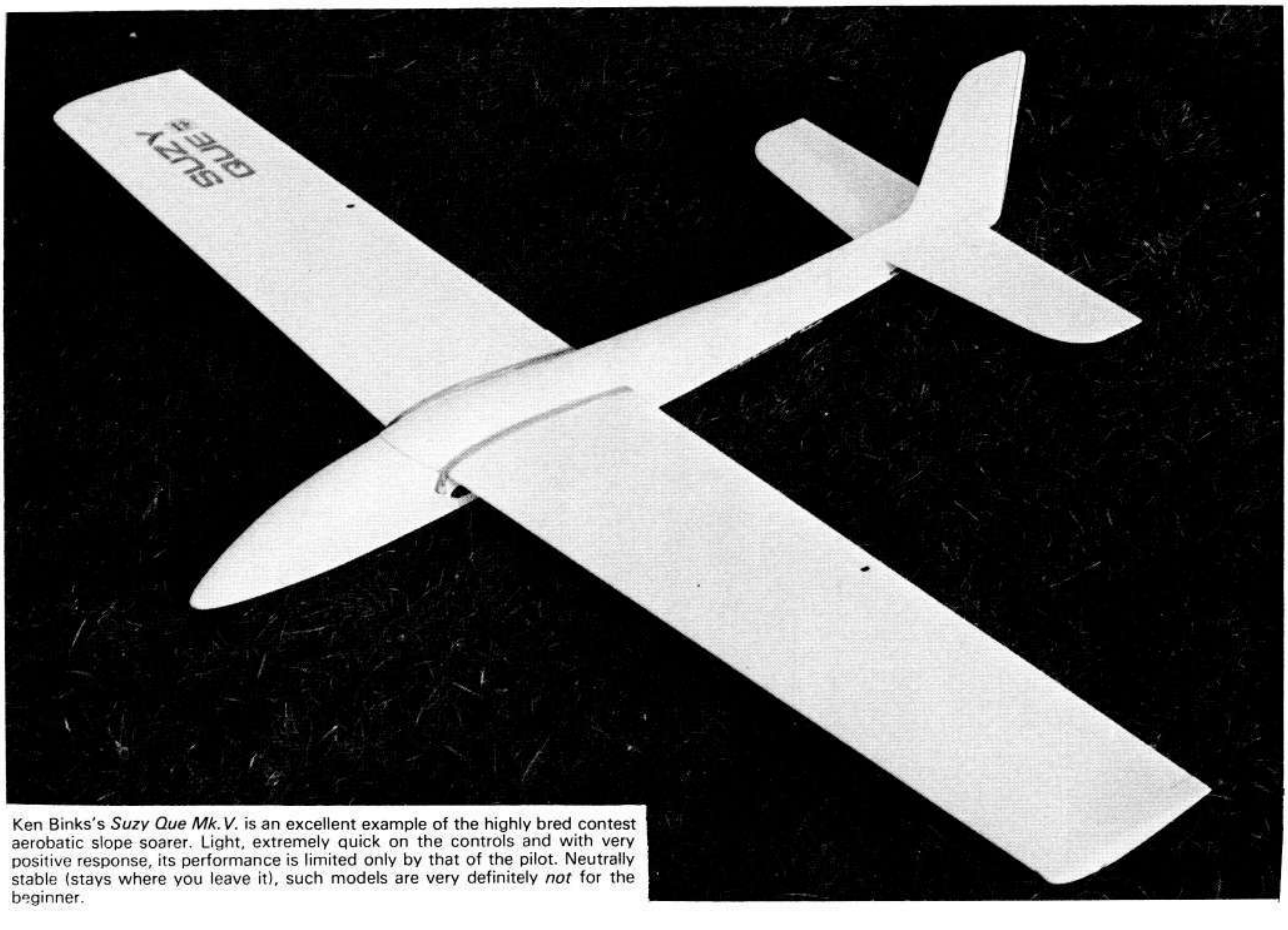
A model which typifies the "compact" type described in these chapters is the *Impala*. Originally designed and kitted as a rudder-only slope soarer, it has almost certainly been flown in larger numbers as an intermediate type, with elevators added. An excellent beginner's choice—probably more people have learned slope soaring with an intermediate *Impala* than any other kit model.



Some intermediate (rudder/elevator) models, like this *Monterey,* are lightly built and, with high-aspect ratios, are capable of excellent soaring—in the fullest meaning of the term—to considerable heights. They will also stay aloft when the more compact models are losing out—but, of course, are not aerobatic. They also serve as tow-launched thermal soarers.

Here we have a full-house sport/aerobatic model, of T-tail configuration, and quite elegant lines. The ailerons are of the "strip" type, with the hinge-lines sealed and thus not visible. The model, which has a 72in. wingspan, weighs 43 oz. and is fitted with a removable pylon and . 049 engine. *(See Chapter 17—The Power Assisted Glider.)*

A good example of a model developed specially for pylon racing. The V-tail has elevator action only (it is all-flying) for simplicity, as rudder manoeuvres are not required for racing. Here the pilot (clad for wind and weather!) holds his model to give an idea of its size.



Ken Binks's *Suzy Que Mk.V.* is an excellent example of the highly bred contest aerobatic slope soarer. Light, extremely quick on the controls and with very positive response, its performance is limited only by that of the pilot. Neutrally stable (stays where you leave it), such models are very definitely *not* for the beginner.

When sufficiently experienced in building and flying sport and aerobatic models, the scale model glider or sailplane presents a worthwhile challenge. Even if this is your sole aim, however, you should force yourself to build and fly some non-scale knock-about models and *learn to fly them.* Otherwise there are disappointments ahead.

The pictures show: Top left, *Pirat,* 148in. span. Right: Slingsby T53, to 1/7½ scale. Centre left: Slingsby T31, *Tandem Tutor* at 1/5 scale. Right: Kirby *Prefect* to same scale. Bottom left: HP14c, also at 1/5 scale, spanning 141¾in. Right: T21 *Sedburgh,* again to the popular 1/5 scale, which gives a model large enough to have realistic flight characteristics.

At first, once this was established as a distinct class, the requirements were still relatively simple, calling for consecutive loops, stall turns, and, perhaps, a spot landing. The more daring organisers added rolls and spins to their contest schedules. After this, the rolls were required to be more axial, and inverted flight was required. This is where ailerons became a necessity, and aspect-ratios became lower. (The lower the aspect-ratio, the greater the roll rate and, therefore, the better the chance of completing two or three consecutive rolls in the relatively restricted space afforded by the lift area or the length of the ridge used).

The rudder/elevator models (or, at any rate, some of them) could be made to remain inverted for short periods, but it was usually a losing battle, and the model's course was very erratic, due to the way in which the models had to be flown in order to stay inverted at all—very much a case of the tail wagging the dog—or, at any rate, the plane flying the pilot!

Ailerons changed all this, allowing sustained controlled inverted flight, and consecutive axial rolls, as well as much greater general manoeuvrability, tighter turns and easier landings in any sort of conditions, on any sort of terrain. Once the increased scope, aerobatically, of the aileron-equipped model began to be appreciated, the requirements became more stringent, the inverted circle and outside loops appearing in the schedules, to the consternation of most fliers of the time! At this point, much more attention was paid to aerofoil sections, and the use of fully, or nearly fully, symmetrical sections became widespread, thus rendering possible virtually unlimited inverted flight and consecutive outside loops—and, in fact many of the figures from the power flying schedule.

While most three-function compact type models are described as "aerobatic," the label "*fully* aerobatic" is usually reserved for those in this latter category—that is, those capable (in "good" conditions—say, steady winds of 15 m.p.h. upwards) of prolonged inverted figures (in other words, fully controlled inverted flight) and consecutive outside loops. Such additions as four-point rolls, "top hat" and "avalanche" manoeuvres are sometimes thrown in, for good measure, in contests where certain manoeuvres may be selected by the entrants.

Fig. 18a

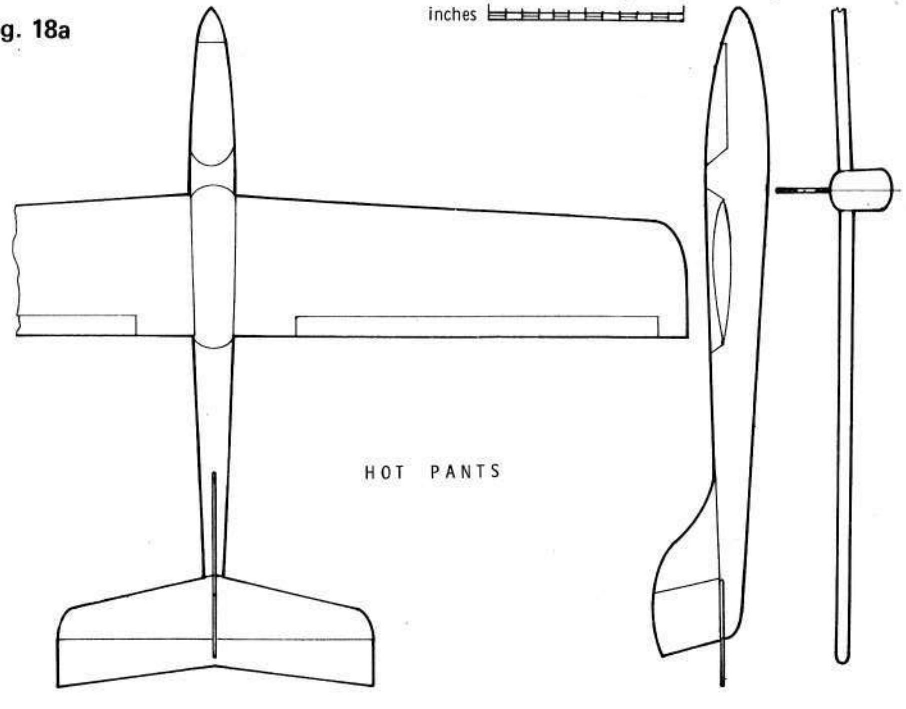
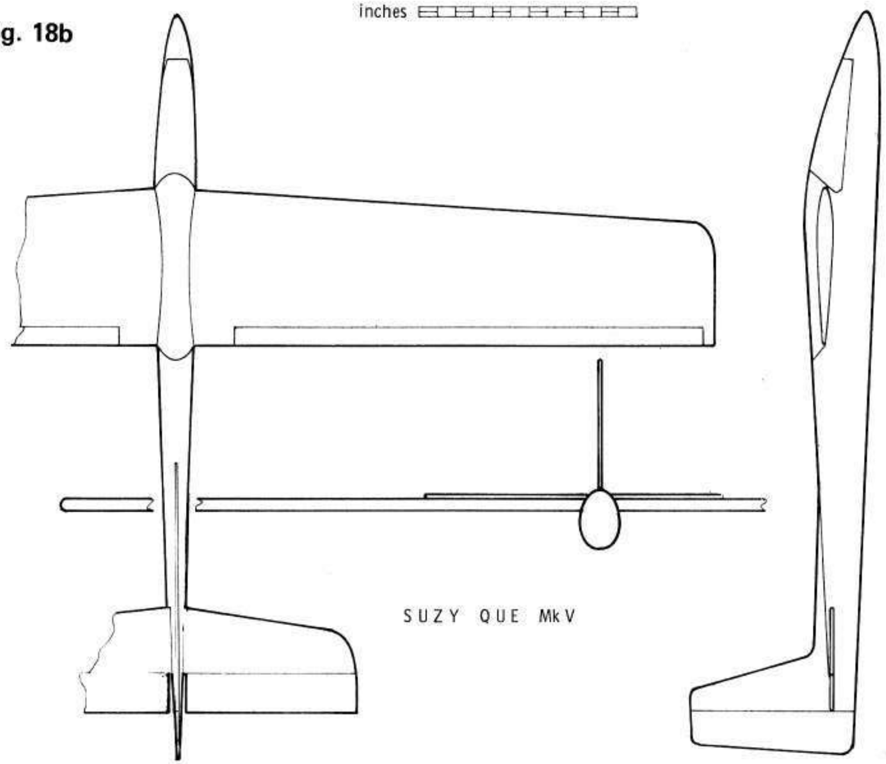


Fig. 18b



Details of these, and of aerobatic contest flying techniques, are included in the relevant chapter, later on.

Our full-house aerobatic model, then, will tend to look something like those shown in Fig. 18. It will have a fairly low aspect-ratio, a shoulder-wing, or almost mid-wing position, little or no dihedral, ailerons (usually of the "strip" type) and lines, in general, as sleek and functionally streamlined as possible. In order to be able to do very tight manoeuvres, and cope with sudden changes of attitude, it is also built as lightly as possible. (Remember, here, that the heavier the model, the greater its momentum and inertia—and thus its resistance to any change of attitude, and the slower its response to aerodynamic control surfaces.) In general, the wingspan of our aerobatic contest model will be between 50in. and 72in. After enjoying a period of popularity, the smaller types have tended to give way to those at the other end of the scale, as the models are smoother flying and can usually cope better with stronger winds.

Such models, however, although they often have a surprisingly wide speed range, do sometimes find themselves "losing out" when the wind velocity drops, say, below about 10 m.p.h. Here the "converted" (i.e. ailerons added) intermediate model may have some advantage. With its (usually) flat-bottomed aerofoil section, it makes better use of the available lift, and can often maintain or gain height better than the fully aerobatic, symmetrical sectioned, model, thus being in a position to perform at least some of the manoeuvres required, whereas the other type is requiring all its pilot's skill and attention to stay airborne at all. The keener contest man, having observed this on a few occasions, usually now carries two or more wings, with different aerofoil sections, to be used in different conditions, thus enabling him to get the best performance from his model under any given set of conditions.

This may seem, to the reader, to be becoming too much the slave of specialisation—but aerobatic contest flying is, by definition, a very specialised branch of soaring, bringing with it these specialised model designs. A variation of the "alternative wing" approach, has been the experimentation with *variable camber aerofoils,* to enable a "drooped trailing edge" to be used for increasing the lifting properties of a normally symmetrical section wing, to gain height. At the neutral position the aerofoil resumes its symmetrical section, while a further movement of the control gives a "reflex" section, to provide extra lift when the model is inverted (see Fig. 19). When incorporated with a strip-aileron system, this becomes known as the "flaperon" since the ailerons then work partly as flap and partly as aileron.

The other piece of specialisation on aerobatic models is the use of interconnected flap (or flaperon) and elevator. By arranging for the wing flap to move upwards when the elevator is moved downwards, and *vice-versa,* the lift co-efficient of the wing is increased at the very moment the most demand is put on it, and models so equipped are capable of very small diameter loops, and very tight turns. Thus, they are tending to be used on *pylon racing* models—yet another form of specialised model, but grouped under "aerobatic" at the beginning of this chapter, for the sake of conciseness.

The pylon race soarer is the latest arrival on the scene, having been developed from the aerobatic soarers which have been used for pylon racing for several years now. Once more the will to win has led keen modellers to develop a specialised craft. The pylon racer is built for speed, with sleek lines, thin wings and often a vee or "butterfly" tail. It is usually rather larger than the average aerobatic model, having a higher aspect-ratio wing. A typical pylon racing slope soarer is shown in Fig. 20. Two-function equipment is often used, rudder being unnecessary. These exciting models, as well as their special equipment—coupled flaps and elevators, and v-tail linkages—are discussed more fully in Chapter 8, as are pylon race flying and tactics.

The remaining category for us to describe here is the "semi-scale or scale" type. Here,

Fig. 19

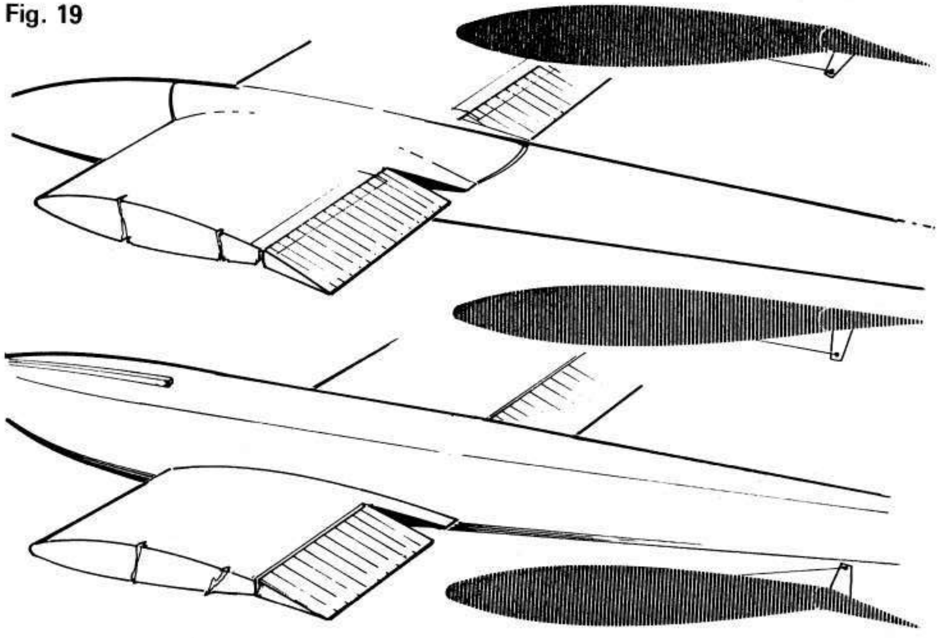


Fig. 20

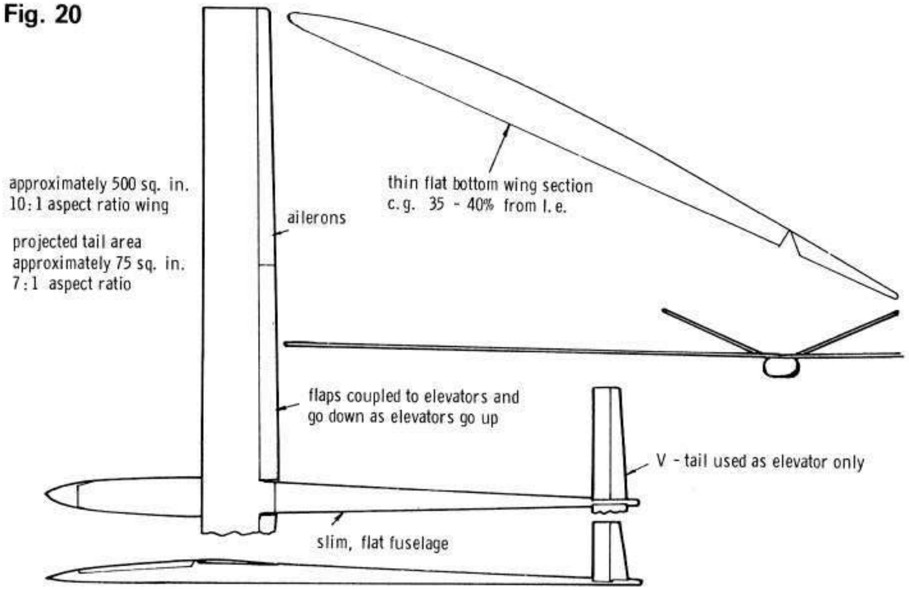
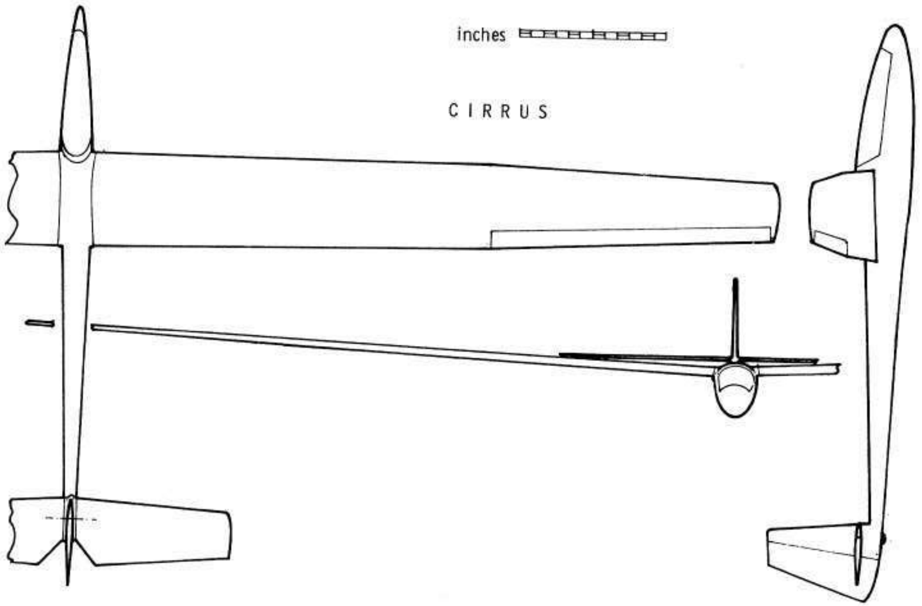


Fig. 21



as with the intermediate, we have the free-lance but realistic looking model, with a high aspect-ratio—sometimes as great as 18:1 or even 20:1 and wingspans of 8 to 12ft. They will (by definition, under our "full-house" heading) have ailerons, elevator and rudder control, and sometimes spoilers or airbrakes, worked by a fourth servo, for increasing the sink rate for landing. (We will be looking more closely at these interesting and useful devices later on). The scope for the free-lance semi-scale designer, then, is a very wide one—the limits only being the designer's imagination, constructional ability and design experience, coupled with a sense of what "looks realistic."

After the free-lance design types, we come again—as with our intermediate class—to the "near-scale" models which are actually named after the full-size prototypes they represent. Names such as the *Skylark, Dart* or *Kestrel* spring to mind, as well as that of the aileron version of the *Cirrus* (Fig. 21). Usually, the designers of both free-lance and near-scale types of model will have made certain concessions to "practicality," in terms of detail—wings and tailplane held in place with the traditional rubber bands, and so on, or with "knock-off" fixings by the "tongue and box" method.

The near-scale types are, as we have said, based on full-size sailplanes, it being largely a matter of the designer's opinion (or conscience!) just *how* near to true scale the outlines are. If we look at the drawings of the full-size *Dart 17,* for instance, we realise (if we have any aeromodelling experience at all) that it would take a brave man indeed to attempt to fly a model with that tiny (one might say almost non-existent!) tailplane. But full-size designs vary a great deal, and a careful choice of prototype will mean less departures from scale.

The performance of both the semi-scale and near-scale type of model is measured not in terms of aerobatic prowess (usually limited to loops and stall-turns, and perhaps spins) but of sheer *soaring* ability. With their flat-bottomed, or even undercambered wing sections and efficient, high aspect-ratio wings, they gain height very quickly in anything like respectable conditions. They are often quite highly loaded and fast-flying, and so have the facility of "penetrating" the wind, as well as using the slightest upward component to gain height, so moving well out and away from the slope face, unlike the more compact, "functional" models which tend to stay relatively close in.

It is interesting, when there are a variety of models being flown together in good* conditions, to note that each model seems to have its own particular "ceiling." That is, a certain height beyond which it is reluctant to go. One invariably finds, at such times, that it is the slender, elegant high-aspect-ratio semi-scale or near-scale craft that is by far the highest. So, in terms of pure soaring efficiency, if that is what we want, we find it pays to emulate full-size configurations of modern high-performance sailplanes.

There are no competitions for "height gain" (though several methods of measuring altitude have been put forward) but, as we shall see in more detail later, there are "Cross-Country" events, and the prime requirement of these is the ability to gain height as quickly as possible, coupled with fast-flying when needed. So, as one might guess from the foregoing, this is where the semi-scale and near-scale type of models come into their own. Let it be said here, however, that there is a case for using the two-function, intermediate class of model for this type of event, since, with its generous dihedral, and all-round inherent stability, it has to be "flown" less by the pilot, who can often leave it to its own devices for relatively long periods, while paying attention to where he himself is going, over rough terrain.

As we have seen, when a model is designed for control with ailerons, the dihedral angle of the wings does not have to be so great (indeed, *must* not be so great, or the ailerons will have to fight the "centralising" stabilising effect of the dihedral) and our full-house semi-scale and near-scale models will look even more realistic because of this. The flying technique for such models also more closely approaches that of the full-size craft, in that instead of turning simply by applying, firstly, aileron to "bank" the model and then elevator to tighten the turn, we now have co-ordination of aileron *and rudder* with elevator. This

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*"Good conditions" for pleasant slope soaring with intermediate or full-house models usually mean: a steady wind (not blustery) of 15-20 m.p.h. blowing directly onto the face of the slope. If the wind is less than this—say about 10 m.p.h. then some thermal activity will help to make conditions interesting.

produces smooth, gracefully realistic, turns, which further add to the realism of these beautiful machines in flight.

At the risk of digressing, it must, for the sake of accuracy, be pointed out here that some advanced aerobatic fliers also use the co-ordinated rudder/aileron turn technique in certain circumstances, as we shall see later. However, whereas in aerobatic and general three-function flying it is the exception rather than the rule, the reverse is the case with the type of model we are now discussing; these *can* be turned using aileron and elevator only, but much more efficient and pleasing turns result from the correct use of all three controls. We will discuss the technique later on, when more fully discussing the actual flying of the models, whereas up to now we have only touched on this, when it has been relevant to our discussion of different model types.

Our final model type, in the full-house control category, is the fully-fledged scale model. These are relatively rare, but are now being built in increasing numbers, as the "pioneers," as it were, demonstrate that—as with power—such models really can be practical fliers. Indeed, the flying of scale models is really very much akin to that of flying the near-scale types, except that in many cases it is more critical, due to the marginal stability reserves of the scale-outline tailplane, or the easily stalled highly tapered, narrow-chord, wings.

Flying surfaces have to be fitted either in a scale manner (perhaps with functional, load-bearing struts, where applicable) or, at any rate, by some concealed means, such as faired-over nylon bolts. Not a rubber band must be seen! All this, of course, means that scale models have to be landed in a very "scale" manner or they will inevitably sustain damage. With that sort of rigid wing fixing, one does not get a second chance, and one cannot expect to get away with digging in a wingtip on landing, any more than could the full size glider pilot.

In short, the "pukka" scale model sailplane is for only the very experienced—at both building and flying! Those who aspire to the scale model would be wise to serve a full apprenticeship to the other types first. This being so, it is not proposed to discuss the design or flying of scale gliders since, by the time the modeller feels equipped to embark on such a project, he will have formed his own ideas on the subject. Illustrations of some excellent examples, however, are to be seen amongst our photographs, which may be a source of inspiration, when the time comes.

Choice of model

This is such an individual and personal matter that it is very difficult to generalise. Our best plan, therefore, is first to decide on the situation, as it were, of the person making the choice. The model chosen to commence one's soaring career will be different for different individuals, depending largely on their existing modelling experience, and r/c flying experience. It can also depend, to some extent, on the soaring site on which it is intended to make one's first flights.

If we had to be pinned down, so to say, to advise on the best *all-round* type of model to commence with, then our choice would undoubtedly be the two-function (rudder/elevator) "compact functional" type we have described. It is simple, ruggedly constructed to take the inevitable bumps and thumps to which the beginner will subject it and, being compact, manoeuvrable enough to be "set down" almost anywhere.

It may be, however, that you are determined to start with a rudder-only model—perhaps because you already have some single-channel equipment, or that you don't yet wish to commit yourself to the expense of anything more sophisticated. Then your choice of model is between the lightweight and medium weight rudder-only types. What about the lightweight? This is, given the right conditions, probably the safest and most pleasurable sort of rudder-only slope soaring—where the model "floats" around, slowly and gently, and can be merely "nudged" in the right direction, from time to time, in a relaxed, unhurried manner. Will you have the patience, though, to wait for the right sort of conditions for this sort of thing? There should only be a gentle breeze (say 5-10 m.p.h.) for the lightweight, so that you can make your initial flights with the best possible chance of success—plenty of time to make decisions, and to be able to land the model without its being blown away "over the back" of the hill or ridge.

You may feel, on the other hand, that—British weather being what it is—you will need a model for stronger winds, if you are going to be able to soar on more than half-a-dozen weekends in a year. Winds of, say, 15-20 m.p.h. Then your choice must be the heavier, more ruggedly constructed, compact type model. Don't forget, however, that in windier weather the model will be travelling faster—especially downwind—and so decisions have to be made quicker. And, if the wrong decision is made—the model hits mother earth that much harder! The keen rudder-only man will have *both* types of model, of course, which can save much frustration.

Do not be tempted to try using, say, the larger two-function semi-scale type of model on rudder-only. It may look nice, and "like the real thing," but it is not likely to survive long when the beginner attempts to make it perform on less control-functions than it was designed for! With the rugged, compact, rudder-only model, however, it *will* be possible later on, to add elevator, should you decide to invest in some more sophisticated equipment. You will then have the added advantage of flying a model you already have the feel of, with that enormous bonus of being able to point the nose up or down at will.

We have already given our choice of the two-function compact, functional type as the best all-round choice for *any* type of beginner—and by this we mean either for the complete beginner to radio control flying, or simply to the soaring branch of the hobby. Even those who fly full-house power models would be well advised to start their soaring on the rudder/elevator model. This is not only because it can usually be flown in a wider range of conditions than the pure aerobatic model, but also because of its built-in self-righting properties—"inherent stability"—so that it will usually "sort itself out" on its own (given sufficient height, of course!) if the pilot gets into difficulties.

If you are already an accomplished aerobatic power flier and you intend concentrating on aerobatic soarers, then you *could* take the short cut of building one of this type to start with—but preferably not unless you have an experienced soaring friend who will stand by to take over in case you should get into trouble. By this we do not mean that you should have much trouble in actually piloting the model, for this will be second nature to you—except for the all-important difference that you have no engine to make it climb, should you manage to get it too low down. You have to find *lift*, and this is where there is no substitute for experience! By careful coaxing, and what almost amounts to a sixth-sense, that the veteran soarer develops, he will very often be able to find sufficient lift, even when the model seems to be a long way down towards the foot of the hill, to be able to salvage a situation which would have meant either a long walk or a broken model—and very likely both—for the newcomer to the slope. This is what soaring is all about, of course, but like anything else that is worthwhile doing, it can only be achieved by much practice and experience, so it is wise to give oneself the best possible chance by not attempting to run before one can walk, as the saying goes.

If you are a beginner to radio control, as well as to slope soaring, then the aerobatic type of model is definitely out of the question—even if you have an experienced aerobatic soarer at your elbow. It flies fast, is very sensitive to small control movements, and has to be "flown all the time," as it were. Moreover, it is neutrally stable. That is to say, instead of having self-righting properties, it tends to stay in whatever attitude the pilot leaves it. Beginners often "freeze" on the controls, and things can happen far too fast for even the most experienced tutor to salvage the situation with this advanced type of model. So, even if your ultimate aim is aerobatic soaring, you must put quite a number of flying hours in, "solo," with an intermediate model first. Any other course will lead to very early discouragement by way of "using up" a large number of models in very short order.

What about the large, heavy, sluggish intermediate model, mentioned in our survey of model types? Would this, you may ask, perhaps suit me better than the smaller type? Don't be misled by the word "sluggish." We have explained that this means sluggish in response to the controls, not in actual flying speed, and that one has to *anticipate*—to apply rudder an appreciable time before it begins to take effect, and to neutralise some moments before it is headed quite in the direction desired. Rather like steering a slow-moving, heavily loaded, boat, in fact. Such models, having considerable "mass," tend to have a high landing speed. They may *look* slow-flying when high in the air, simply because of their size, but it is when they are approaching the ground that one realises their actual speed.

Like our ponderous boat again, they take more space to stop than the lighter craft; they "steam" in and need to be well lined up and have an unobstructed approach. You should not choose a model like this unless you have a good flat landing area (the "plateau" type) which is not frequented by crowds of ramblers or spectators. Once committed for a landing, "avoiding-action" with this type of model is very difficult to take.

If you have a soaring friend with this class of model, however, try to persuade him to let you take over the controls for a brief period, while it is well up in the blue. This is by far the best way of learning! And, if your friend is agreeable, you can then extend these periods until you really have the feel of the model. If you can then use your powers of persuasion on another soarer with the other class of machine, you'll be able to compare the two types, and decide which you will feel more in tune with. But there!—we're begging the question again. We must come back to earth and assume that you are going to "go it alone" from scratch.

We are going to discuss the actual flying of the models, in the following chapters, so we will now assume that, one way or another, you have made your choice of model, and have built it, either from kit or plan. We will be discussing the flying of the rudder-only soarer first, but would advise the owners of multi-function equipment *not* to "skip" this chapter, since there will be a number of basic things to be learned, which will be applicable to all types of slope soaring.

Before setting out for the slopes, it will be as well to know what sort of clothing you should take—it can be quite cold standing in a breeze at the top of a hill, even in the summer. Some hints are given in Appendix III, "Clothing and equipment," towards the end of this book.

CHAPTER 4

RUDDER-ONLY SOARING

General principles. Manoeuvres. Landing.

LET us now assume that the reader has built his rudder-only model, and has made sure that the centre of gravity (c.g. for short) is in the correct place as shown on the plan, and that there are no warps in the flying surfaces. In the case of the light and medium weight models, a gentle hand launch on any piece of open ground near home will serve to check the overall trim, before starting out for the hills. It is safer to leave the larger models to be launched from the slope, as it may not be possible to launch them at their correct flying speed over flat ground.

The actual wind speeds at which a particular model will soar best, depend on both the model and the hill itself, so here we can only take a "typical" example. Let us assume that we have a medium sized model, with a wing-loading of between 10 and 12oz./sq.ft., and that the wind is blowing nicely onto the face of the slope at between 10 and 15 m.p.h.

Now, before launching the model, we must look first at the possible landing areas. Many an otherwise enjoyable first flight has ended in disaster because no thought was given to the landing—until it was too late. (It is very difficult, for the beginner, at any rate, to search around for a place to land, and fly the model at the same time.) We will be discussing different types of landing—dictated by different sites and conditions—later on, but it is necessary to establish, at this point, that we look at the possibilities *before* attempting to fly at all. Since we have to start somewhere, we will assume that we have a site with a reasonable "back area," of the "plateau" type described in Chapter 2.

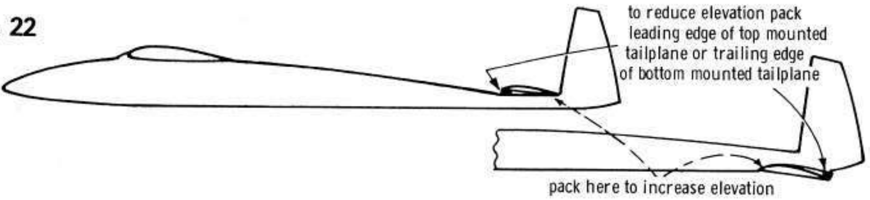
You can either launch the model yourself, or have a companion do it. You may prefer the former method, if you are not a trusting soul—or the latter if you think it will enable you to concentrate better on the transmitter end. After checking the rudder operation, the model should be held aloft to "feel" the amount of lift. This is important, because on it will depend the way the model is launched. If the wind is at the lower end of the scale, and you have to move it forwards to feel any lift, then a smooth, fairly hard shove will be needed. If you can already feel the wind tugging at the wings, and it feels as though it is impatient to get airborne, then a less powerful push will be needed—in fact you may find that you can almost simply "put" the model into the air. Either way, it should be pointed slightly downwards, aiming at a point slightly below the horizon, and launched straight out into the wind. If it takes you all your time to hold the model steady, and you are not sure how long you can hang on to it, then it might be better to wait until the wind has gone down a little—or try another day, as you have evidently misjudged the wind velocity. Launching is all a matter of "feeling" the wind with the model's wings, as it were, and this will come naturally after a few tries. Beware of launching the model so hard as to stall it, however, and *never* launch it upwards! A stall induced at the launch can be awkward to cure with the rudder-only model, and may result in the model coming in backwards against the hillside before you have time to turn.

Trim states

Now, with the rudder-only model there are broadly three states of trim, and it can be seen from the behaviour of the model which of these it is in. The states are (a) over-elevated, (b) under-elevated and (c) the correct trim for the conditions.

The most commonly seen of these states is (a) where the model rises fast, on launch, with hardly any forward movement, and goes into a series of stalls. This, in fact, *could* be due to an over-enthusiastic launch but, assuming the model has been released at about its

Fig. 22



correct flying speed, it can be taken that it is over-elevated. In this condition, if it can be kept straight, it will, in fact, fly "backwards," relative to the ground, and can thus be taken over to the area of dead air, or "sink," some little way back from the edge of the slope. The cure for over-elevation is to increase the incidence of the tailplane. We do this by adding some packing to either raise the leading edge or lower the trailing edge, according to whether the tailplane is mounted on the top of the fuselage, or underslung (see Fig. 22). Do not use more than $\frac{1}{32}$in. of packing at a time—and certainly not more than $\frac{1}{8}$in. altogether, or the model will lose too much of its longitudinal dihedral (the difference in angle of incidence between wing and tailplane) which it needs for its stability.

Do not attempt to cure over-elevation by adding weight to the nose of the model. The c.g. shown on the plan will be the optimum one. If weight is added to keep the nose down into wind then, once turned, the model will tend to dive and, in all probability, will not respond to the rudder.

If the model is *under-elevated,* it will fly outwards into the wind, but steadily losing height, instead of gaining it. Unless you want a long walk, you will have to turn it parallel to the slope and bring it in for a slope-side landing, as best you can. The cure is the opposite of that described for over-elevation—*i.e.* decrease the incidence of the tailplane, by raising its trailing edge, or lowering its leading edge.

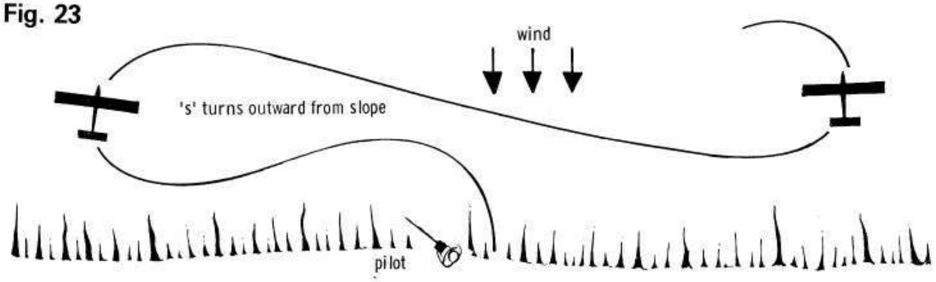
If we are lucky, and the model is in its *correct* trim state, it will move outwards from the slope and also upwards at a gentle rate.

Turning and tacking

Having achieved this satisfactory state of trim, we can now try some "S" turns. When the model is some little way out from the slope (say 50 to 75ft.) put on some turn and, *before* it is quite parallel with the slope, put on opposite rudder to bring it back into wind. As it comes into wind again the model's nose will rise and it will appear to slow down, relative to the ground, and then settle back to its normal flying speed. By tacking up and down along the face of the slope, doing these outward turns (Fig. 23) it should be possible to gain some height on each lap, until a natural "ceiling" has been reached, beyond which the model is reluctant to go. This will vary with different wind speeds and different sites.

Keep making the turns *outwards,* away from the slope, on all these first flights—even if your model is higher than the hill. Later on, when you have got the feel of your model and can anticipate its turning radius, allowing for drift, in various conditions, you will be able to turn towards the slope with confidence. But distances and speeds are easily misjudged, so do not try it too soon!

Fig. 23

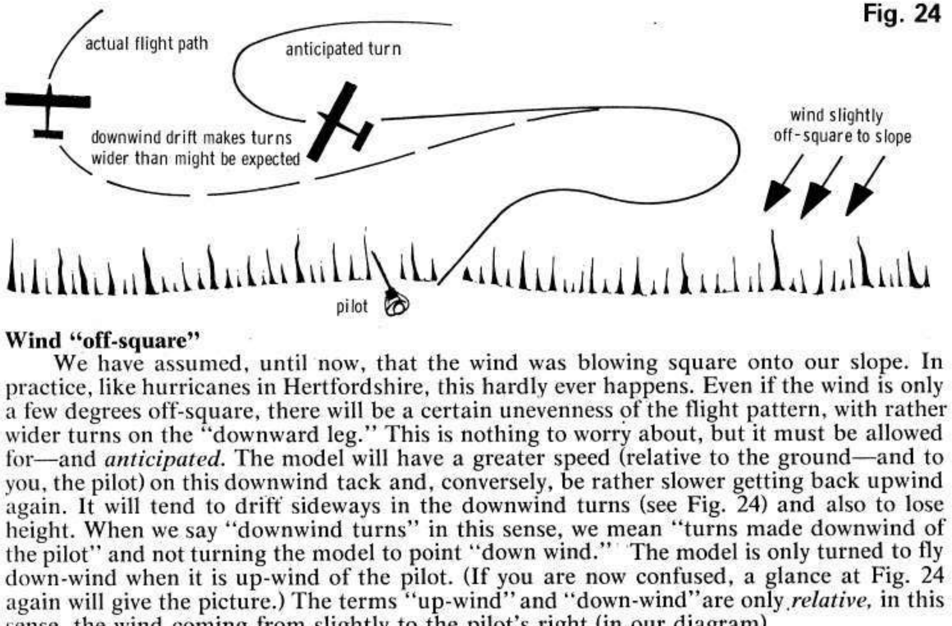


Take things steadily and continue practising tacking up and down along the slope face, and getting those turns just right. See how you have to *anticipate* all the time, and start applying the rudder just that little bit *before* you need the model to start turning the other way. Notice again how, when turned into wind after picking up speed on a turn, the whole model becomes buoyed up—like a boat in a gentle swell—and tends to hover before, once again, easing forward into the wind. If you have turned too suddenly, and the model comes up into a definite stall, instead of simply riding up, then another turn should be made—again *anticipating* that stall—to dissipate that excess flying speed, and the model again brought more gently into the wind.

This business of anticipation is the whole key to flying your soarer, and simply must be learned, until it becomes second nature. If the model stalls, it is no use applying rudder at the "top" of the stall; that is too late. Rudder must be applied *before* the stall actually breaks, so as to put the nose down and fore-stall it, as it were! This can be practised, since, if you are too late the first time the model stalls, it will certainly stall again immediately afterwards, and you can then pick your moment to "head it off," so to say.

With time and practice, you will begin to know the "sit" of your model in the air, and realise when it is not quite right—and take the necessary corrective action before anything untoward happens. Before long, you will find that you are doing this, all the time, without really thinking about it. You are then flying the model as it should be flown.

Fig. 24



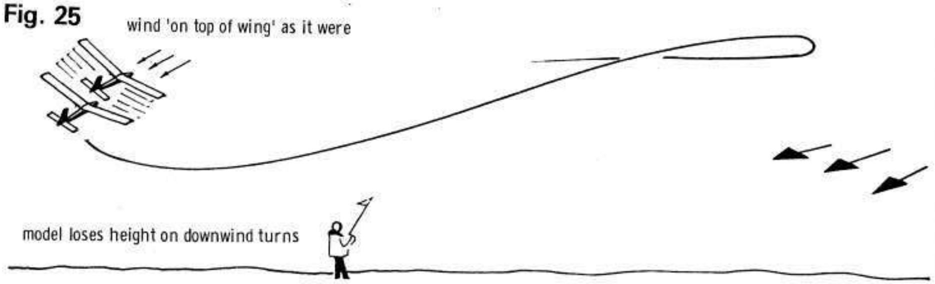
Wind "off-square"

We have assumed, until now, that the wind was blowing square onto our slope. In practice, like hurricanes in Hertfordshire, this hardly ever happens. Even if the wind is only a few degrees off-square, there will be a certain unevenness of the flight pattern, with rather wider turns on the "downward leg." This is nothing to worry about, but it must be allowed for—and *anticipated.* The model will have a greater speed (relative to the ground—and to you, the pilot) on this downwind tack and, conversely, be rather slower getting back upwind again. It will tend to drift sideways in the downwind turns (see Fig. 24) and also to lose height. When we say "downwind turns" in this sense, we mean "turns made downwind of the pilot" and not turning the model to point "down wind." The model is only turned to fly down-wind when it is up-wind of the pilot. (If you are now confused, a glance at Fig. 24 again will give the picture.) The terms "up-wind" and "down-wind" are only *relative,* in this sense, the wind coming from slightly to the pilot's right (in our diagram).

As we said, the model will also tend to lose height on these turns which are started on the downwind leg. It is as if, when turned sideways to the wind and banked, the model tends to be pushed downwards, as it were, by "wind on top of the wing." Fig. 25 shows what we mean.

It is advisable always to try to fly the model "upwind" of oneself (to the right, in our diagrams) and to start making the turns, on the downwind leg, a little before the model

Fig. 25



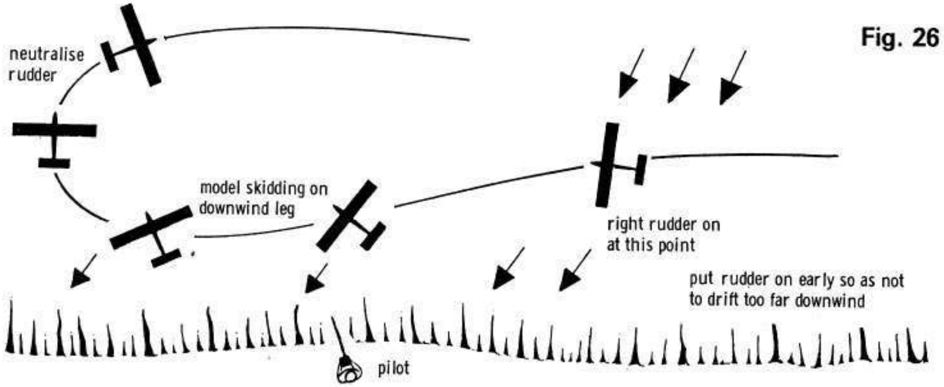
reaches you. It will then not drift too far down wind. Only practice will show you at just what point to start these downwind-leg turns, to bring the model back into wind at the desired point. Remember that you must always anticipate, and put on rudder just those few seconds before you need the model to turn, to allow for this drifting effect (Fig. 26). Some models "skid" sideways more than others in these conditions, and the models with more dihedral (especially tip dihedral) will usually come round more readily than those with less, but there will always be this sideways drifting effect to be allowed for. This skidding effect, and the slowing up of the model when coming back into wind, can be used to good effect when landing, as we shall see shortly.

"Marginal lift" conditions

What if the wind should start to die down, or should even have died to a very slight breeze by the time you reach the slope? Then we have what we call "marginal" conditions. This is a favourite term of the slope soaring veterans, and it means "barely enough lift to keep the model airborne." This is, in fact, where a great deal of the challenge and enjoyment of slope soaring is to be found. With our 10 to 15 m.p.h. wind, we had plenty of lift, but it has now dropped to (say) about 5 m.p.h. This means we not only have to pay attention to flying the model around, but we must now urgently seek out the areas of best lift, in order simply to maintain height.

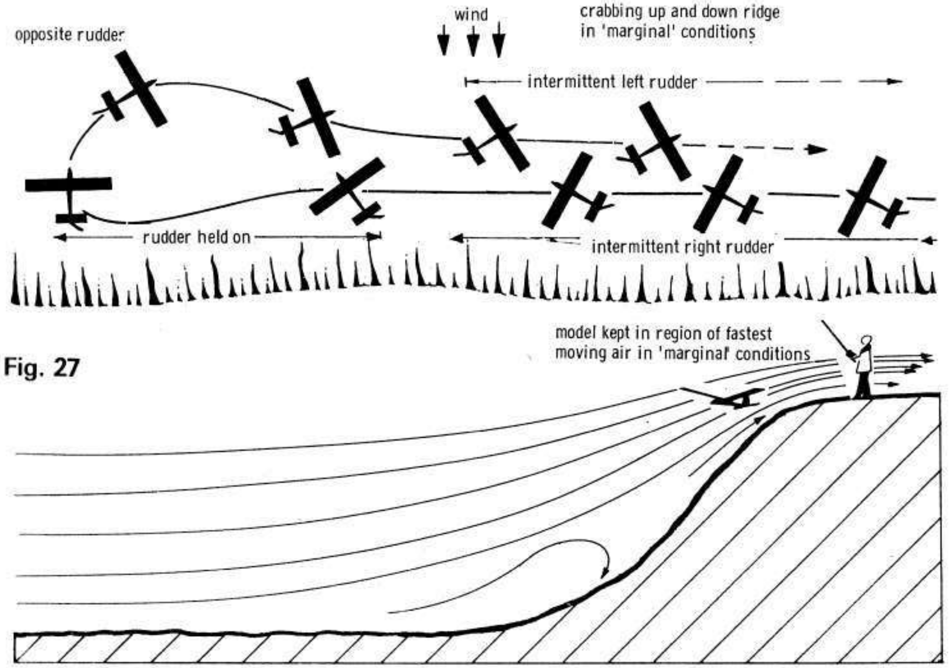
We will often find that tacking nearer in towards the slope will help, in these conditions, and that the model can be made to ride the tide of air that is so very gently rising up the side of the slope. The model, when "crabbed" sideways along the slope, will ride up, almost like a boat buoyed up by an ocean swell. See Fig. 27. It is in these conditions that we can begin to break our, till now, strict "outward turns only" rule, too, and gradually increase the amount by which we point the model's nose out of the wind until we have it skidding gently towards the top of the slope and judging the exact moment we have to apply rudder to skid it round outwards again. If we leave it too late, the model will simply "sit down" on the slope—and we have done (even if unintentionally) a "slope-side" landing.

Fig. 26



If we manage to maintain height with our crabbing up and down, hugging the face of the slope, we may notice that the model hits a "bump"—and noses up a little more in a certain spot—often tipping up its outermost wingtip. If we now turn outwards at this point we may find that there is an area of extra lift that may stretch outwards from the hill for quite some distance. We point the model outwards from the slope and see it rising—not nose-upwards, but bodily—the whole model rising "like a lift," as it were, for a while. We make a mental note of this region and, on our next trip back along the face of the slope, we turn out at the same place and—up it goes again! This can become very engrossing, as you may imagine. If the effect continues, each time we turn the model at this spot, then it is likely to be extra slope lift, induced by some particular property of the slope face at that point. If, however, the area of lift disappears after one or two useful rises, then it was probably thermal lift, due to warmer air rising faster than the gentle flow of surrounding air against the slope.

Fig. 27



Some areas of thermal lift, on these otherwise "marginal" days, can be really useful, and take our model up to quite unexpected heights—sometimes very much higher than the model's normal slope-lift "ceiling." Once a certain height above the top of the slope is attained, in such conditions, it will often be found that it is easier to maintain height, after the thermal lift has drifted away, by cruising up and down along the top of the edge of the slope— above one's head, as it were, than it was when just "scraping" along level with the top of the slope, or a little lower. Fig. 28 shows the relative height and area where this condition often occurs.

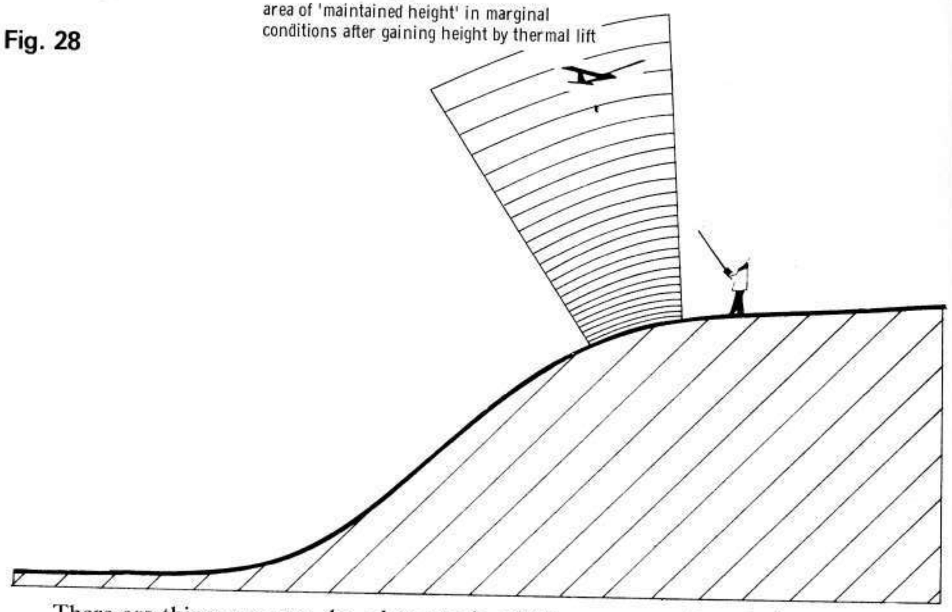
On days of marginal lift, you will soon find yourself able to detect very small amounts of lift, by the way the model rises, and stay in them as long as possible, or keep returning to them, so gaining, or recouping, a little height each time. You may even find this sort of soaring more challenging and satisfying than when there is steady slope lift, and it is probably here that the rudder-only model flier scores over his more sophisticated companion craft with their multi controls. His model is often more suited to these conditions—and, of course, he will not be impatient for a "good blow" to do aerobatics, for aerobatics with the rudder-only model are virtually non-existent, anyway, as we shall see.

Here, too, is where a great deal of the enjoyment comes from being with a group of fliers, as there is much satisfaction to be had, either in trying to be "the last one to have to land," or, if thermals are kind, to be the one who manages the best height, in marginal conditions. This is assuming, of course, that you are flying with superhet equipment, for, in this day and age, and "state of the art," it could be considered almost "anti-social" to use super-regen equipment, so that everyone else has to stop flying in order that you may take to the air for a while! Of course, if you are a confirmed "lone hand," then this does not matter, and cost may be the prime concern. But, by always flying alone, you cannot but miss a great deal of soaring pleasure.

Stronger winds

Going to the other extreme, now, what if we should arrive at the slope to find that it is much windier than we expected? As we have already said, as beginners, we would be well advised not to chance our luck. Rudder-only models can very easily be blown backwards over the top of the hill—and out of sight of the pilot—in stronger winds, and so damaged, or completely "written off"—or even lost.

Fig. 28



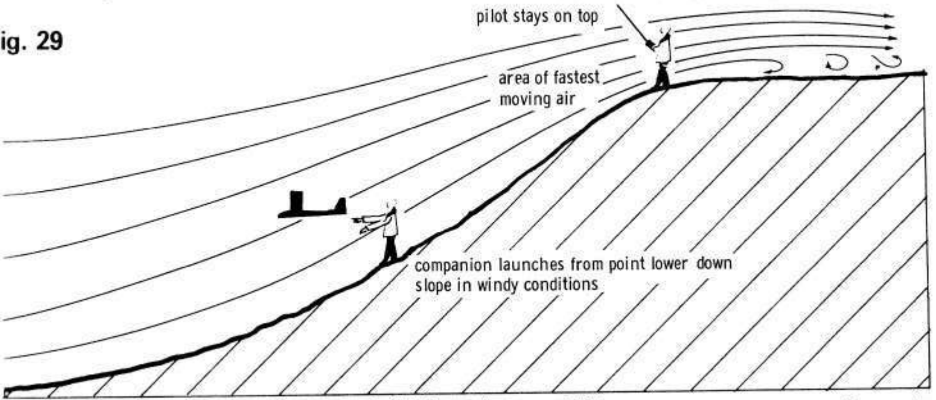
There are things one can do, when one is a little more experienced, however. One of these is to launch the model from a point part-way down the slope, as shown in Fig. 29, so that it is out of the region of fastest moving air. This way it can be made to fly outwards more easily, and not be flung backwards by the excessive wind speed, and turbulence, which may be experienced at the crest of the slope. It is preferable to have a companion launch the model, while you remain on the top of the slope; otherwise, if the model still tends to go upwards and backwards, you will lose sight of it before you have a chance to make your way up the slope again. By remaining at the top, you command a better all-round view, and will be able to see and maintain control of the model.

There will be a limit to the wind-strength in which a model of a given wing-loading will satisfactorily fly, however, and there remains but one thing to do. Increase its wing-loading. We do this by ballasting the model, not at the nose, but at or about its centre of gravity. We do not then upset its trim, but simply make it heavier. This, essentially, makes it fly faster, so that it can "penetrate" the stronger winds. The increased mass of the model then has more momentum, and will fly in a steadier way than its more lightly loaded counterpart, not being affected too much by buffeting of wind gusts. Of course, our added ballast makes the model "come down" harder, if not landed well, so this ballasting is best left until we have had quite a lot of soaring experience in less difficult conditions. (See "Speed and Efficiency"—Chapter 20).

Using ballast can sometimes endanger the structure of a model, since, if landed heavily, the lead weights used can tend to try to burst their way out of the model. For this reason, the weights—in the form of flat pieces of metal, are sometimes strapped onto the undersurface of the fuselage, below the wing, so that, in the event of a nose-in landing, they simply shoot forwards and away from the model, instead of bursting out of the structure. Some designs, however, include a built-in ballast-box, which is specially strengthened to withstand such loads. This is certainly rather a more elegant solution than the somewhat "agricultural" strapping-on of external ballast.

Full-size sailplanes use "water ballast" to increase their wing loading for speed, and this can be jettisoned by the pilot, should conditions require the wing-loading be lightened.

Fig. 29



This can only be done once on each flight, of course! There seems no reason why water ballast should not be used in models but, at present, there seems to be no record of anyone having tried it.

Alternative wings

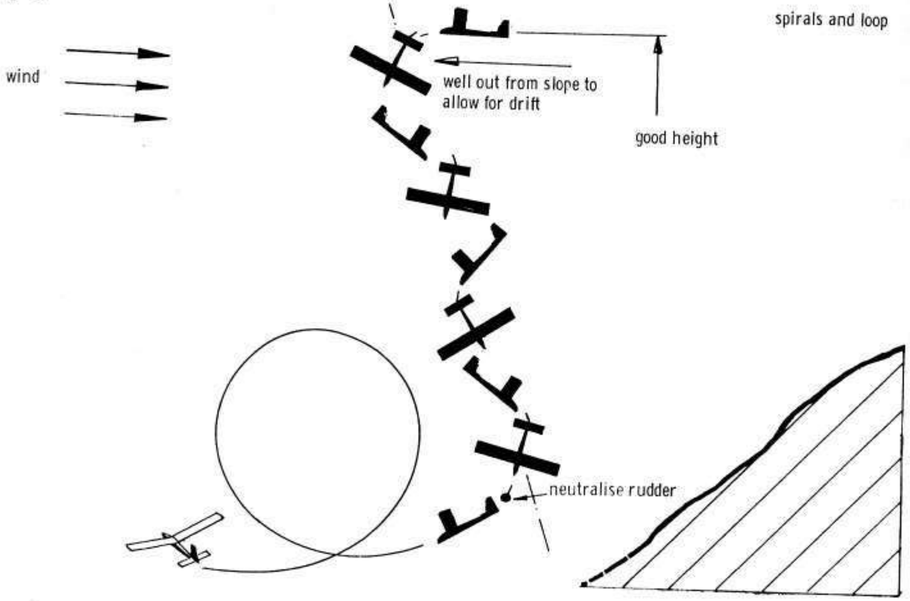
An alternative method of increasing the model's wing-loading, of course, is to *reduce the wing area.* Occasionally we see models with three-piece wings, the centre panel of which can be removed, and the outboard panels joined together, to provide a wing of roughly two-thirds the area of the original, for flying in stronger winds. Alternatively, some modellers will provide themselves with a pair of smaller wings, for the same purpose.

It is more common, however, for the alternative wing to be *larger,* for flying in marginal conditions, as this is generally more pleasant! Just as the increasing of the model's wing-loading enables us to fly it in stronger winds, so *reducing* the wing-loading enables it to remain airborne in much lighter breezes than it normally could, and make use of even the weakest patches of thermal lift. We are thus virtually turning the model into a thermal soarer—except that we still hand launch it from the slope, and pick up thermal lift rising from the valley, instead of having to tow up our model with a tow-line, kite-fashion.

Many rudder-only fliers (and, indeed, some fliers of the much more sophisticated multi control designs) therefore have a set of wings, of greater area—and perhaps with an under-cambered airfoil section, giving a higher lift coefficient—which may be used when the model would, otherwise, be grounded for lack of lift. Other modellers, as we have mentioned, will often bring two or three models with them, and choose which one to fly, according to the conditions of the day—or even according to the changing conditions during a day's outing.

Fitting the larger area wing will not usually entail re-trimming the model, as it is usually the *span*, and not the *chord* that is increased, so keeping the centre of gravity the same, in relation to the wing. Carried to extremes, however, the addition of wing area can cause a model to become longitudinally unstable, since it also effectively reduces the *relative* size of the stabilising tailplane! Most rudder-only and intermediate designs have an adequate safety factor in the size of their tailplanes, however, to cope with increases in wing area of up to (say) one-third.

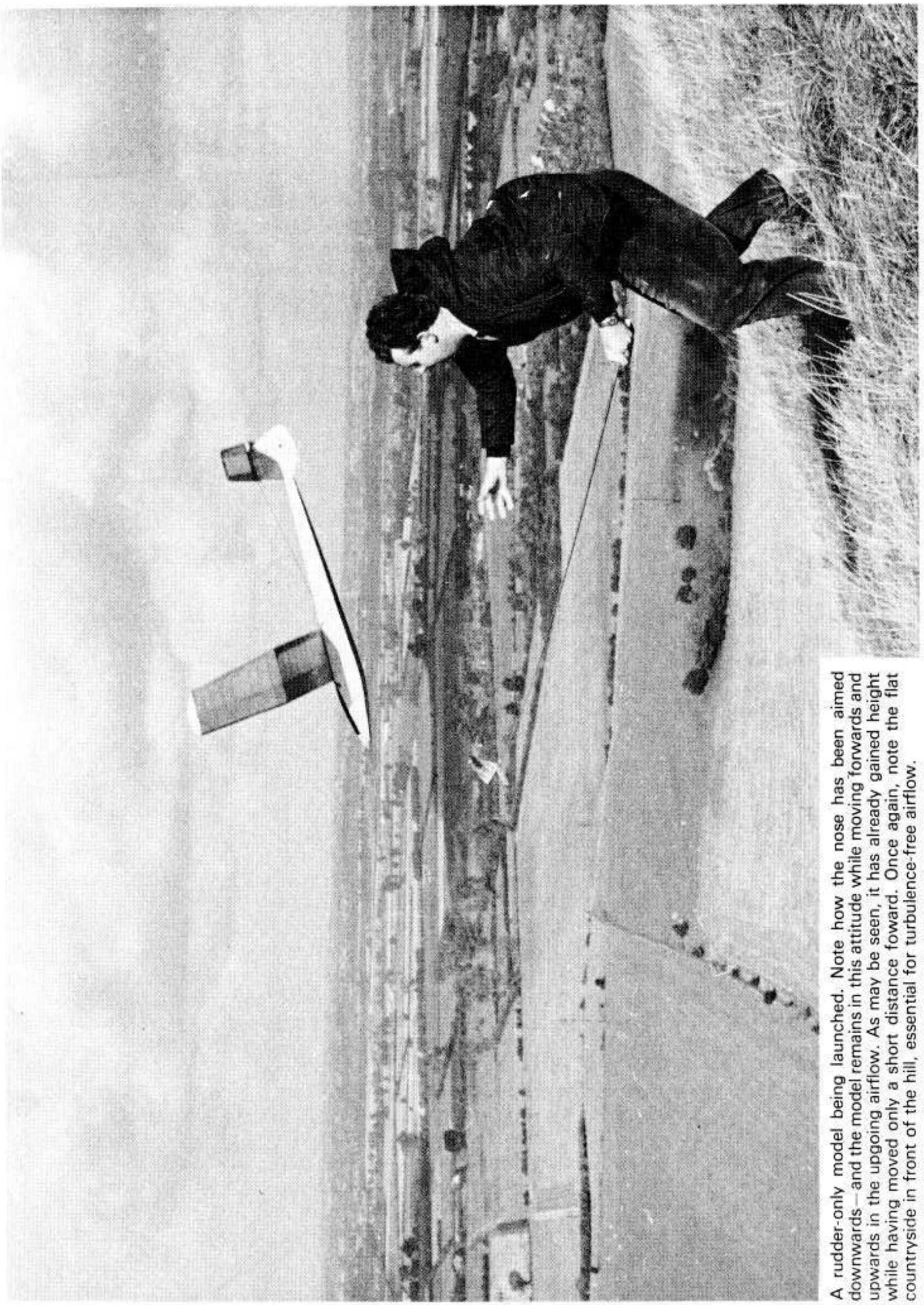
Fig. 30



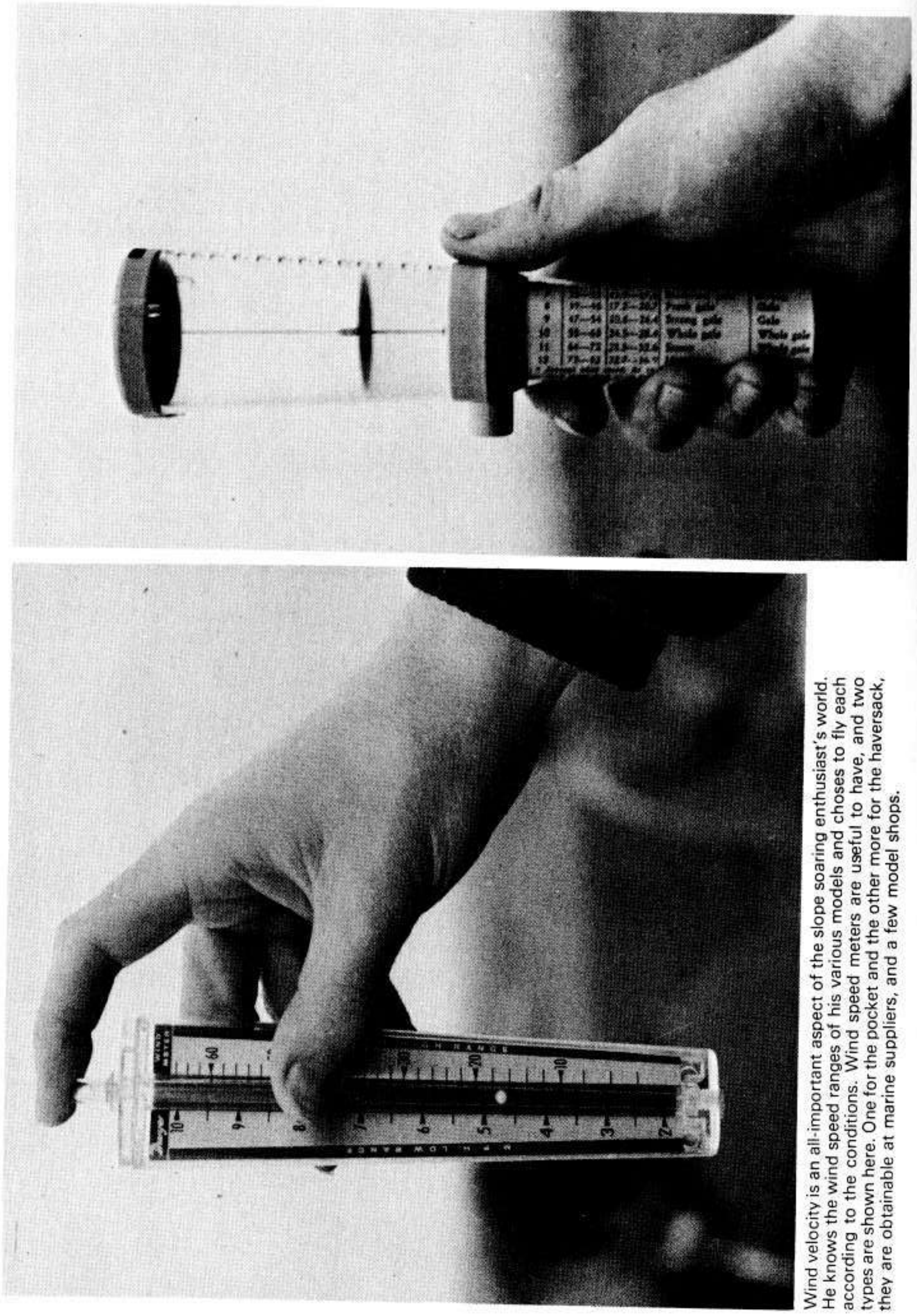
Manoeuvres

Having become fairly accustomed to the general basic principles of soaring then, what manoeuvres can the pilot of the rudder-only model expect to be able to make his model perform? The answer to this question, as far as "aerobatics" is concerned, and in comparison with the intermediate and multi control models, must be "practically none," but this does depend, to some degree, on the particular model and its trim state.

All manoeuvres for the rudder-only soarer, as with its powered counterpart, are dependent on the building-up of excess speed. That is to say, speed over and above that required to maintain steady flight. In order to achieve this it is necessary to dive. As we have no elevator, our dive has to be a spiral dive, which is achieved by simply holding on the rudder. Unless it is enormously over-stable, or rigged in an unusual fashion, the model will hold the turn and point its nose downwards. Needless to say, before doing this sort of thing, it behoves us to coax the model to a good height "above eye level," as it were, and also to keep it as far out from the slope as possible, to allow for the inevitable towards-the-slope drift, which will occur the whole time. After two consecutive spirals, the rudder should be



A rudder-only model being launched. Note how the nose has been aimed downwards—and the model remains in this attitude while moving forwards and upwards in the upgoing airflow. As may be seen, it has already gained height while having moved only a short distance foward. Once again, note the flat countryside in front of the hill, essential for turbulence-free airflow.



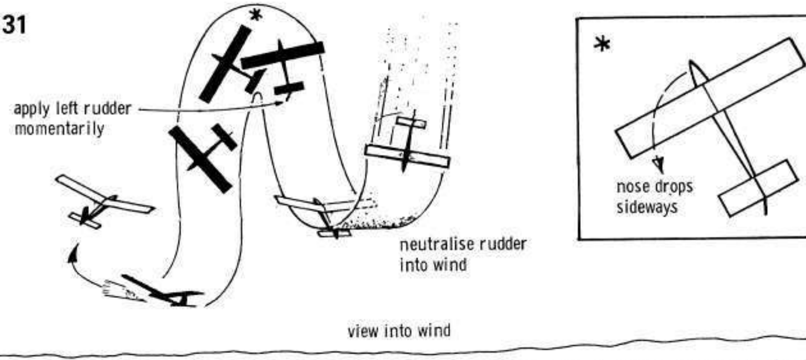
Wind velocity is an all-important aspect of the slope soaring enthusiast's world. He knows the wind speed ranges of his various models and choses to fly each according to the conditions. Wind speed meters are useful to have, and two types are shown here. One for the pocket and the other more for the haversack, they are obtainable at marine suppliers, and a few model shops.

neutralised, just *before* it is quite pointing into the wind again (see Fig. 30). With the excess speed built up in this spiralling process, the model will "zoom"—that is to say, swoop upwards in a curved flight path. Whether this zoom results in a loop, or simply in a stall, depends on the model and its state of trim, and on the relative wind speed.

If, after spiralling and neutralising the rudder, the model simply stalls, then we must apply rudder to hold it in a gentle turn—not to build up more speed this time, but to dissipate the excess speed—gradually widening the turn as the model slows down to normal speed. With proportional rudder, this is relatively easy. With "bang-bang" escapements or actuators, it is a question of holding short pulses of rudder and gradually decreasing the amount of time the rudder is held on, until, eventually, the circle widens and the model is once more in a steady state. As we have seen earlier, the secret is to apply the rudder—once the model has been seen to stall—just that fraction of a second before the *next* stall, so as to damp it out before it starts, so to speak! We make no apologies for once again stressing that this *anticipation* is necessary in all our soaring flying, and with whatever class of model we are dealing, since we must always be concerned with what our model is doing *relative to the wind*, so this is a habit which is best learned early.

If our model manages to get "over the top," in a loop, then we can consider ourselves lucky—not very many rudder-only models will do this to order, unless over-elevated to quite a degree, which can make them difficult to fly "normally," as over-elevation results in a wallowing flight pattern, with a tendency to stall easily. In any event, once over the loop, the model will pick up more speed on the way down, and, unless it is to stall madly now, must again be put into a turn to "work off" this extra energy.

Fig. 31



The stall-turn is a manoeuvre which your model will certainly do, even if it cannot be made to loop. Again making sure that you have plenty of height, and plenty of space between the model and the slope, spiral it down once again—*one* spiral will probably do for this—and neutralise, as before, just a fraction before the nose comes into wind again. This time, as the model zooms up, give a sharp dab of full rudder, neutralising immediately. If you hit it at the right moment, and hold for just the right length of time, a nice stall-turn can result. (Fig. 31). It is all a matter of timing and judgement. Left too late, the rudder will have no effect, because the model will have no "steerage way"—having stopped, poised, nose-upwards in the stall, before plunging downwards again to find some airspeed. Rudder applied too early, on the other hand, will simply mean the model will do a tight climbing turn and not the stall-turn we are after. The real stall-turn sees the model rearing up as though to stall, facing into wind, then—when it is almost vertical—the nose drops *to one side*, and the model swoops downwards—*downwind*, towards you, having in fact moved its longitudinal axis through 180°. Fig. 31 should make this clear. Once having completed the stall-turn, of course, you must turn back into wind with as little delay as possible, and position the model out away from the slope once again.

On days when your model can be made to gain plenty of height, you may like to try out these manoeuvres, and see if you can perfect, at any rate, a controlled stall-turn, even if your model will not loop. Eventually, you will find that you are not so completely dependent upon wind-direction to achieve the desired results, and can perform a stall-turn in more or less any direction. This is not at all easy, of course, and you will find it best to start with the model facing into the wind, as we have described.

Why bother?

Many people will say "I am not at all interested in even these simple manoeuvres—there is sufficient interest and enjoyment for me in just flying in different conditions, seeking out the lift, gaining height, and so on." Fine. It is as well for the rudder-only flier to be content with this, in general. But, to be able to cope with a stall—to convert it into a stall-turn, or to damp it out by turning at the right moment—will make you that much better a flier, able to contend with sudden awkward situations without having to think about it. And, in awkward situations, there is usually very little time *to* think what to do. If you have already done enough stalls and stall-turns, and generally whizzed the model around, then the corrections necessary for a given situation will come as second nature. It is better to put the model into a stall, deliberately (at a safe height, of course) so as to learn how to deal with it, than to fly always "gingerly"—because, sooner or later, the situation *will* arise where you need this experience to avert disaster, and only if you have practised for it will you be equipped to deal with it.

Landing —the "crunch"!

As with full-size flying and gliding, the landing is the hardest part to get right—primarily, of course, because there is no room for error! We also tend to get less practice at landings, because we only do one per flight. The temptation to stretch out a flight, and put off the moment when we must land, is great. The wise man will make sure he gets practice at landings, by keeping his flights short. If one makes a mistake when the model is well up and out from the slope, there is plenty of room to recover the situation, and try whatever it was we were attempting again. Such is not often the case when landing, the ground tending to stay resolutely where nature saw fit to place it—or perhaps (as it often seems), a foot or two higher!

It is with landing that the type of slope from which one is soaring most influences the procedure used, as we shall see. Methods have to be adapted to conditions, as well as surroundings, however, and the wind velocity can be helpful in some conditions, and just the opposite in others.

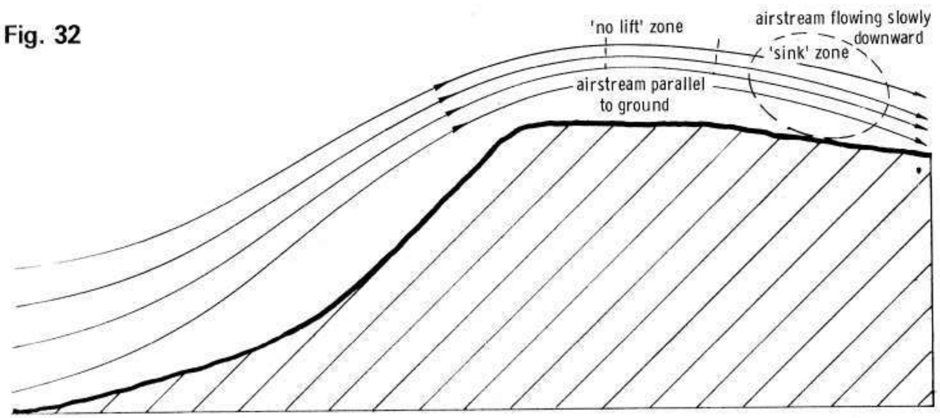
Plateau back-area landings

Taking, once again, our "ideal" site first, we have the hill with the flat, or nearly flat, area at the back of the slope. This will have a zone where the air is moving more or less parallel with the ground and, a little further back, slightly downwards. We have shown this in Chapter 2, when dealing with types of slope, but now our Fig. 32 shows it with particular relation to the landing.

Provided the model has sufficient height (say, at least 30ft. above "pilot level") we can either turn in a "square approach" pattern, to bring it into the "no lift" zone at the beginning of the last (into-wind) leg or, by keeping it headed into wind all the time, allow it to "float" backwards, relative to the ground, so that it enters the no-lift zone. Either way, when the model reaches this part of the back-area, it will begin to descend. This is because, although there may still be plenty of wind, it is now blowing parallel to the ground, and there is no upward component in it. Remembering that our model is really always gliding downwards, relative to the air—it now also is seen to begin gliding downwards *relative to the ground*—which is, of course, what we want.

How, then, do we determine the exact point at which our model is to come to earth? Well, "exact" might be putting too fine a point on it. Let us say the approximate area. This is a question of whether we *undershoot* (fall short—*i.e.* down-wind—of the desired area) or *over-shoot*—or judge it to a nicety and place the model in such a way that it comes between the two extremes. Obvious, you may say, but how does one actually tackle it?

Fig. 32

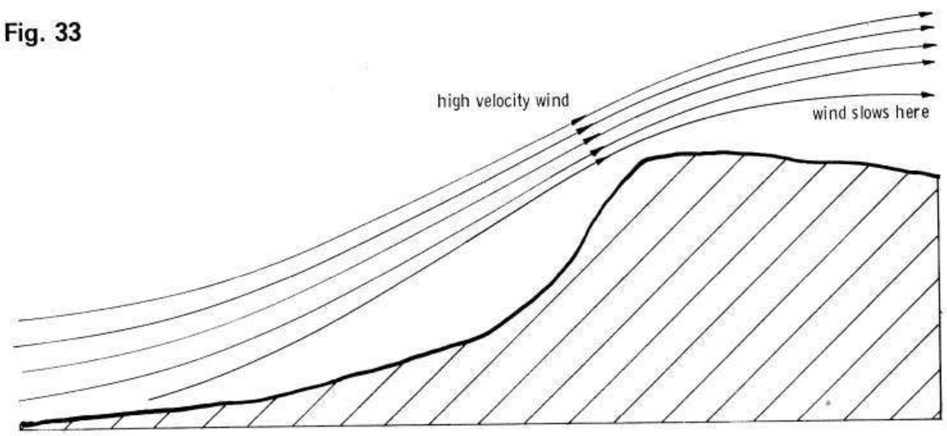


There is very little one can do about undershooting. If you have left it late in turning back into wind, then the model will undershoot, and fall short, and that's all there is to it. There will be no harm in under-shooting, of course, if the back-area stretches well down-wind. Many people prefer to deliberately under-shoot rather than over-shoot and possibly get into turbulence near the slope edge. However, if the back-area of the slope drops away after a little distance, then the airflow will be moving *downwards*, and our model will descend quite rapidly, and also start to move faster in relation to the ground because the air will also be moving slower. The transition between layers of air moving at different speeds can be quite spectacular, and only practice and foresight can make the difference between the model's taking on just the right amount of "sink" for landing, and suddenly dropping its nose for lack of forward speed when it hits the area of slower, downmoving, air. Fig. 33 shows the area where this occurs.

By varying the length of our down-wind leg (*i.e.* the amount of time we let elapse before turning the model cross-wind and then back into wind) we can experiment to find the sort of approach needed for different conditions. One of the interesting things about slope soaring, of course, is that this can change, sometimes quite considerably, during the course of an afternoon's outing, with only small changes in wind speed.

Overshooting, unlike undershooting, is not completely unavoidable, once the model is

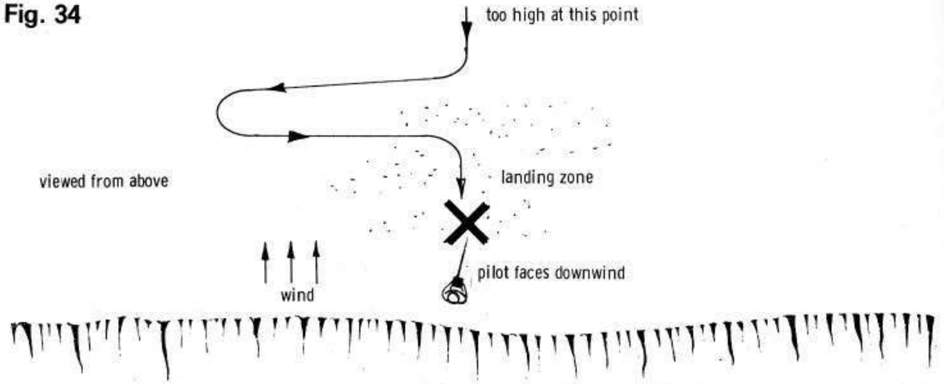
Fig. 33



headed back into wind. If, on coming into wind, we begin to realise that the model is too high, and likely to over-shoot, we can lose height by turning slightly, first to one side, and then to the other. Just one slight deflection and then back into wind may be enough (see Fig. 34) but, if we have badly misjudged, and are much too high, then some larger "S" turns may be necessary. If even this does not seem to be going to work, and the model is beginning to get near to the edge of the slope, then we will be wiser to make up our mind rapidly to "go round again." A decision to do this must not be left too long, however, or we may find the model poised over the brink of the slope, with hardly any forward speed. It is then in a most vulnerable condition, and the slightest turbulence or gusting can cause it to stall, and be blown backward, either to contact the ground tail-first, or with a wingtip. Either way, it will probably sustain some damage. Try never to be caught low down near the edge of the slope without some reserve of forward speed, in anything but the lightest of zephyrs.

We have been discussing, here, the "square approach" pattern, and variations of it (most people's idea of a square approach is probably nearer to an "elongated semi-circle," anyway!) but what, now, of that "floated backwards" approach? Floated backwards into the no-lift area, the model will pick its own moment to put its nose down and descend. We can, however, control this to a certain extent by deciding the height at which it enters the zone. Within certain limits, decided for us by the shape of the hill and the velocity of the wind, the higher it is when floated back over the edge of the slope, the further back it will begin to descend. It is almost impossible to generalise on this, because, as you might imagine, the number of possible permutations and combinations of wind speed and hill shape are almost infinite. As with most things appertaining to model aircraft, compromise is often the best way, and it may well be that a combination of both the square-approach and the floating-backwards-and-hovering method, combined with some S-turning, will be how we make our landing.

Fig. 34



Slope-side landings

Now let us look at a rather different situation. The wind has dropped, while we were flying and, somehow or other, we find that the model cannot be coaxed back up to "pilot level," in order to set down on top of the slope. We *could* continue flying and guide it down all the way to the foot of the slope, provided there is a clear area there to land, but we would really rather not, for two reasons. The obvious one is that this will involve a long and tiresome journey down the hill, and the second one is that it becomes increasingly difficult to judge the model's distance from the ground—or above fences and trees—the further away from us we fly it, so the risk of damaging it becomes greater. We must, therefore, land the model as high up the slope (and so as near to us) as we can. This is best done, in these conditions, by "crabbing" it close in towards the slope, as described for marginal conditions (Fig. 27), but this time we will deliberately and not accidentally, let it "sit down." Try not to let the nose of the model point in too much towards the slope, however, since—without elevator to raise the nose, this may mean a "thump" which could possibly put an end to the day's flying. Remember, we want to turn the model back into wind "just too late," so that we slow it up, and it just settles back onto the slope.

The slope-side landing has to be used in other circumstances, too, even when there is still strong lift, such as when flying from the side of a large hill, or a mountain, rather than the top. Or when there is some obstruction at the top, such as rocks or—on some lower slopes—trees. In these circumstances it is wiser not to attempt to fly the rudder-only model in anything but the lightest of breezes. However, the principle is the same—crab the model along as near to the side of the slope as possible—first having positioned it at a level somewhat *below* that at which it is aimed to land it, perhaps even pointing the nose just slightly in towards the hillside, before suddenly turning it outwards, when it should "mush"—skidding sideways—and sit itself down, vertically, flat, with little forward motion. The technique is to let it rise, with the rising air coming up the slope then, when it is turned, it will slow up, and settle. This is why we should first aim to position it a little lower than the point at which we would like it ultimately to land. If you turn outwards too early, the model will pick up forward speed and go out away from the slope again. You may have to have several attempts before you time it just right.

Landing on a ridge

If your site is a ridge, with only a narrow top, like the one shown in Fig. 3 (p. 12), when discussing types of site, then you will have the choice between landing either on the side or on top. It depends upon the wind strength, and is all a matter of timing and judgement. The slope-side landing may be used if the wind is light or moderate, and the model can be first flown in such a way that it is below pilot level. It can then be crabbed along and turned into wind at the last moment, as we have seen in the slope-side landing.

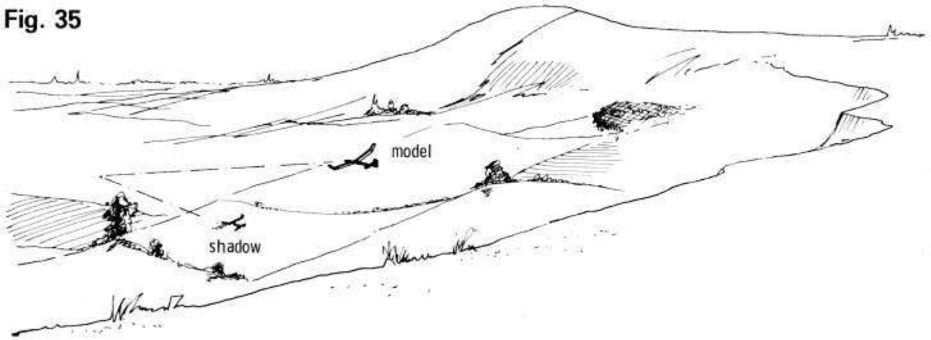
By crabbing the model a little higher, up to the top of the ridge, one can allow it to float back a little further, to "sit down" on top. This takes a great deal of practice—and possibly some broken models, as it is easy to be caught by a sudden gust at this stage, when the model can be "cartwheeled" along the ground, on its wingtips. One has to learn to judge the conditions, to decide whether to try for this sort of landing or not.

The third method is to take the model *just* over the ridge and immediately turn back towards the ridge (*i.e.* into wind) so that it sinks down on the "calm" side. This is probably the most satisfactory method for windier conditions. The important thing here, however, is not to allow the model to go too far past the top of the ridge before turning it back—otherwise it can either "drop out of the air" due to suddenly finding itself in an area of slower-moving air, or else get into severe turbulence, depending on the nature of the ridge itself, and on the wind velocity. Some "razor-back" ridges are very vicious in this respect, but if this type of ridge is all that you have, then it will pay to learn its foibles, and how the air behaves over it in different wind speeds.

It may happen that, in attempting to turn at the top of the ridge, you find that the model is not answering well to the rudder, and that it continues on, downwind. It will then probably dive, to try and pick up its natural airspeed, and may possibly go into a series of stalls. Remember what we have said about killing a stall by applying rudder on the way "down the trough," as it were—*before* the nose comes up for the next stall. This way, with luck, you will be able to level it out before reaching ground level. Once over the back of the ridge, into the "shadow" of it, so to speak, the model will, of course, have no extra lift from the air, and will be simply gliding downwards. You will, therefore, be in the position of *having* to land the model down towards the foot of the slope—on this occasion, the "wrong side" of the slope.

As we said earlier, it is very difficult to judge the model's height above the ground, when looking down on it from above. It may suddenly appear to "stop"—at what you thought was at least 20ft. above the ground—or, contrariwise, it may seem to go on and on, when you thought it must surely have landed by this time. Some people are better at judging

Fig. 35



this sort of thing than others, but one trick you can make use of, should the occasion arise, and if the sun is shining, is to watch for the model's *shadow*, on the ground. As the model sinks lower, its shadow will get nearer and nearer to it, until, at the last instant, they come together (Fig. 35). You should be able to slow the model up, just at the last moment, by waggling the rudder from side to side, fairly rapidly. By doing this, you are presenting each wing, in turn, with an increased angle of attack (due to the dihedral), and the model will tend to slow down and raise its nose slightly—just what we want for a "flared out" landing. This technique may be used at any time when we wish to slow the model down slightly, but it is most useful—and most noticeable, when the model is near the ground—Fig. 36.

Bowl landings

If your site is a bowl then, again, the wind velocity will largely determine how the model is landed. In light and moderate breezes the slope-side technique can be used to advantage, when the curving face of the bowl will help to bring the model to rest. In higher winds, the landing procedure will depend upon what sort of a back-area the bowl has. If it has a "plateau" type of back-area, then things are relatively simple, and we just lead the model over this until it starts to sink, when we turn it back into the wind. In strong winds, with some bowls, the air goes on rising for a considerable distance back, so that you may begin to think it is not going to start coming down at all! Don't panic—it *will* start coming down. If it is quite high up, you *could* help it by doing one turn of a spiral, and then "turning off" the excess lift as we have described earlier. But this should not be necessary, unless you have gained a considerable height before going back over the crest of the bowl. Once faced into wind again, further height may be lost, without increasing the flying speed very much, by doing a series of "S" turns, as described for our over-shoot correction earlier. Fig. 37 shows this as applied to the bowl with the flat back-area.

If the bowl has a back that drops sharply away, however, it becomes, in effect, a ridge. (See Fig. 38). The model must not be allowed to go so far over as to get into the region of turbulence that will exist just downwind of the ridge so formed (Fig. 39). With a bowl this can be very severe and the model could be flung around, willy nilly, and not respond at all to rudder movement. Again calling for judgement and practice, the optimum landing spot will be just towards the back edge of the ridge, but before the ground drops away sharply, as shown in side-view in Fig. 39. This does call for quite a degree of skill, however, and should be thought of as something to aim at, at a later stage. The novice may prefer to take the other extreme, and land low down on the front of the slope.

If he feels that he would not like to take the risk of "going over the back"—with its

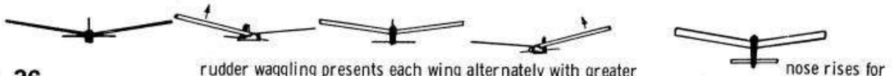
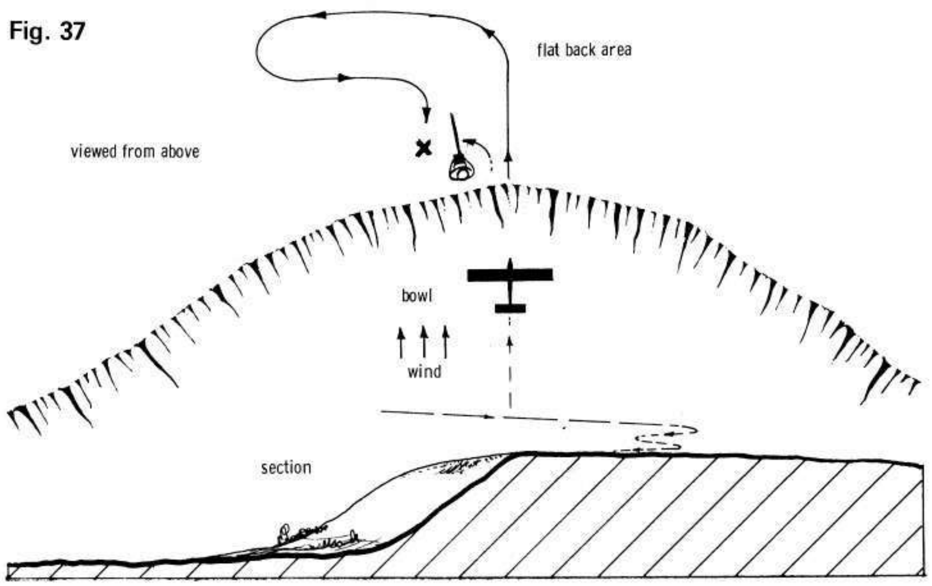


Fig. 36

rudder waggling presents each wing alternately with greater angle of attack - raises mean angle of attack - slows model

nose rises for 'flare out'

Fig. 37



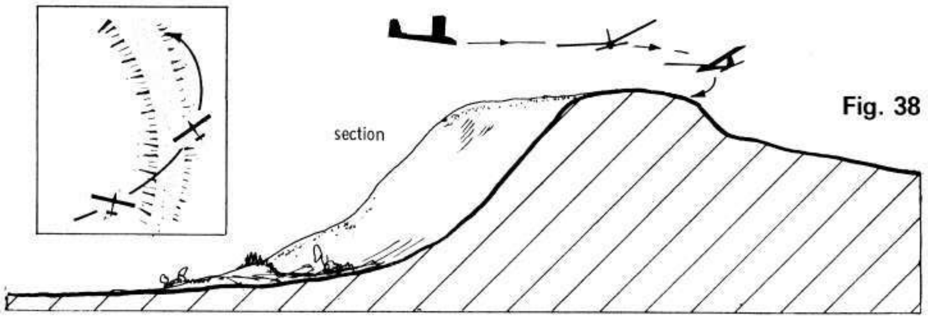
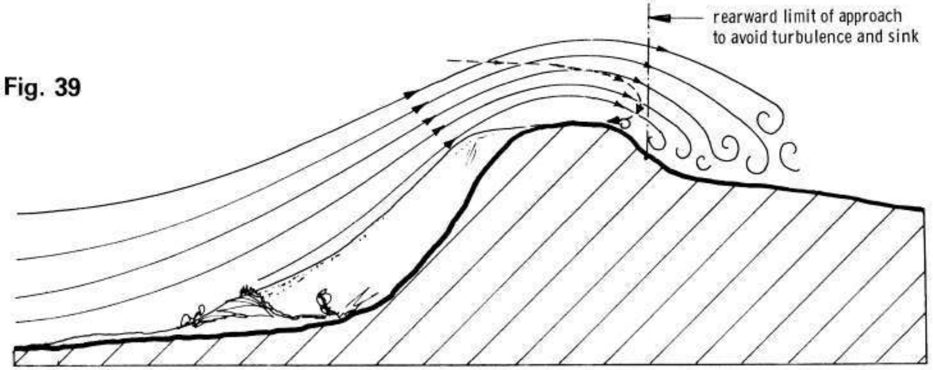


Fig. 38

Fig. 39



possibility of getting into the severe turbulence through lack of sufficiently fine control, then a safe procedure will be as follows. The model should first be flown some considerable distance out and away from the slope. Then the pilot can make his way down the slope, and bring the model down—spiralling it, if necessary, to a point about half to two-thirds the way down the slope. It will then be in an area of much less lift and, since the pilot has come down the slope, he will be able to see it well enough to land it fairly comfortably. Provided, that is, of course, that there are fields and not rocks at the lower part of the slope!

This sort of thing does, of course, mean a great deal of walking and climbing about, on the part of our pilot. But, he should look on this simply as a question of preserving the model through a few flights, until he has sufficient confidence to try a slope-side landing further up—or else aiming for the no-lift area on the ridge. If our beginner is wise, however, he will not have attempted to commence his soaring in a wind that is sufficiently strong to make this sort of safety approach necessary.

As we have said, the rudder-only model is limited as to the conditions and situations in which it can be flown safely. A model can be made to respond much more precisely—and so be handled in a wider variety of conditions and situations—when we have more control surfaces at our disposal. The addition of elevator control makes both general control and, especially, landing, so very much simpler that, once one has it, one begins to wonder how one ever managed without it!

If your model has survived the rigours of rudder-only control (it may be your third or fourth model, of course, that has survived to this point!) and you have obtained some two or three channel equipment, then an elevator can usually be added to the tailplane of the existing glider without too much difficulty. Or you may decide to build another machine of the same design, but adding the elevator from the inception. You will then know the general "feel" of the model—plus the wonderful feeling of freedom and ease of positioning that the elevator brings, as we shall see in the next chapters.

The "1 + 1" model

With the advent of the "1 + 1" r/c outfits, we really have another class of soarer—a sort of "Rudder-only—plus." This "plus" does not quite amount to another *complete* control, since the "One-plus-One" outfits usually consist of one fully proportional servo plus one *positionable* actuator, similar to a single channel secondary throttle actuator, which gives two or three selectable positions. This positions are only selectable in sequence. That is to say, that they cannot be selected out of order. From position One, the actuator must move to position Two before going on to position Three—and from position Three, it must go back to position One before going to position Two. It changes to the next position on receipt of a signal from a push button on the transmitter.

We can therefore arrange a "trim elevator," to have two or three positions, so that we have a certain degree of "in-flight trim," though this will not be nearly so fine a degree of control as we would have with the trim function on a fully proportional two-function outfit. And, since the trim is "sequential"—it will not be possible to use the control as "elevator" in the normal control sense, as we cannot apply a small amount and then neutralise, more than once, without going through (i.e. using some of) the opposite control—which is not, in fact, desired, and which would have a negating effect on the control just given.

The trim-elevator, therefore, must be used with *caution* but, if used correctly, within its limits, it does give some extra scope to the otherwise limited rudder-only flying.

CHAPTER 5

INTERMEDIATE SOARING

Rudder and elevator control

We have seen, in Chapter 4, that rudder-only models are, for all practical purposes, rather limited in the conditions in which they can be flown, and that this is primarily due to a lack of control of the pitch attitude. By adding elevator control, this obstacle is removed, and a whole exhilarating new world of soaring is opened up to the radio modeller.

No longer do we have to consider wind strength as anything like so critical a factor; we can put the model's nose down at will and, not only prevent its being blown backwards, but make it move more rapidly forwards into the wind. Ease off our forward pressure on the control stick and the model zooms upwards—some back pressure and it comes over the top for the loop with consummate ease. A dab of 'down' next and a further zoom is prevented, bringing the model into level flight once more. Turns, once initiated with rudder, can be tightened up surprisingly by pulling back on the stick. And, again, when coming into wind, that stalling tendency is damped out immediately by the small amount of down pumped in just half a second before the stall would have occurred.

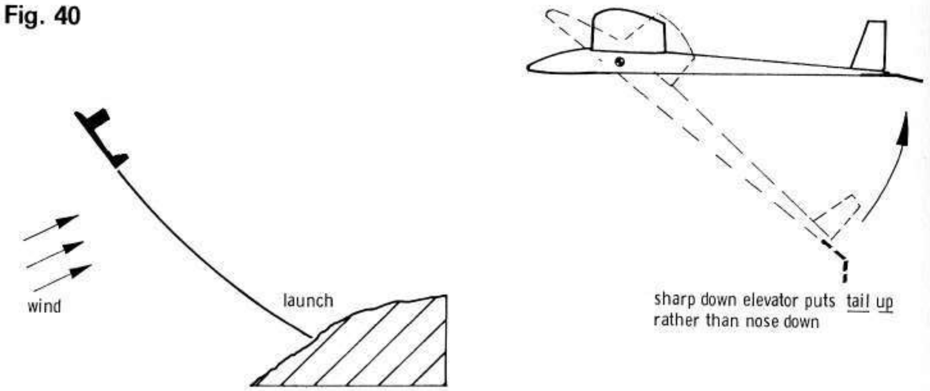
General flying

Now that we have elevator, we must be ready to make the most of it. Beginners often are taken aback at the way their models zoom upwards when launched from the hillside. They seem to be hypnotised by this uncanny phenomenon—and forget to do anything about it until it is too late, and the model has either stalled, or turned and fled over the back of the ridge.

Whenever you launch your model (or have it launched for you) *be ready to put in down elevator*, especially if the wind is fairly strong. If you are coming into soaring from power model flying, remember that, especially with the intermediate model, the control movements need to be much greater for a given response. Don't be afraid to really move that stick about. It is not until we get to the advanced contest aerobatic and pylon race soarers that the response becomes more like that of a power model. It is not uncommon for power fliers, who are trying slope soaring for the first time, to get into trouble simply because they are still giving the very small stick movements to which they are accustomed. If your model zooms up and points its nose in the air as soon as it is launched—*slam* that stick forward *before* it loses all its airspeed, to pick the tail-end up. Once again, as we have seen earlier, *anticipation* is the keynote here, as it is in all flying where the wind effect has to be taken into account. As you will see from Fig. 40, the application of down-elevator with the model at this large angle to the wind does not so much put the nose down as put the tail *up*. But, of course, once it has come up most of the down-elevator must be taken off again, leaving just enough to ensure that the model now moves forwards and out from the hillside.

Once safely airborne, the beginner should tack the model to and fro along the face of the slope, to get the "feel" of the controls. Keep fairly well out from the hillside, so that there is room for error. You will be surprised how that wind drift can catch you out. Don't forget, you are flying the model in a mass of air which is all moving towards the hill at a more or less constant rate. You have to allow for this all the time, so that eventually, like flying towards yourself, it becomes automatic. When the model is flying cross-wind, it will fly at a certain speed, and when it is turned into wind it will slow down—some models will actually *stop*, relative to the ground, and have to be coaxed forwards with some down elevator. You can, of course, make nearly any soarer "hover" like this in the right wind

Fig. 40



velocity, and, if yours wants to do it, without your help, then it means that the wind speed is equal to the model's normal flying speed, so you will need to be "leaning on the stick" for most of that particular outing.

It is often possible to gain quite a respectable height by continuous tacking to and fro along the ridge, but remember—*always turn outwards from the hill, never towards it!* This is not because it is dangerous in itself to turn the model towards the hill, but simply that the model is then flying much faster (flying speed of model plus wind velocity) and that, seeing his model hurtling towards him, the beginner will often "freeze" on the controls, letting his model either fly over the back of the hill—or thump into the hillside.

When you have acquired "second nature" reflexes with the transmitter, and the ability to fly a model towards yourself without getting confused between *your* left and right and the *model's* left and right, then it will be safe to turn your model in towards the hillside because, by that time, you will have also become able to judge turns and drift.

While doing your tacking to and fro along the front of the hill you will be using the elevator quite a lot. Mostly *down* elevator. Perhaps that surprises you? Well, you must remember that a slope soarer gains its height from *lift*, which cannot be produced by pulling the stick back. In fact, as a rule, this will only result in the model's stalling, and so *losing* quite a lot of height. To gain height we must seek out our lift, in the very air in which the model is flying. This is where slope soaring is very much akin to sailing—we are using the wind to our ends, not just barging through it by sheer brute force, like the power boat, or powered aircraft.

At each turn into the wind, the model will tend to rise—and you should be ready for this and dab in just a touch of *down* elevator *which will help it gain height.* If the wind is not blowing straight onto the face of the slope, we will have the same effect as was noted in the previous Chapter (Fig. 25) where height is only gained on the up-wind turn—and is usually only just maintained, or even lost, on the downwind one. Nevertheless, on this downwind leg and turn, do not be tempted to pull the stick back too much, or you may stall the model and could then lose so much height in recovery from this condition, that you may have no choice but to land it at the foot of the slope.

Fly your model a little further afield now, exploring what the whole length of your particular hill face or ridge has to offer. Perhaps there's a bowl shaped area at one point; position the model over it and see if it is getting more lift. Watch it closely and, again, be ready to put in that jab of down elevator as soon as it rises. As with the launch, putting in down elevator will bring the tail up, so that, in fact, the whole model has risen instead of just the front part. This way, you keep the model flying "downhill" instead of rearing up and drifting backwards, as it otherwise would.

While flying the model leisurely around, you may decide to see how far out from the hillside you can get it, without losing height. This can be interesting—and often quite surprising, as some hills go on "working" quite an unbelievable way out. When the model is out there, you may see the nose go up, and put in a touch of down-elevator (this will become an unconscious reflex action after a while)—then you find the model is no longer riding up nose-first the way it does in slope lift, but is rising bodily. You have it in thermal lift! This is the time to sit back and enjoy—because it probably won't last long. Thermals, by their very nature, move across the country, so your model has to fly out of its thermal if it is to come back to its owner. There is a detailed description of these rising currents of warm air in the section devoted to thermal soaring, but even the most diehard of slope men will not disdain to use thermals when they pass by, even though he may never wish to build or fly a thermal soarer as such.

Turns—the use of elevator

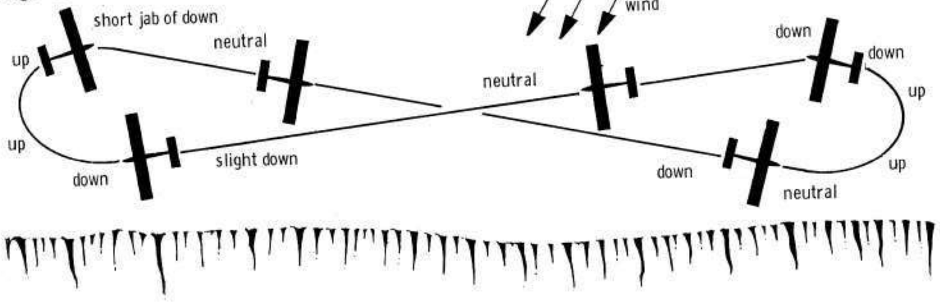
The emphasis we have been placing on down-elevator does not mean, of course, that there are not times where up-elevator is used. Naturally there are, and one of the commonest is in tightening turns, as we mentioned very briefly in the opening paragraphs of this chapter. Now that we have elevator, we become conscious of controlling the pitch axis of the model virtually all the time, instead of having to cope with changes by either turning into wind, or out of it.

To make a turn, therefore, we first put on a little extra speed, by holding just a fraction of down elevator. This is eased off, as we put in (say) right rudder, to bank the model and start it turning. We then pull back on the stick to tighten up the turn—*and, at the same time, neutralise the rudder.* If the rudder is not neutralised at this point, the model will put its nose down and go into a spiral dive. Speed must be maintained in this type of turn, or the model may stall. When the model is heading in the desired direction, we give enough opposite rudder to bring the wings level once more, plus a touch of down elevator to prevent a zoom. The actual degree of control movement will vary with different models and, in any case, can only be found with actual practice.

For the sake of simplicity in describing the turn above, we have not taken the wind direction into consideration. As we have said earlier, the wind is very rarely exactly straight on to the slope face, so wind direction must, in fact, be allowed for. Let us now attempt to analyse the elevator movements in simply turning at the end of each pass along the slope face—in other words, of executing a very elongated figure of eight.

If we imagine that the wind is coming from slightly to our right as we stand looking out from the hill, our elevator movements will vary, roughly, as shown in Fig. 41. For the sake of clarity, only elevator is shown—we can assume that the appropriate rudder movements will be fairly apparent, bearing in mind that, to complete a turn, a touch of *opposite* rudder—not just neutralising it—will be necessary. With this sort of flying, it is not usually necessary to use very coarse movements of the elevator; fairly light movements of the stick suffice, being increased proportionately to tighten up the turns. The more bank you have put on, the more elevator you can "pull"; the wider the turns (i.e. less bank) the less elevator

Fig. 41



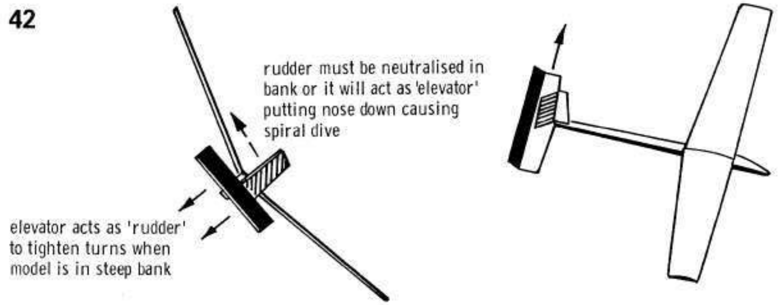
will be needed, until, with the very wide, flat, turns, elevator need hardly be used at all, except for correcting any upsets due to air turbulence.

To clarify this tightening of turns by using elevator, Fig. 42 shows how the elevator acts as a rudder when the model is in a steep bank. It also conveys why the rudder must be neutralised, once the bank has been initiated, as it can act as an elevator and put the model's nose down steeply.

It will be seen (Fig. 41) that when flying to the right—partially into wind—some degree of down-elevator is maintained, then the elevator is neutralised as rudder is applied for the turn, followed by some up elevator to tighten it. The model faces into wind at this point and rides up, gaining some height. Some down elevator is then applied to keep the tail up. This is maintained on our right-to-left pass as the wind is partially at the model's tail and we have to keep its airspeed up. It is now travelling quite fast (relative to the ground) so we start to turn well in advance of where we normally would, to allow for drift. We put on a fraction more down elevator, to build up speed for the turn, then commence the right turn with the control stick making a gradual transition from down to slight up—and then neutralising. A brief touch of down as the model comes into wind, and then neutralise the elevator . . . and so on.

It is a good plan to practise elongated figure of eight turns like this until your stick movements are thoroughly and automatically co-ordinated and you do not have to think about what your hands are doing any more. If you have a relatively responsive model, of the "compact" low-aspect-ratio type, you will be able gradually to shorten the distance between the turns, until each leg of the course, as it were, is only about 30 yards or so. Anyone watching the transmitter then will see rapid and more or less continuous stick movements! I call this "goldfish bowl flying" because the model dashing to and fro reminds one of a goldfish swimming to and fro in its bowl. It is very good practice for training your reflexes to become automatic.

Fig. 42



The stall

We have mentioned the stall several times in the foregoing pages, but so far have not described it. As it is all too easy to induce a stall by incorrect use of the elevator, it is appropriate that, at this stage, we should think about what happens to bring about a stalled condition.

Models may be made to fly faster by putting the nose down (down elevator) or slower by giving up elevator. This has the effect of altering the angle of attack of the wing—decreasing the angle for higher speed and increasing it for lower speed. Unfortunately, every model has a certain critical speed below which it cannot be made to fly. This is the stalling speed and, when the wing reaches a high enough angle of attack, the previously more or less smooth airflow around it (Fig. 43a) which produces its lift, breaks away (Fig. 43b) and upsets the lifting properties of the wing. For lack of lift, the wing (and thus the nose of the model) drops and the model then dives until it has once again picked up flying speed.

We tend to think of the stall being sharply defined, with the model first rearing up like a frightened horse and then dropping its nose (Fig. 44a). This is the "classic" stall, and usually only happens when a beginner fails to give down-elevator in time, after too hard a launch. Or, of course, it may be induced purposely by diving the model and then neutralising the elevator, letting the model zoom up into wind—without getting the tail up. That sort of stall we all recognise, but it is the other kind that is more treacherous—the one that sneaks up from nowhere and plucks the model out of the sky before the pilot has realised what is going on. The model does not *have* to rear up in the classic fashion. Certain models, if flown slowly enough, will simply appear to put their noses down and dive. Now, the worst thing the pilot can do at this point is to pull the stick back. The wing is already stalled and he would only be preventing recovery—even if heaving back on the stick does seem the most natural thing to do!

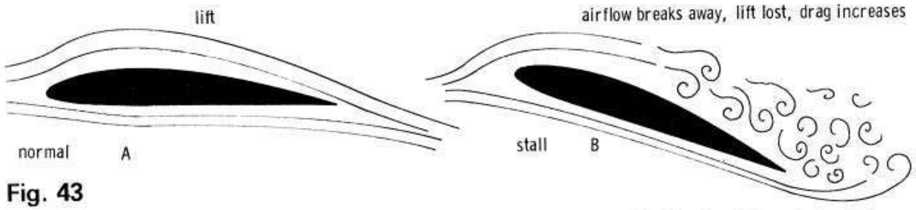


Fig. 43

Often a model will not only stall in this way, but one wingtip will stall first, then the model may go into a spin. To pull the stick back in these circumstances is to ensure that the model continues spinning—right down to the ground. The best procedure is to give a dab of *down* elevator (there it is again!) to restore the airflow over the wing, and *then*, gradually, ease the stick back until level flight is attained.

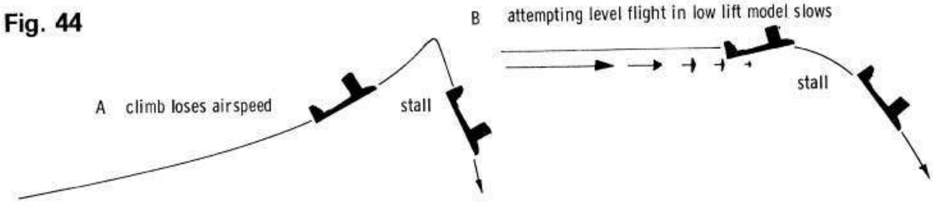
Near-stalled launch

Not only does the wing cease to work as a result of the stall, the control surfaces become increasingly less effective as the speed slows down towards the stalling speed. This is particularly noticeable on some of the larger models, especially the semi-scale types with high aspect-ratio and little dihedral. With models like this, it is vital to keep the speed up in order to maintain rudder authority. To launch them with a nose-up attitude can be fatal. They should always be launched fairly fast, and with their noses pointing well down, so that they can be "driven" well out from the slope before having to make a turn.

An example of the near-stalled launch, with this sort of model, will perhaps illustrate the point. The wind is coming slightly from our right, once more, and we are holding our model aloft, ready to launch. At the word go, we launch the model, but straight out instead of into the wind, and—somehow or other—its nose got pointed slightly upwards as we let go. . . .

The model immediately starts to head round to the left, and puts its nose up a little further . . . the pilot puts on full right rudder to try and head it back into the wind, but now the right wing has lifted and the wind gets under it, turning the model still further to the left . . . the right rudder doesn't seem to be doing anything at all . . . the model is now drifting sideways to the left and is already over the top of the slope, still in a nose-up condition . . . the pilot, for some reason, still thinks he can regain control, and continues to hold full right rudder, but seems to have forgotten about the elevator . . . but the model's

Fig. 44



nose now suddenly drops, and the pilot pulls in full up-elevator . . . and you both spend the next five minutes picking up the pieces, and arguing about whose fault it was.

Well, it was your fault initially, for not having the nose pointed well down, and the model pointing square into the wind. But it was also the pilot's fault for not recognising the condition earlier. What could he have done? First, he could have bent that stick forward, and got the nose down—even if it meant doing a touch-and-go on the hillside; he would have then had the air flowing fast enough past the rudder to make it effective, so that he could have turned into wind. If he wasn't able to react fast enough to do this, and was still holding on right rudder, he should have seen that it was not going to respond to this, and given *left* rudder as the model began to get round, over the top of the slope. The nose would then have tended to drop (the rudder tending to push the nose down in this attitude, instead of keeping it raised, as did right rudder) and, at least, he could have straightened out and landed, instead of stalling and dropping out of the air in a heap of debris.

Keep the nose down, then, especially with this type of model and, if it obviously is *not* going to turn back into the wind, then "give it best" and turn it the way it's already trying to go. This latter is not a general rule, however—only for the small-dihedral, semi-scale sort of machine. With the more manoeuvrable "compact" model, *you* must be the master, and place it where you want to, not let the model fly the pilot!

Simple manoeuvres

Just cruising the model around all day, gaining height, or just maintaining it, depending on the conditions, is completely satisfying to some people. Others prefer to liven things up with some aerobatics, or "stunts." This is where the type of model used can make quite a difference. Bearing in mind that we are talking here about "Intermediate" models, using rudder and elevator controls, there is still a wide variety of types and sizes of model, and their aerobatic capability varies accordingly. Every design has its own particular characteristics but, for our purpose here, we need simply divide them into two groups—the "compact" type, with relatively low aspect-ratio, and the more graceful, but less nimble, high aspect-ratio types.

Only the models with a fairly low aspect-ratio will roll, but all models should be capable of stall-turns and loops. The spin is not so clearly defined; some models—of both categories—will do it, and others will not. Generally the most stable models, with their centres of gravity at the "safe" forward end of the range, will not spin. Let us now look at how we go about doing some of the simple manoeuvres open to the fliers of intermediate models.

The loop. Head the model into the wind and make a long, fairly shallow dive, to gain speed. Then ease the stick back until the model is upside-down. Now gently let off some of the back-stick to keep the loop nice and round. How this is done will depend on the individual model, and trial-and-error will be necessary to achieve a good round loop. As the model returns to the straight and level attitude once more, press in some down, so as to make a clean and level exit, without zooming up again. Fig. 45 shows the sequence.

Fig. 45

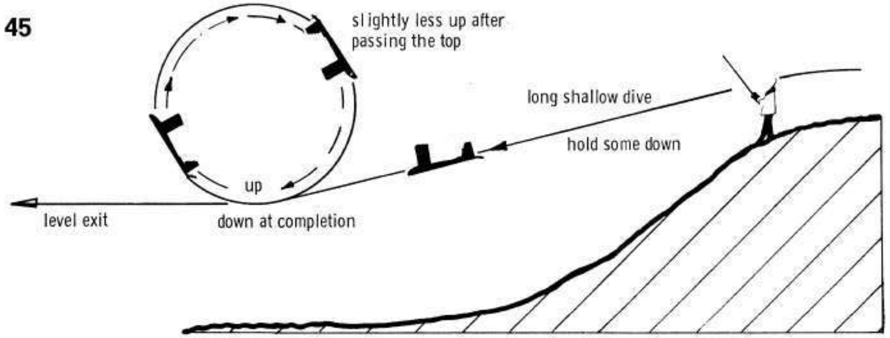
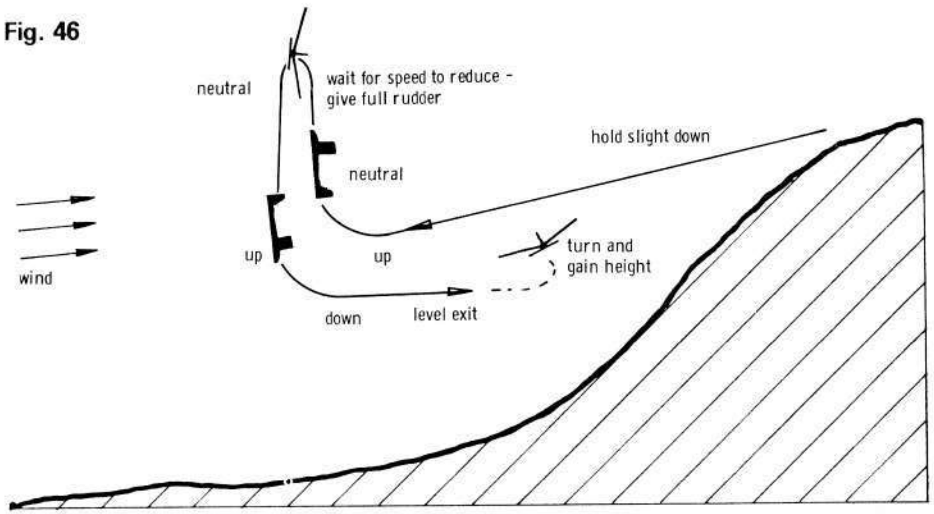


Fig. 46



A great deal depends on attaining the correct speed before entering the loop. If the model is not going fast enough, it may just *flop* over—or even simply stall, instead of flying right round the loop at a fairly even rate. Again, this will vary from model to model and so can only be arrived at by experiment, as also with the actual amount of stick movements needed.

When you can loop the model in this manner to your satisfaction, try doing the figure sideways on. This will usually mean doing it cross-wind, but you will be able to see the roundness of the loops. Rudder can be used, to a certain degree, to prevent the model "screwing out" due to the cross wind. (Only ailerons will give the lateral control necessary to do this properly, however, and we will be dealing with the "multi"—3-function—model in the next chapter.) The size of the loop is, to a certain extent, governed by the weight of the model. The large heavy model will do large loops, whereas the small, light model will perform quite tight ones. If we try to "open out" the light model's loops, we find that it slows down before it can complete the figure, as it lacks the momentum which carries the large model round.

The stall turn. Timing is the essence of this manoeuvre and, although it is a very simple figure in itself, it needs a great deal of practice to be reliably repeatable to order. Once again we dive to gain speed, but not so much as for the loop, then pull up fairly sharply, so that the model is climbing at an angle of about 70°. Now—*fast*, before it stops and drops back—bang in full left (or right) rudder, *sharply*. This will kick the tail over to one side, so that the nose drops to the other side, instead of dropping forwards as it would in an ordinary stall. Let the nose drop right down and allow the model to pick up flying speed. When you are sure it is safe to do so, gently ease the nose up into a level position and then turn the model (which is now heading towards you, if you commenced into wind) back away from the slope. Fig. 46 shows the sequence.

Where does the timing come in? It comes in deciding the *exact* moment to bang that rudder in. Too late and it will have no effect; too soon and the model will try to roll. The rudder must be able to kick the tail over, without there being enough speed for the dihedral to take effect and produce a rolling component. Quite a narrow path to estimate! Practise until you know the exact timing that will produce a nice stall turn. Later you can try doing crosswind stall turns, and then downwind ones.

For downwind stall turns you will need to take the model quite some distance out from the hill, and then turn it towards you (do an ordinary into-wind stall turn). The model will be coming towards you now, quite fast and, generally, it will not need to be dived—just pull back on the stick and—bang in the rudder. Don't forget that right stick will take the model to your left and vice versa in this situation. Let the nose drop and allow the model to pick up speed again before pulling up to the straight and level once more, facing into wind.

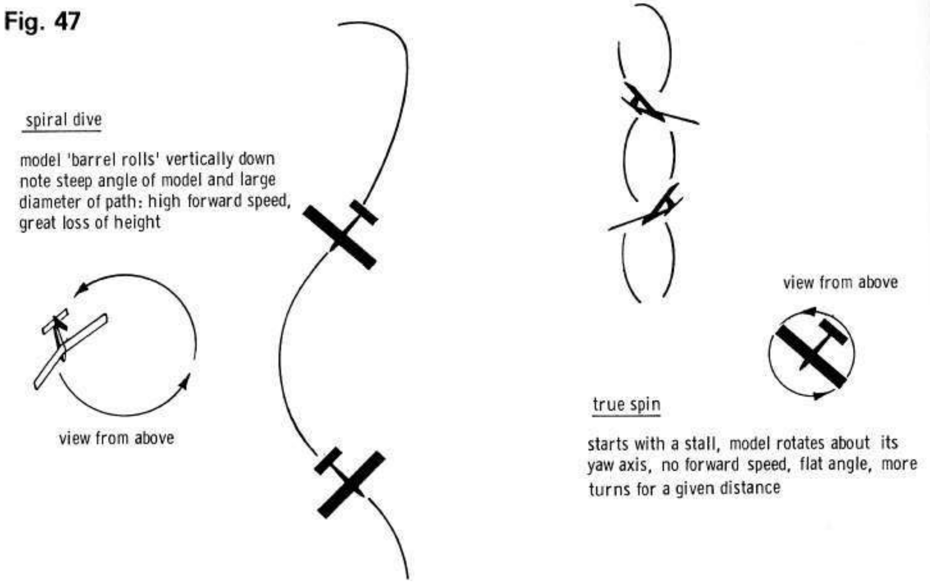
You can practise the crosswind stall turns by doing them along the slope face, rather as we did with the figure eights, going into one stall turn to your right, passing along the slope face and then doing one to your left, and so on. This can be made into one continuous sweeping pattern, and you will find that you get into a kind of rhythm, which makes it easier.

The spin. We have seen how a stall occurs, and this background knowledge is important as the stall is the first requirement for entry into a spin. This fact is not always appreciated by the beginner, and we have witnessed an almost incredible example of this, which will illustrate what we mean.

A group of fliers were soaring their models about in a quite haphazard manner for a while, and then two of them began doing spins. They had "compact" type models which were performing quite a pretty manoeuvre. A third flier, obviously a relative beginner, thought he would try to spin his model (of the same type) too. But it went into a rather vicious spiral dive, from which he only just pulled it out in time. He worked the model back up to starting height and announced that he was going to have another try. By this time suspicion was nagging at us so, instead of watching the model, we watched his stick movements . . . and our suspicions were confirmed. He hadn't the slightest idea *how* to spin! He pushed the stick forwards until the model was diving almost vertically, then to one side, so that the model performed a sort of downward roll.

The difference, as we explained tactfully to this game, but uninformed, beginner, is that the way he was doing it was *driving* the model downwards—and putting considerable stress on the wings in so doing—whereas, in the true spin, with the wing in a stalled condition, it is simply dropping. The speed does not build up as it does in a spiral dive and there is virtually no strain on the wings. Fig. 47 shows the difference between a spiral dive and a true spin. The *stall,* then is the key. Let us try doing a spin now, and follow the sequence. . . .

Fig. 47



spiral dive

model 'barrel rolls' vertically down note steep angle of model and large diameter of path: high forward speed, great loss of height

true spin

starts with a stall, model rotates about its yaw axis, no forward speed, flat angle, more turns for a given distance

First gain some height and take the model well out from the hillside (remember it will drift in towards you while it is spinning). Now, head it into the wind and pull the stick back—right back, so that the model does that classic stall—and, at the instant the nose begins to drop, put in full rudder, while still keeping in full up-elevator. The model should now spin, and keep on spinning, until you release the controls. We say "release" rather than "neutralise," because most people find it best to let go of the stick(s) momentarily, to ensure correct and speedy neutralisation of the control surfaces. Let the model dive straight for about half a second, to unstall the wing, then gently pull the nose up level, and go about regaining your lost height.

Models vary in the amount of time and space they need to recover from a spin, once the controls are centred. Some will only continue spinning for half a turn—others for 1½. It pays to watch closely and see how much your particular model needs, and allow for this, so as to complete an even number of turns, and pull out on the same heading as you entered the spin (*i.e.* into wind). For instance, if your model takes half a turn to stop spinning, you should release the controls after 2½ turns, and then the model will complete a 3-turn spin and straighten up into wind, ready to be pulled out onto an even keel.

As we have seen earlier, when examining the stall, if we *hold* on up-elevator the wing will stay in a stalled condition and the model will continue to drop. Some models (though fortunately very few) actually require a touch of down elevator and opposite rudder before they will stop spinning. The down-elevator reduces the angle of attack of the wing and restores the airflow over it.

If your model does not seem to want to spin, first try increasing the amount of travel of the control surfaces. This may be done by using the inner holes of the control horns or, if you have rotary output servos, using extended output arms on these. If this does not do the trick, then suspect that the centre of gravity is a little too far forward. Try removing some ballast from the nose (a very small amount at a time!), but if the model then tends to be unstable generally, stalling with the slightest provocation, or even with apparently none, it must be accepted that it isn't a spinning-type model. Let's hope your next model will be, because the spin is one of the prettiest and most satisfying manoeuvres, and it does not take an advanced aerobatic model to perform one.

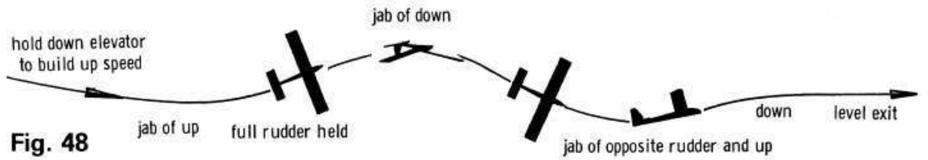


Fig. 48

The roll. This is a manoeuvre that can only be performed by the lower aspect-ratio models. (There are, of course, the odd exceptions, but this is a general rule.) If your intermediate model is of the "compact" type, you may like to try. As with most manoeuvres, except the spin, this needs a dive to generate a reserve of speed. At least as much as for the loop, and preferably a little more. When the model is going nice and fast, level it out and immediately apply full rudder. Now, as the model banks to the vertical-bank position, apply a small amount of *down-elevator,* holding it on while the model is inverted and releasing it as the opposite vertical bank is reached. Then, applying a little up-elevator, pick up the nose as the wings come level once more.

The timing of the elevator movements, and the degree to which they are moved, make an enormous difference to the neatness, or otherwise, of the roll. You may find that, if you put in too much down elevator, the model slows down when it is inverted. As a result of this slowing down, the effect of the rudder decreases, and the model is reluctant to continue rolling. You are then presented with the problem of how to bring it out of the inverted position! Don't take too long to ponder over it; things tend to happen quickly in these circumstances and you may find yourself running out of sky. Your choice, at this stage, is between pulling back on the stick and so pulling the model out by tucking it under, as it were, or doing the more scientific thing (if there is room!) and simply increasing the speed once more by just taking off a very little of the down-elevator so as to put the nose down (having kept on full rudder all the while) when the model should continue its roll. You will probably opt for the first method, as it will seem the natural thing to do, at least until you have had much more practice. Try not to pull out too suddenly, or tightly, however, as this sort of thing can pull a lot of "g" and impose quite a strain on the wings. (Fig. 48).

One can easily spend whole flying sessions just practising rolls and getting the timing right. If the lift is good and it is possible to take the model well out from the hillside, see if you can do two—or even three—consecutive rolls. The rudder is held on all the time, of course, and the elevators will be alternating between down (while inverted) and up (as it comes upright). Remember, the model should emerge from the rolls pointing in the same direction as it started. Incorrect timing of the elevator movements can easily upset this and result in the exit from the manoeuvre being anything up to 90° off the original heading.

Of course, with intermediate models, even the best rolls are not the true axial rolls of the aileron model, being all rather more like barrel rolls. The true barrel roll, however, requires the use of up elevator, so that the model performs a much more corkscrew-like figure. We shall see this when we come to fly the full-house aerobatic machine, in the following chapter, when the difference between the axial roll and the barrel roll will be more apparent.

Inverted flight. If your model will roll reasonably well, you may like to see if it will stay inverted for any length of time. If it momentarily paused inverted while you were trying your first rolls, as just described, there is a good chance that it can be kept that way, at least for a limited period. Nearly all intermediate models have flat bottomed wing sections, which makes them poorly suited for inverted flying. Some of them, however, can be coaxed into it, at least to some degree.

For the first attempts, you may prefer to start from a half loop (which should be commenced with the model flying towards or parallel with the slope) putting in the down-elevator when the model is upside-down at the top of the loop. If it does not seem to like this treatment, then you can simply continue the loop, and no harm done—except that you have performed a loop with a flat top—or perhaps a wavy one. If, on the other hand, things appear to be promising and the model is not losing too much height, then try to *steer* it a little, *but make sure all the time that you have sufficient height in which to pull out.* If the idea of half-looping into inverted flight does not appeal to you, then by all means half roll, which is, of course, the correct way.

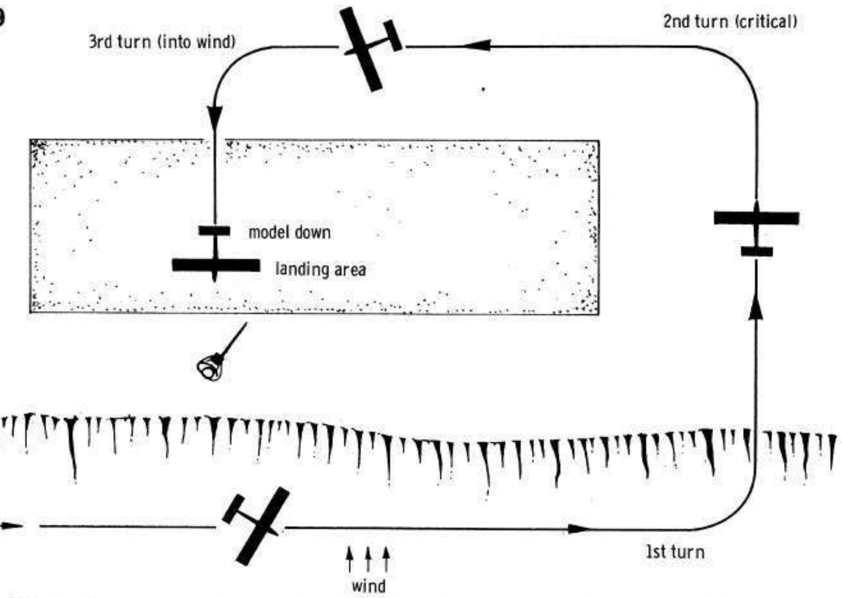
When we come to steering an inverted intermediate model we are confronted by a curious and interesting phenomenon. Although we have to "transpose" our elevator movements—giving "up" for "down" and "down" for "up"—we do *not* have to do this with the rudder. The model is inverted, and we give right stick; the rudder moves to our left but the model turns to our right! This may sound like so much nonsense, but the reader may check it for himself. It is the combined effect of the wing's dihedral (inverted) and angle of attack. So we "steer" normally while inverted, but transpose our elevator, mentally.

While flying inverted, try to avoid giving too much down-elevator, or you will stall the model. Keep the speed up by easing out some of the down, which will give better rudder authority, too. Don't be disappointed if all your model's inverted flying is "downhill." After all, that flat-bottomed airfoil section must be having a pretty hard time of it generating any lift at all, with its flat side uppermost, so that we can expect it to lose out, except in the most favourable conditions. It was fun trying, though, wasn't it?

Landing. With the elevator we have now very much more control over the landing of our model than we did with the rudder-only machine, especially over its speed. All the basic types of landing described in Chapter 4 still apply, except that the model can now be positioned with much greater precision.

If unsure of how the airflow is behaving at a new site, we can still employ the "float it backwards" technique, and augment the effect considerably by easing in some up-elevator, when the model will raise its nose and ride backwards (relative to the ground) more rapidly. An actual stall need not worry us unduly here, as we will be aiming to lose some height anyway. When the model is back as far as we feel is right (*i.e.* when it is just beginning to sink, in the slower moving air) we can feed in some down elevator to increase its airspeed for landing, finally easing off to "flare out" for the actual touchdown. This latter must not be overdone, however, or the model may rise up again and be caught by the wind, when it will undoubtedly turn over on its back or, worse, "cartwheel" with resultant damage to the tail. We want it to "sit and stick," so a gentle but firm and positive guidance is necessary.

Fig. 49



Provided you have a flattish area at the back of the slope, the square approach will be your more normal landing pattern, though just how literally *square* it is will depend upon the conditions. Most people tend to clip the corners, so that, if we drew the actual path of the model, it would resemble more an inverted letter "J"—or even simply a large semi-circle. The general idea, anyway, is the same, namely to bring the model downwind over the slope, and then turn it back into wind in time to put down on the landing area.

With the model about 30 yards out, upwind of the hillside, and at a height of between 30 and 40ft. above the top of the slope, get it going parallel with the face of the slope and then turn it (say) left, which will take it on the downwind leg, roughly over the edge of the landing area (see Fig. 49). At this point it will be "mushing" somewhat—in other words, tending to sink vertically, much more than it usually does in relation to its forward speed (Fig. 50). This effect must be expected and allowed for in positioning the model for the next turn. This next turn points the model crosswind once more and is the critical one which decides whether or not we get down in the landing area.

The ability to judge the precise point at which this second turn is made (allowing for wind speed and the particular characteristics of the slope itself) will only come with practice. Left too late, the model will be into the "sink" area and drop down much quicker than

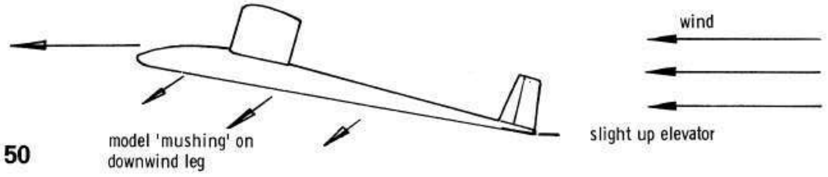


Fig. 50

normal (Fig. 51) (and, since the model is in air that is sinking, up-elevator will have little effect). Judged correctly, the final turn is made, towards the pilot, back into wind, to land the model nicely in the desired spot. But, if you turn too soon, you may find that the model is still too high when you turn back into wind, and is in danger of over-shooting the landing area and going out over and away from the slope again.

There is nothing much you can do about undershooting; if the model is too low at the point where it is lined up into wind, downwind of the landing area, it just lands short, and you will have to go and fetch it from the "rough" (which we hope is not *too* rough!) There are, however, ways of dealing with potential overshooting.

If, having flown the model into wind, and towards yourself, you now appreciate that it is too high and will overshoot, *do not attempt to force it down by giving down elevator,* as this will increase its speed too much. It is a better plan to make some "S" turns, which will shed height without increasing the speed. What we are doing here is, in effect, "using up" the excess height by flying more distance without the model travelling forward very much. And, of course, we lose height in the turns themselves.

Having lost sufficient height, line the model up into wind again and aim for a predetermined spot for touchdown, having first ascertained that the area is clear of people, and having called out a warning to other fliers that you are landing. At this point it usually pays to have some speed in hand—especially if there is some turbulence about. Not so much as one would have had by diving off that excess height, of course, but enough to keep the control response positive. Fig. 52 shows the pattern of this approach.

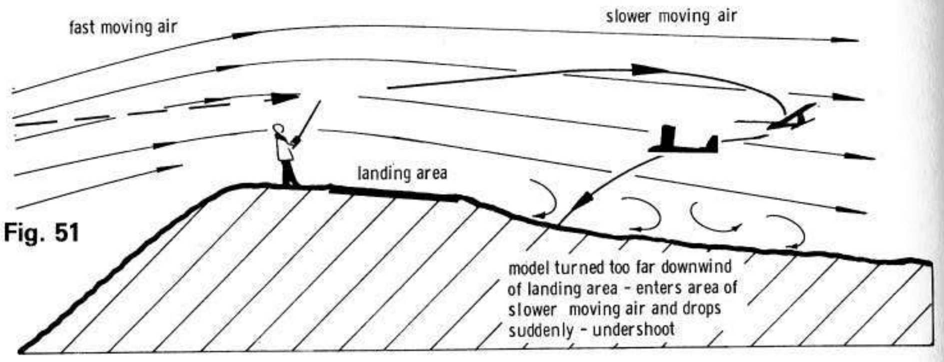


Fig. 51

In really strong winds, the amount of speed one needs for a safe landing increases and one has to land the model very firmly, so that it does not get blown off course and generally tossed about by gusts. In light breezes, however, when there will probably be only slight air movement at the back of the slope, it is possible to float the model in very gently, flaring out and holding back on the stick until it just drops that last inch or two as stalling speed is reached.

The actual tightness, or otherwise, of the turns made during the landing approach is largely governed by the type of model being flown. The larger, heavier model (or even the larger light model, for that matter) will need to make a larger "square"—and, in fact, this will probably be one continuous turn, resembling a large semi-circle. But you will have to learn to judge the size of that semi-circle, in order to be able to set down at the desired spot. The smaller "compact" models, on the other hand, are usually very nimble and can almost be "turned around the pilot" and landed at his feet—with practice. What is more, the "rollability" of the low aspect-ratio models means that they will pick a wing up much more easily, when rudder is applied, than will the larger high aspect-ratio machines. This makes them easier to land in smaller and more awkward areas. Some of the larger models are very sluggish in this respect and, therefore, have to be lined up well in advance.

As an alternative to making the "S" turns described above, to prevent overshooting, we may, of course, elect to let the overshoot actually happen. That is, to fly the model over and beyond the landing area, out from the hill to gain more height, then round again to have another go at landing. You can perform any number of these "dummy runs" (provided you are not interfering with other fliers' landing approaches) until you feel you have the model in exactly the right position for landing. When overshooting and going out again, however, be very careful not to let the model slow down too much and be caught, over the lip of the slope, with insufficient forward speed. It is very vulnerable in this condition, and could easily be caught by a gust and thrown to earth. No amount of control movement will help here, as there is not sufficient airflow over the surfaces. Speed is essential for full control response, so if you intend to overshoot, ease the nose down to pick up the speed to see you safely through any turbulence at the edge of the slope.

Slopeside landing. As we saw with rudder-only flying, in the previous chapter, some slopes do not have back areas conveniently situated for our landings, so other methods have to be employed. Some slopes may have trees at the top, or hedges—or even outcrops of rock, so we have to do a slopeside landing. This simply means flying the model along the face of the slope, as near as possible, and then slowing up by pulling in up-elevator until it settles onto the surface. If the angle of the slope is such that, before the model can be brought sufficiently near in, the inner wingtip will touch, then we must turn the model in towards the hillside and at the same time pull up the nose. Thus it should stall a few inches above the ground, and come to rest with little forward motion.

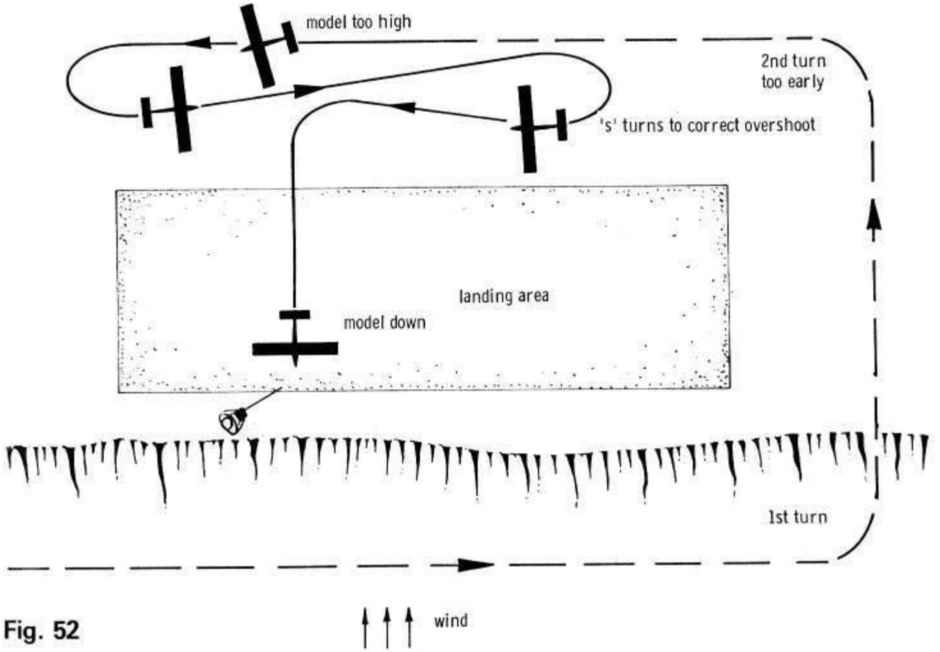
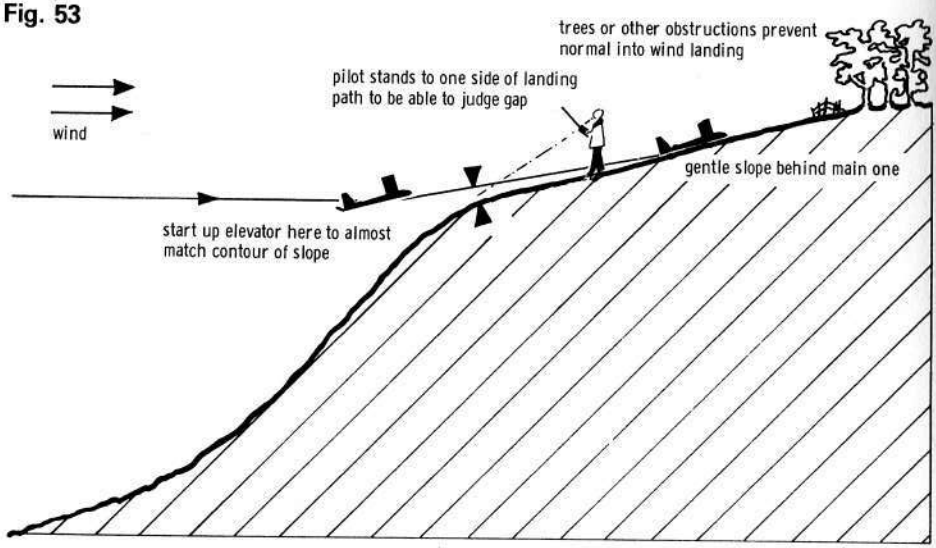


Fig. 52

This sort of landing technique can also be used in bowl sites, and a variation of it is brought into use when the bowl is comparatively shallow—and, in fact, on any site that has *gently* sloping areas before the main drop starts. The procedure is simply to fly the model downwind *at* the slope, but gradually feed in up-elevator so that the model itself follows the contour of the ground, rising with it. Now gradually reduce the amount of up-elevator, so that the ground rises to meet the model, as it were. This is not actually as hazardous as it

Fig. 53



may sound—but we do emphasise that *it should only be attempted on the gentlest of slopes.* Fig. 53 shows the sort of thing.

The model will, of course, be travelling pretty fast, downwind, and will cover a lot of ground in a short time. This sort of landing should, therefore, only be made if there is a good expanse of gentle slope available, which has a fairly smooth surface (short grass) free from obstructions—and people! The pilot should be stationed to one side of the intended landing path, so as to be able to judge the gradually diminishing space between model and ground.

Flying towards you . . .

The business of flying the model towards themselves is often a great stumbling block for beginners to r/c flying, but can be especially so for the slope soaring beginner, because he tends to keep his model pointing into the wind for most of the time—pointing, that is, away from himself, and, indeed, in the early stages is advised to do so. The only time he experiences flying towards himself, therefore, is on the landing approach—where a wrong rudder command could mean a crash! If we are to improve our landings it is essential that we practise flying towards ourselves as much as possible, as soon as we feel we can fly well enough, generally, to do so.

The prime rule is NOT to turn your back on the model and look over your shoulder at it. This may enable you to push the stick to the correct side, but this way you will never learn to do the mental transposition that is necessary. Such behaviour reminds us of the early days of control-line flying (if the reader will forgive the mention of such a thing in a book on soaring!), when for inverted flying, we used to turn the *handle* upside down! This meant that we did not have to adapt to the model's being inverted, as "up-handle" was still "up-model." But, of course, this wasn't really inverted *flying* at all; it was just flying a model that happened to be upside-down. *We* weren't doing anything different, except turning clockwise instead of anti-clockwise. It was not until we forced ourselves to keep the handle the same way up, and *invert our responses,* that we learned how much more satisfying and sensible this was.

It is well worth persevering, therefore, until you no longer have to think about which way to push the stick. Stand squarely facing the oncoming model, and practise turning it to *your* left (*right* stick) and then to *your* right (*left* stick). When you have instinctive reflexes about this, you will see how much more confident your landings become.

Eventually, with constant practice, you will find yourself not thinking in terms of which way you move the stick, but simply which way you wish the model to go. The model has become an "extension" of yourself and you simply "will" it into position—without even realising what stick movements you were making. This what you should aim at. The time it takes varies considerably. Some newcomers attain it in a month or two, others take as many years. Some never really reach this instinctive relationship with their models at all, but they still derive enjoyment from their flying.

Left or right circuits

A similar sort of thing applies to landing approaches. Don't always do anti-clockwise circuits; try changing over every so often, landing from left to right instead of from right to left. It is a great advantage to be "ambidextrous" in this way, as you will, sooner or later, find yourself at a site where it is only possible to make clockwise landing approaches and, if you have not learned beforehand, this lesson may come expensive.

Plan ahead

To conclude this chapter on intermediate soaring, we would like to reiterate the advice given at the beginning of the first chapter on flying. Look at each site you may go to, from the point of view of where you are going to land your model. Do this *before* you gaily launch from the hilltop, so that you will be prepared, in case, for any reason, you should need to set down in a hurry. Have a "flight plan," so to speak, with an alternative landing area (slope-side, or at the foot of the slope) should the lift suddenly disappear and catch your model lower than it started. This little bit of forethought could save you not only some embarrassing moments, but possibly a damaged model.

CHAPTER 6

THE "FULL-HOUSE" AEROBATIC MODEL

Three function control

THE term "full house,'" as applied to model gliders, generally means the use of three radio functions for the primary controls, elevator, aileron and rudder. There are additional refinements such as flaps, spoilers and even variable-camber aerofoils, but these do not come into the basics of flying, as such, and will, therefore, be dealt with later on in another chapter. From the point of view of flying characteristics and potential, we can divide the full-house models into two main categories—the aerobatic model and the semi-scale or so-called "sport" model. (The scale model proper, from the point of view of our generalisation, as far as flying is concerned, may be grouped with the semi-scale models.) Let us first look at the difference between the intermediate and the full-house model. That difference is, primarily, *ailerons.*

Aileron control

Here, for the first time, we have proper control over the *roll* axis of the model. In the intermediate model we produced our turns and our rolls by using the rudder, which first *yawed* the model, then the dihedral effect took over to produce a bank—or a roll, depending on how long we held the rudder over. With ailerons, however, we now have direct control of the roll axis.

Ailerons are coupled to the servo in such a way that when one moves upwards, the other moves downwards. Fig. 54 shows the way in which, when the stick is moved to the left, the left aileron moves up, so pushing that wing down. At the same time the right aileron moves down, moving the right wing up. This, then, produces the rolling action, around the longitudinal axis of the model.

Little or no dihedral is used on models which have ailerons, since they are not required to be auto-stable, laterally, as are the intermediate types. Because of this absence of dihedral the rudder now has its true *yaw* effect; it does not bank or turn the model but simply skids it sideways, and it soon resumes its former course, or almost, when the rudder is centred. Fig. 55 shows the skidding action termed yaw. *We must now forget about the rudder* for turning our model, and concentrate on ailerons and elevator. The rudder will now only be used for stall turns (which, as we have seen, require the yaw action) and spins. (There are other more advanced stages where all three controls are used simultaneously, but we will not concern ourselves with such refinements at this stage.)

Fig. 54

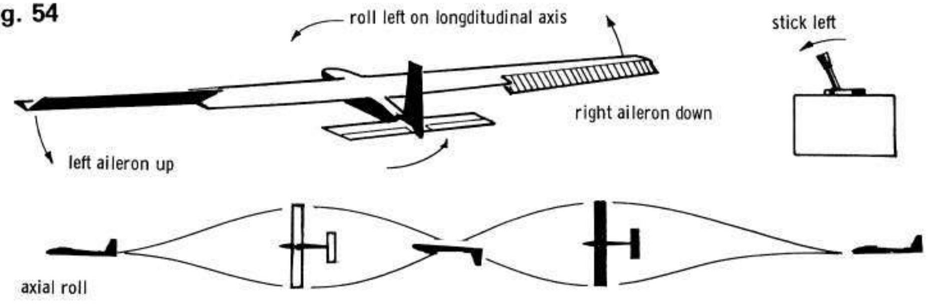
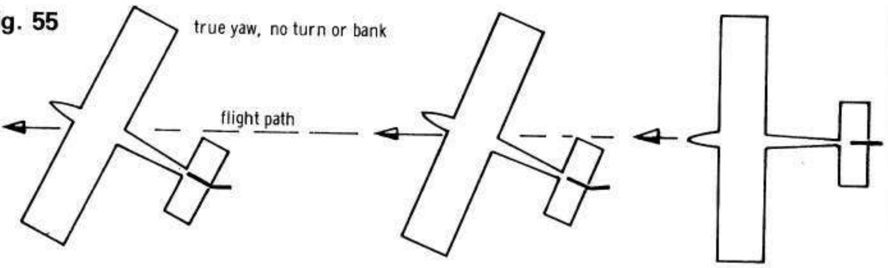
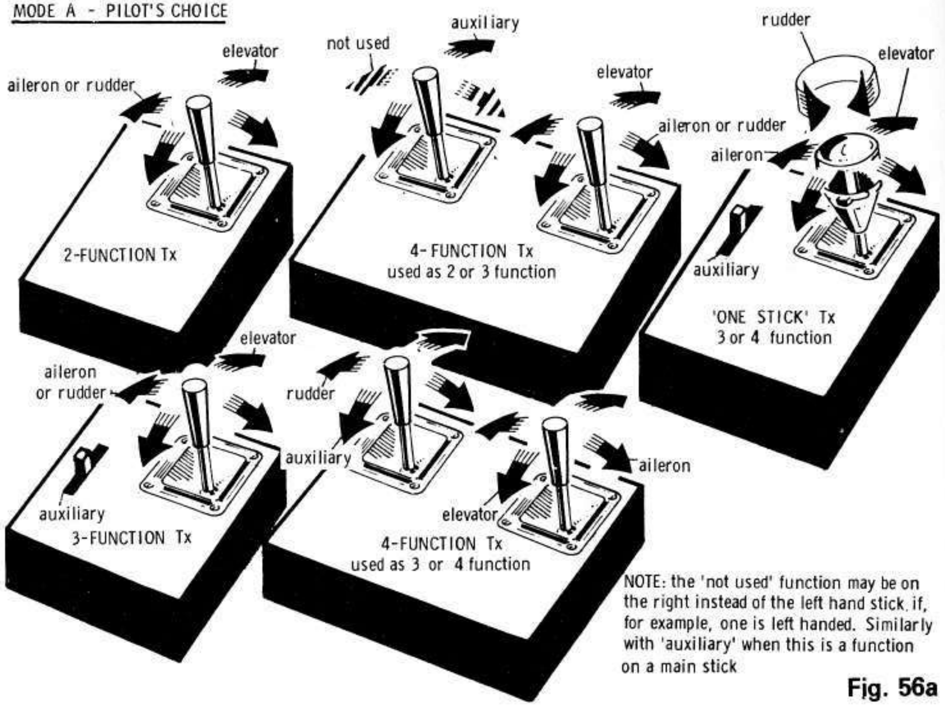


Fig. 55



Prime functions

At this point, a word or two about transmitter "modes" is appropriate. If you have read *The R.M. Propo Book* you will recall that we have two main modes of placing the controls on two-stick transmitters*. Mode A has ailerons and elevator on the right-hand stick, and rudder and throttle on the left. Mode B has elevator and rudder on the left-hand stick, and ailerons and throttle on the right. This is illustrated in Fig. 56a and b.



NOTE: the 'not used' function may be on the right instead of the left hand stick, if, for example, one is left handed. Similarly with 'auxiliary' when this is a function on a main stick

Fig. 56a

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*The two control modes used when flying proportional have, not surprisingly, become known as Mode 1 and Mode 2. However, confusion exists as to which is which and we have decided to denote them as Mode A and Mode B so that at least it will be clear to which mode *we* refer! Mode A (referred to in *The Propo Book* as Mode 1) is where the two primary controls are operated by one stick, with the secondary controls on the other stick. Mode B (referred to in *The Propo Book* as Mode 2) is where there is one primary control on each stick. To be clear, the primary controls are elevator and rudder *or* aileron. On an aeroplane without aileron control, elevator and rudder are the primaries. On an aircraft with ailerons, it is usual for these, together with elevator, to be the primary controls and rudder the secondary control. However, as aileron control can, sometimes, prove to be less effective than rudder, in such a case one would retain the latter as the primary control. In the case of the "One Stick" transmitter (Fig. 56a) the "twist" control is always reserved for the secondary function.

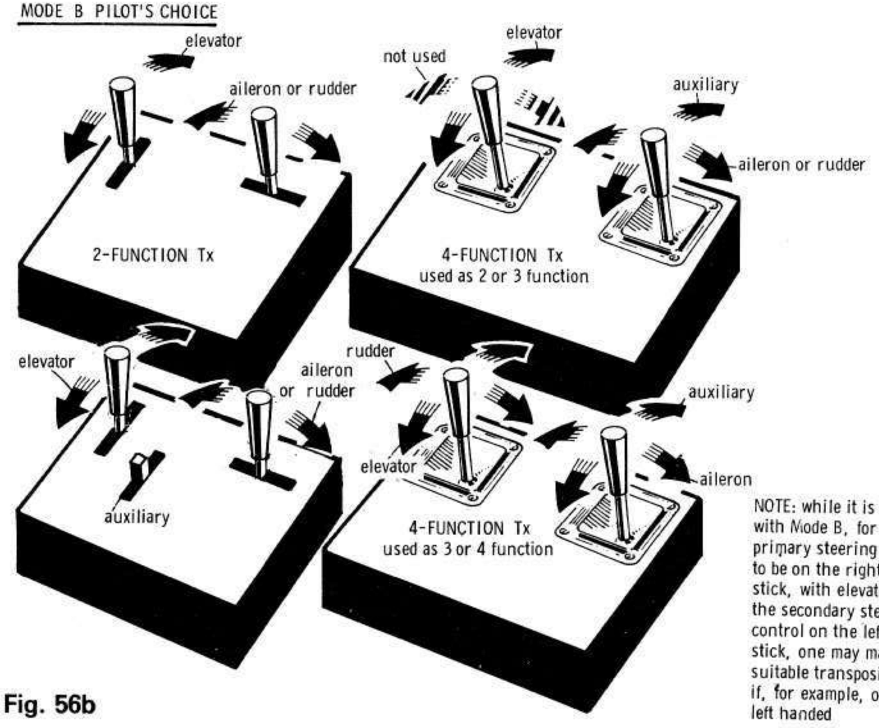
Now, we should always have our prime functions in the same place. That is to say, if we fly Mode A, with intermediate models we have been using rudder and elevator on the right-hand stick, but when we change to full-house, we now have *ailerons* and elevator on that stick, with rudder (now subsidiary) on the left. In the same way, if we fly Mode B, with intermediate we had elevator on the left and rudder on the right. Changing over to full-house it's *ailerons* on the right and elevator still on the left, plus rudder. The rudder has ceased to be the prime function (steering) and is replaced by ailerons—*which are now moved by the same stick movement we used for rudder on intermediate models.*

We have met people who, flying intermediate, have used rudder on the left and elevator on the right. On querying this, it was explained to us that they were "saving" the right-hand stick's remaining axis for ailerons, when they took up full-house flying! This is a curious piece of logic, and will be anything but helpful when they come to change over. Having learned to fly this way, they would be better advised to have *ailerons* on the left, when they add them. However, one would certainly pity any other flier taking over the controls with this bizarre layout!

To sum it up, then, whatever one *steers* with (rudder on intermediate; ailerons with full-house) should be on that right-hand stick, irrespective of which stick works the elevator. Similarly, those with single stick outfits should use the left/right stick movement for rudder when flying intermediate, and for ailerons when flying full-house, with the rudder then transferred to the twisting top of the stick.

Turns

Having said that we must forget about rudder, how do we go about making a turn with our full-house model? To all intents and purposes, the stick movements are the same.



NOTE: while it is usual, with Mode B, for the primary steering control to be on the right hand stick, with elevator and the secondary steering control on the left hand stick, one may make suitable transpositions if, for example, one is left handed

Fig. 56b

However, instead of yawing and banking (and thus also partly turning) as it did with rudder, the bank the model goes into when aileron is applied is *pure* bank. With the intermediate model's rudder, acting with its dihedral, it is possible to turn without using elevator (like the rudder-only model) but, with the full-house aerobatic model, if we only apply bank (aileron) then the model simply tends to fly one wing low. It does not turn until we apply up-elevator. The radius of the turn is, of course, determined by the amount of control movement applied. Many beginners making the change from intermediate flying, we have noticed, tend to be a little too tentative with their control applications. We must bear in mind that if only a small amount of bank is applied, then only a small amount of elevator is required—and a wide, sweeping, almost flat turn, results. If the model is travelling particularly fast (say downwind) when this command is given, it can skid out of its track, sideways. So the faster the model is flying, the more acutely it should be banked—rather like a cornering motor-cyclist.

If a large amount of elevator is given after only a small amount of bank, this will not tighten the turn so much as lift the nose and cause the model to try to do a stall turn or, more likely, simply a stall with one wing low. If, on the other hand, too little up-elevator is applied after a generous amount of bank, the model will not turn tightly enough and its nose will drop. If not corrected quickly, the whole model will begin to drop, in a sort of sideslip action.

At this point, some people may be wondering if it is worth their while changing over to ailerons! If that is so, then we have—in the interests of thoroughness—made the whole thing sound a lot more complicated than in fact it is. The intermediate flier will already have a feeling for the co-ordination between the two controls, and most fliers very quickly develop an instinct for the relationship between aileron and elevator, and their common relationship to the speed and attitude of the model.

The sequence for a turn, then, is as follows: (1) Maintain sufficient speed, (2) Apply bank (say 45°), (3) Centralise ailerons and pull up-elevator simultaneously, holding elevator until the desired heading is reached. (4) Give opposite aileron for long enough to bring the wings level and, simultaneously, a touch of down elevator to prevent the nose rising.

A little practice doing turns, like this, and the co-ordination will become so natural that all you have to think is "I'm going to turn"—and it happens.

There is no doubt at all that the addition of aileron control makes as great a difference to our flying as did the addition of elevator when we changed to intermediate from rudder-only. It makes models vastly more manoeuvrable and adds considerably to the number of figures they can perform. For landing, especially in awkward or restricted spaces, or in turbulent conditions, ailerons enable a wing to be picked up immediately, instead of having to go through the sequence of yawing first, and so pushing forward—towards the ground—that very wing we wish to lift up. Is aileron flying really *so* much superior, for slope soaring? many people will ask. Well, while it might be putting it a little strongly to say that full-house is "the only way to fly," we do not know of anyone who has once used ailerons, ever to go back to regularly flying rudder/elevator again. This is not to say, of course, that everyone's aim is flying aerobatic models. Far from it! But, while there are many semi-scale sport models flying on rudder/elevator, genuine *scale* models, by definition, must have the controls that their full-size counterparts have. Not only is it scale—it also makes them easier to fly! But we will be looking at semi-scale and scale models later on. Let us now look at some further manoeuvres, noting the differences, when we have ailerons, as applied to the aerobatic model.

The loop

Nothing very different about this one, of course, except that ailerons are used to correct any "skewing out" caused by the wind. This could not be done to any extent with the intermediate model because of the turning effect of rudder-yaw.

The roll

As we have seen, in Fig. 54, the roll can now be virtually completely axial. We dive, as usual, for speed, then briefly straighten up before applying aileron and holding it on. As the wings pass the vertical position, ease in some down-elevator—just enough to keep the nose

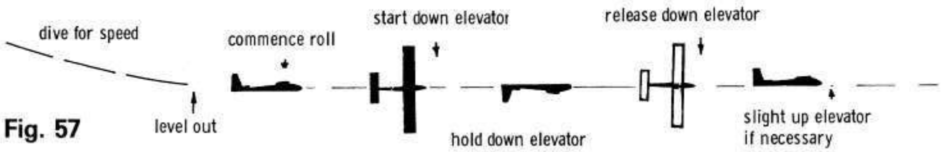


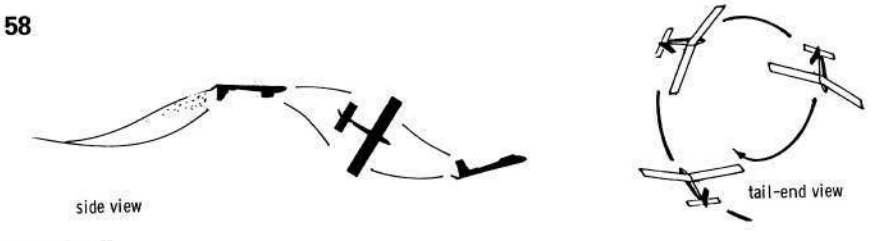
Fig. 57

on the same level—and, as the wings again reach the vertical position, take off the down-elevator and put in a small amount of up-elevator, if necessary, to keep the nose level. As the wings come to the horizontal once more, with the model again upright, neutralise the ailerons. See Fig. 57.

In multiple rolls, one holds in aileron, while using a sort of pumping action, giving first down, then up, then down, then up-elevator—to keep the roll as near axial as possible. The reason for having to give these elevator movements is because the model is rigged to fly upright, and will normally not fly so efficiently inverted. Because of the use of different airfoil sections—some more nearly fully symmetrical than others—different models will have different characteristics in this respect, some of the more highly bred contest machines requiring very little change in trim for inverted flying, and very little indeed for the short period they are inverted during a roll.

In particularly strong winds, it is often possible to make one's model perform a continuous roll without any progress forwards over the ground. It is amusing to see how many "rolls on the spot" it is possible to perform before the concentration weakens and the co-ordination of the elevator gets out of step!

Fig. 58



The barrel roll

With the intermediate model, even our best rolls were of rather a barrel roll nature. Doing a barrel roll with a full-house model, however, calls for it to be made purposely "barrelly." This is achieved (after first attaining some speed) by putting *and holding* on a little up-elevator at the same time as we apply aileron, so that the whole model flies round, corkscrew fashion, instead of on its own axis.

Only a very small amount of elevator must be used, of course, or the model will try to do an upward roll—not what we intended. Fig. 58 shows the barrel roll as performed by our full-house aerobatic glider.

Immelman turn

This is a simple method of reversing direction of flight. It consists of a half-loop followed by a half-roll (Fig. 59). As with most manoeuvres, first we dive for speed. Next level

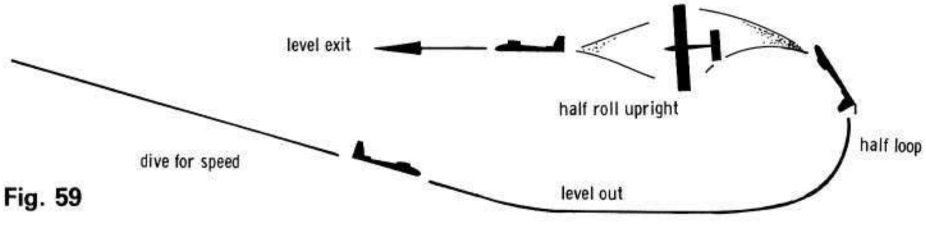


Fig. 59

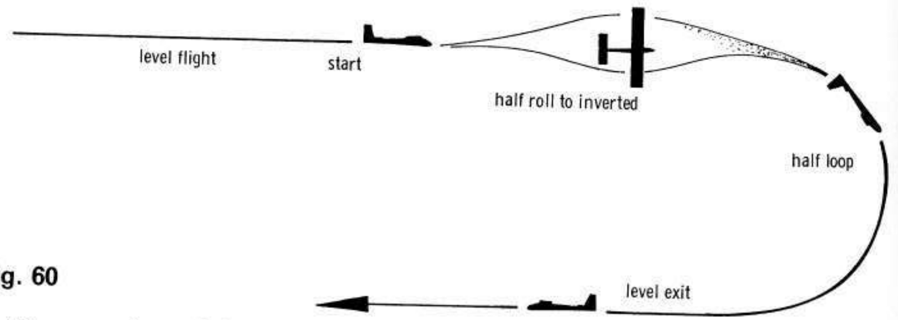


Fig. 60

out for a second or so before starting a loop. When the model is inverted, at the "top" of the loop, we half-roll it back to the upright position and resume level flight.

Reversal

Virtually an Immelman in reverse, (Fig. 60). From level flight, half-roll the model inverted, then pull it round in a half loop to resume level flight. This manoeuvre builds up considerable excess speed and is, therefore, a useful starting point from which to go into other manoeuvres when doing a series of them as a "pattern." It does have the disadvantage of having its exit considerably lower than its entry, of course.

Stall turns

The rudder is used for this manoeuvre—not ailerons. You may find it difficult to force yourself to do this, at first—with your left hand, not your right, but a little practice will see that left hand trained! At first we can do stall turns away from the slope, into wind (as we have seen, in Fig. 46, with the intermediate model), but later we should try doing them parallel with the slope. Thus we can judge the model's angle better—and also enlist a little help from the wind, to tip it over for us, making the manoeuvre much more positive. (Fig. 61).

Spins

These are performed in a very similar manner to that in which we did them with the rudder/elevator model (Fig. 47) except that *some* full-house models (usually those with no dihedral at all) also need to have aileron applied, in the same direction and at the same time as rudder—*i.e.* just after the model has stalled. Most models stop spinning when the controls are centred—most easily achieved by momentarily letting go of the sticks—and we have already seen (Chapter 5) how it is best to familiarise oneself with the period (measured in turns, or fractions of a turn) that a particular model takes to do so.

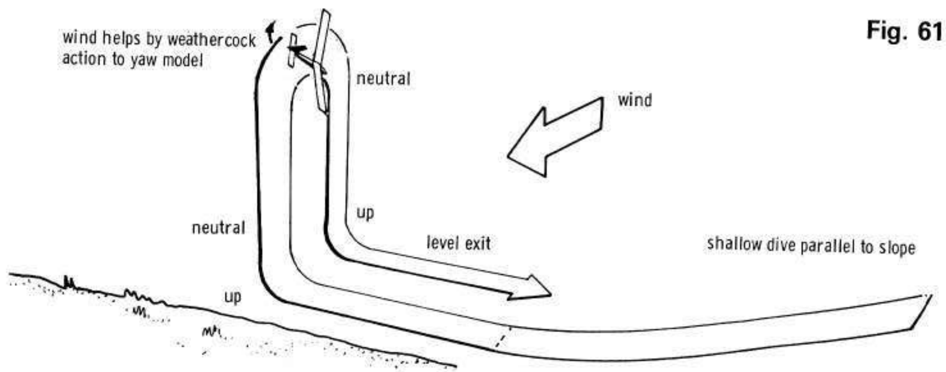


Fig. 61

Inverted flying

We may have found our attempts at flying our intermediate model inverted somewhat less than rewarding, meeting with only partial, if any, success. With the full-house model, however, we have an aircraft that was designed for this sort of thing. A symmetrical, or nearly symmetrical wing section does not mind too much which way is "up," and we have ailerons for lateral control. Because of the wing section, not nearly so much down-elevator is required to keep the model's nose level and, of course, the ailerons work in the same "sense" whatever the model's position.

To try some inverted flight, then, first position the model well out from the slope, and at sufficient height to allow plenty of room for mistakes. (It is surprising how quickly height can be used up by a few unintentional "up-elevators" when the model is inverted!) Now, put on a little speed by slight forward pressure on the stick, level out and then apply aileron (either way—whichever side seems natural) when the model will roll. Neutralise the ailerons just a *fraction* before the wings reach the horizontal position with the model on its back and, at the same instant, apply a little down-elevator (Fig. 62), to keep the nose from dropping, which it would otherwise try to do.

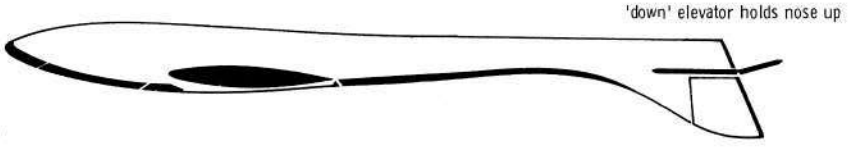


Fig. 62

It will be necessary to experiment in order to find the exact amount of down-elevator to put in at this particular roll-over point, as each model will have different requirements. If anything, err on the mean side, since too little will cause the model to gain speed—which is always safe—whereas too much could stall it. Once the flight path is more or less stabilised, the speed can be controlled by the use of the elevator in the usual way—apart from having to "think upside-down."

Persuading the model to take up the inverted position, then, is simply a matter of going through the actions of the first half of a roll. *Flying* it inverted takes rather more concentration. The elevator has now changed 'senses' and, to put the model's nose up, we have to give a stick movement corresponding to "down-elevator," and vice versa. Most people develop their own aids to this mental transposition, while learning, but one of the best methods is *not* to think in terms of your own "up" or "down" but in terms of the model's—*relative to the model itself,* not to the ground.

As we have said, the ailerons work the same way whichever way up the model is (they have to, if we think about it, or we could not perform a roll), so we use them normally to correct any wing-low tendencies. When you have had as much of this rather tantalising "inverted elevator" as you can stand, for the moment, bring the model back upright. The correct way is to roll back to the upright position, but it is a great temptation to the novice simply to pull back on the stick and half-loop out. This is in order, provided there is still sufficient height, for the first few tentative attempts (and admittedly it seems the easiest thing to do, at the time!—what a relief to relax from that intense concentration!). But do try to start to *roll* out, as soon as you feel you have sufficient confidence.

When you find yourself able to keep the model inverted for a reasonable time (say, 10 seconds), the next thing to do is to try some turns. Build up a little speed first, by easing off some of the down-elevator, then apply bank and tighten the turn by means of elevator in the normal way—*except* that it is down-elevator that we increase to tighten the turn, not up.

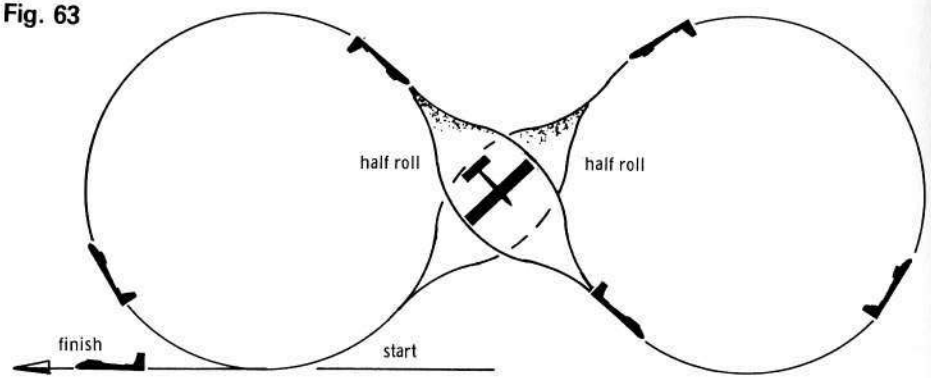
When you eventually get the feel of this, you will want to try prolonged inverted flying, and figures like inverted circles or eights.

Inverted spins

While you are practising your inverted flight and generally familiarising yourself with your model's inverted characteristics, you may like to try an inverted spin. You will probably already have stalled the model inverted, through putting in too much 'down.' For the spin, of course, we first need just this inverted stall. From level inverted flight, into wind, ease in all the 'down' available, so that the model stalls positively. Then, as the nose drops—and keeping in full down-elevator—put in full rudder (and ailerons, if they were necessary for a normal spin). The model should now perform an inverted spin.

Recovery from an inverted spin should, by rights, be back to inverted flight. You will no doubt be glad enough to have the model recover any old how at first—while you yourself recover!—but it should be borne in mind, for later on, that that is how it should be done. Start inverted; finish inverted, and on the same heading (*i.e.* pointing in the same direction).

Fig. 63



Cuban eight

If you can loop and roll your model, then you have the basis of a Cuban eight. The actual execution of this figure, however, calls for a well-developed sense of timing. It consists of two interconnected loops, the model performing a half-roll, to the upright position, at the intersections, on each pass, as shown in Fig. 63.

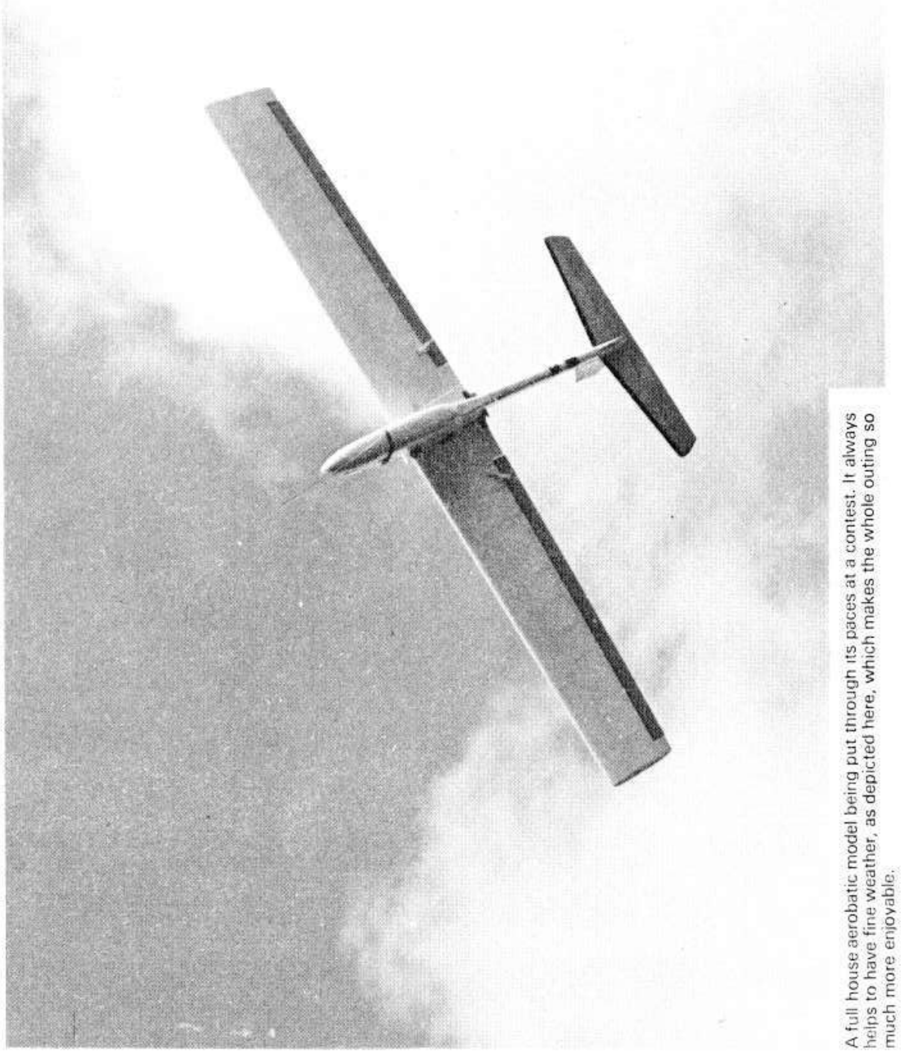
Dive the model as for a loop, commence the loop and then, at the "two o'clock" position—when the model is inverted and diving at about 45°, make a half-roll to the upright position—still at the same angle of dive—and then continue with another loop, again half-rolling at the intersection. Pull round to the bottom of the loop, and level out.

In words, it sounds complicated, but in practice it is not too difficult to do a recognisable Cuban eight. What *is* difficult is to position the loops properly relative to one another, and to make them nicely circular and of the same size.

Outside loop

This is one of the manoeuvres that really started the model designers working overtime, and has resulted in some of the highly developed aerobatic gliders we have today. With a power model, it is relatively easy to execute an outside loop, with a powerful motor pulling the model all the way. With a glider, however, it is a different matter, and both aerodynamic design and flying technique come much more into the picture.

Plenty of initial speed is needed for the outside loop, so it should be commenced from as high as is reasonably possible. Now dive for speed and, just before you intend to commence the manoeuvre proper, level the model out briefly, then ease in the down-elevator to make



A full house aerobatic model being put through its paces at a contest. It always helps to have fine weather, as depicted here, which makes the whole outing so much more enjoyable.

Start of an aerobatic contest flight. You have to be something of a showman to be at your best at times like this. The challenge (and the spectators!) bring out the best in some fliers, while others go to pieces. It's all a matter of temperament.

the model arc downwards and "tuck under" the bottom of the loop, (Fig. 64), easing in still more down until you have in almost full travel at the "ten o'clock" position—pushing in the remaining amount between this point and the top. If the model is a good one, it may actually speed up over this last part, but if it is not, it may slow down alarmingly, and even stall, flopping over either forwards or on its back.

As with all other manoeuvres, much practice is necessary to achieve anything like the correct shape, so try varying the amounts of down-elevator at different points in the loop and you will find how your particular model needs to be flown round it. Probably the most crucial part (though it varies) is the "7 o'clock" to "9 o'clock" one and, if the model has not sufficient speed, this is where it will show up. When attempting an outside loop for the first time, therefore, be ready to roll out or—if the model is almost vertical—simply let it stall and recover in the normal way.

We have described the correct way of performing an outside loop. Another way, often seen, is to start from level flight at normal speed, and gradually increase the down-elevator until the model goes round in an increasingly tight curve. This way, the manoeuvre has no definite beginning (Fig. 65a) and is usually elliptical rather than circular, with the exit much lower than the entry point. Not really ideal but easier, perhaps, to start with than the "classic" one shown in Fig. 64.

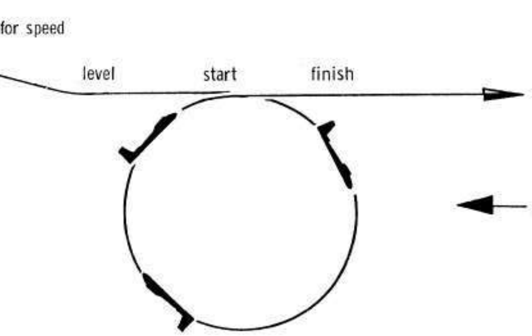
If all your model can manage is something like that shown in Fig. 65b, then either the model itself is not very suitable (wing section not symmetrical enough? Model too heavy?) or else you are not putting in enough down-elevator at point 1, and too much at point 2. Aim all the time for as nearly a circular track as possible.

All in a row . . .

Not content with "improving" the breed to the extent that all aerobatic gliders worthy of the name can do a "bunt" (as it is—incorrectly—nicknamed), some of the contest organisers are now demanding two, and even three consecutive outside loops, so it behoves the would-be contest goer to make sure he can do at least two!

There are, of course, ways of executing and presenting all manoeuvres to score high

Fig. 64



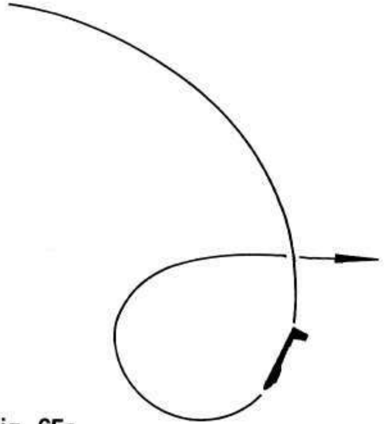


Fig. 65a

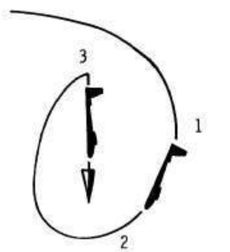
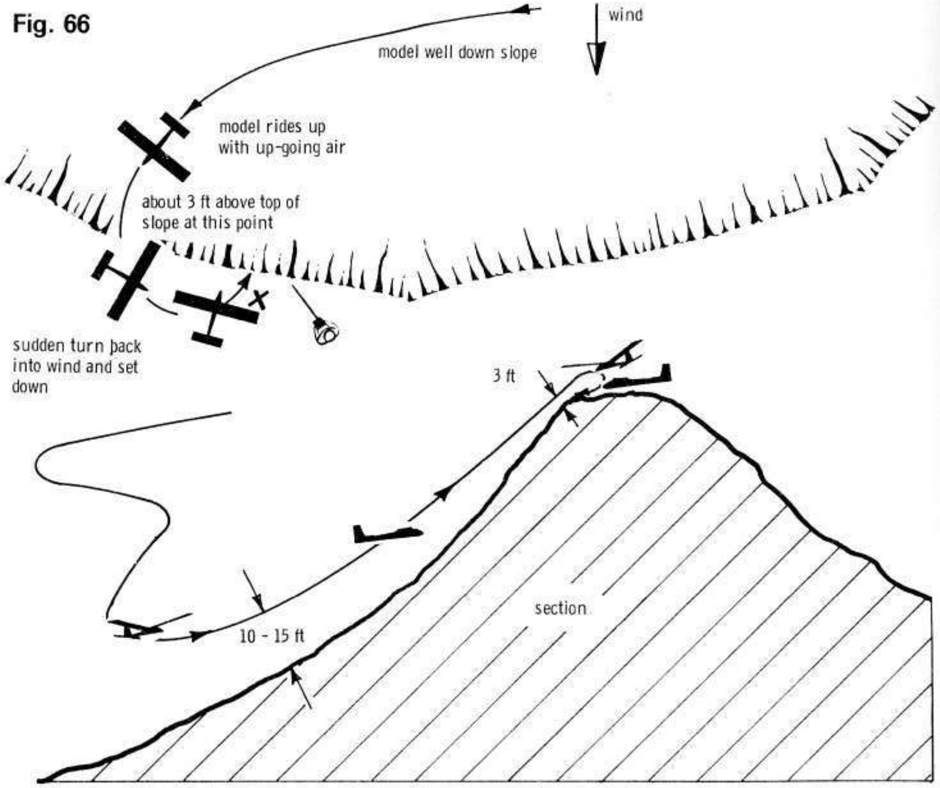


Fig. 65b

Fig. 66



marks, and some of these are explained by our guest writer, Ken Binks, in the chapter "Approach to Contest Flying," a little later on.

General flying

A mistake many newcomers to full-house aerobatic soaring make, after graduating from the more sedate intermediate model, is to fly their models *too slowly.* They then complain that the model is unresponsive and "mushy." The aerobatic model needs *speed* for correct performance and should not be cruised about like a "floater" or it will be near its stalling speed all the time, when its control surfaces cannot be expected to be very effective.

Landing

With full-house, landings become yet another stage easier, simply because one has control of the model's movement in all three axes—pitch, roll and yaw. In a sense, of course, this means that it can also be more complicated, because there are more controls to operate. For most purposes, however, we continue to use only elevator and ailerons.

Depending on the terrain we are flying from, landings may be made in any of the ways described in previous chapters, with the added advantage of being able to *pick up a wing, quickly,* perhaps at the last instant, without having first to make the model yaw, and push forward—towards the ground—that very wing we want to lift clear.

It will be found that ailerons give the model such great near-the-ground agility (as long as the proper flying speed is maintained) that you become more and more able to control precisely the spot at which it lands, instead of being glad to get it down safely anywhere within 50 yards! When you can land the model within six feet of yourself, *every* time, then you can claim to have perfected your landing technique. (If you have not achieved this after a year or two's flying, don't worry too much—there are probably only a dozen people in the country who can do it, anyway!)

A handy way of landing, for most places where there is no flat landing area available, is what we can call the "quick about-face" method. First determine the spot at which it is proposed to set the model down (say, about 6ft. to your left, at the lip of a bowl). Now lose some height, so that the model is some way below you, but do it in such a way that it does not build up too much speed. With the model pointing towards the slope (Fig. 66) and perhaps ten or fifteen feet away from it, *let it ride up the slope with the upgoing air* until it is at the crest, when you turn it quickly back into wind. This sudden into-wind turn gives the model more effective airspeed, which reduces its actual ground speed to virtually zero. At this point, it is only two or three feet from the ground, so ease in the down-elevator to bring it forward, steering the model to the predetermined spot—or as near as you safely can.

The main thing, in doing this type of landing, is not to let the model get too high as it comes up to the lip of the slope or, by the time you ease it down (and thus forward)—it will have gone out away from the slope again! If you start the turn—a steeply banked, tight one—as the model passes over the lip of the slope, it should be facing back into wind and two or three feet up, some six feet back from the lip. This is the general idea but, of course, the wind velocity, type of model and type of slope will all play a part in modifying the details.

A variation of this technique has the refinement of using rudder, as well as ailerons, for the final stages, and is used by the most advanced fliers, who have no trouble in co-ordinating the three controls simultaneously. This is done as follows. . . .

Again position the model well down the slope, and 10 or 15ft. away from it, flying parallel with it. Now turn in towards the slope face, but do not point the model directly at it; an angle of about 45° would be about right (Fig. 67 shows this). Now let it ride up the hill with the rising air, as before, while it is coming towards you, but turn it back into wind while it is still some way down the slope and "crab" it sideways towards you, using the rudder to keep the nose pointed into wind, whilst using the ailerons in the usual way and the elevators to control the height and speed. The last few yards will be covered with the model only two or three feet from the ground, so one needs a steady, reliable breeze for this sort of landing, especially when trying it for the first few times.

Fig. 67

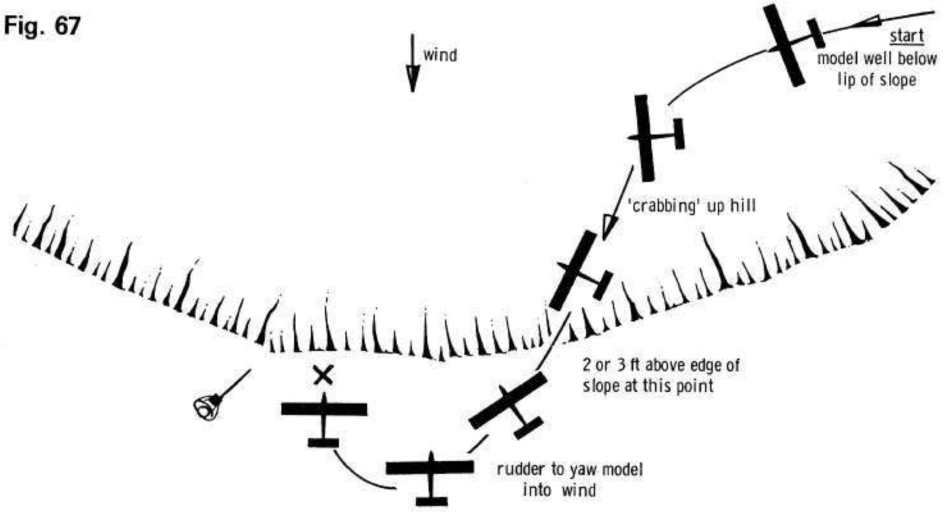
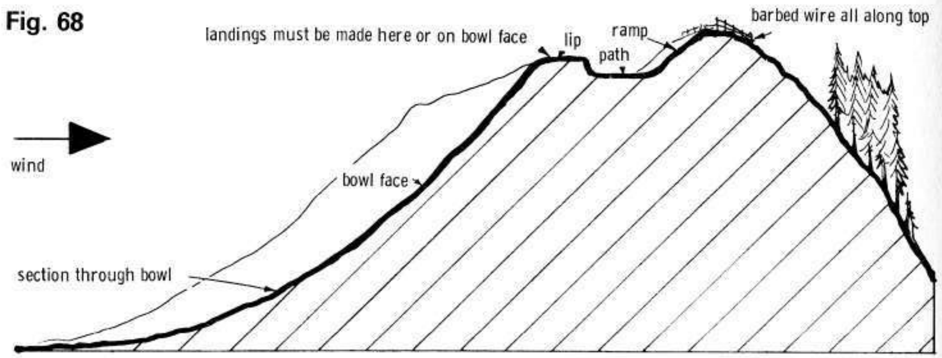


Fig. 68



Be versatile

If you happen to fly regularly from a site with the "classic" plateau top, affording a "sink" area and plenty of nearly flat landing space, then you could well find yourself at quite a disadvantage when faced, perhaps at a contest, with a very different type of site. A bowl, perhaps, with a very narrow lip—say about 5ft. wide—behind which is a path, some 6ft. lower and about 10ft. wide, and then a ramp, topped by a barbed wire fence, beyond which the hill slopes away sharply downwind. Fig. 68 shows the sort of thing. We are not dreaming this up as an extreme case, either—it is based on a well-known contest venue! (Little wonder the local soarers are such expert fliers—their environment encourages it!)

To attempt a square landing approach at this sort of site could be hazardous, as you will readily see. Too far back and the model is in turbulence and sinking air. Turning earlier, and aiming to set down on the lip, could mean the model either hitting the barbed wire fence or, if it clears that, to drop into the downwash coming from the lip—and fall onto the path. If it is high enough to clear all these hazards, it will not be low enough to land on the lip, so unless able to do a "sidle up and sit," the only remaining option for the pilot is to do a slope-side landing somewhere on the curved face of the bowl. From this you will appreciate that it pays to be able to land in quite a number of different ways.

It is very beneficial, not to mention enjoyable, to travel around the country, either to contests or simply trying out new and different sites (take a model on holiday!). This way, you will be landing in all sorts of unfamiliar surroundings, and have to adapt to them. It must not be expected that any single one of all the landing methods described will apply specifically; the combinations of different site configurations are too great. Having become familiar with the kinds of approach, however, it will be possible to combine parts of two or three of the approaches described, and create your own landing technique for any given set of conditions.

Climate makes the model?

Britain seems to have made the aerobatic slope soarer its own. In nearly all other countries of the world, slope soaring gliders still look like full-size sailplanes(!) with high aspect-ratios and slender lines. Mostly these are without ailerons, and so with little, if any, rolling or inverted flight capability. However, the aerobatic lead set by British modellers is spreading. British designed soarers are being flown in South Africa, New Zealand and Australia, and in Germany models are appearing with ailerons—although maintaining their high aspect-ratios and elegant "sailplane" appearance. with correspondingly limited potential in the "extreme" performance range required for outside or inverted manoeuvres.

The British aerobatic soarer is capable of handling almost anything that the weather here can hand out, from 10 to 50 m.p.h., steady or turbulent, and the British weather could well be the reason why our models have developed, as they have, into a quite unique position in the world of r/c gliding.

CHAPTER 7

FULL-HOUSE SPORT AND SEMI-SCALE SOARERS

HAVING dwelt on the nature and flying of the full-house aerobatic glider at some length, we now turn to the so called "sport" and semi-scale models.

There are many modellers—indeed they undoubtedly form the vast majority—to whom contest flying (and thus the specialised contest aerobatic model) is of no interest. In fact, they cannot understand why anyone should make a round trip of anything up to 400 miles just for two five-minute flights, when they could be flying the whole day long at their home slopes! It is to these modellers, who enjoy slope soaring purely for its own sake, rather than as an outlet for an urge to prove themselves better, in some way, than the next man, that the sport and semi-scale models appeal. They can be extremely elegant, and are often very efficient, rising to much greater heights than their "compact" aerobatic cousins. The sight of a near-scale *Skylark* or *Kestrel* circling gracefully aloft is very satisfying indeed.

From the flying aspect, these models, with their high aspect-ratios and resulting large wingspans, simply take up more room to manoeuvre than do the aerobatic contest jobs. They have more mass-inertia and their large spans tend to make them slow to roll, even with ailerons. These characteristics give them an air of majestic serenity—even though they may actually be travelling quite fast. A sort of "scale effect," one might say, which really befits their appearance.

As a general rule, flying this type of model, one must not slow it up too much or a tip stall* and incipient spin can result. While this is usually controllable, sorting it out takes up room, as it were, so a tip stall near the slope or on the landing approach is very much to be avoided. The semi-scale or near-scale model is more prone to tip stalling then is its "free-lance" counterpart because the latter will often have a lower aspect-ratio and probably ample washout at the wing tips, thus being very stable and docile, if not perhaps so sleekly elegant in appearance.

Launching the large model

For its first launch, the large sport or semi-scale model is best held, not by the pilot, but by a helper, with possibly—if the wind is at all blustery—a second helper steadying one wing. The nose should be tipped slightly downwards—about 10° from the horizontal (Fig. 69) and the model launched, straight into wind, with a smooth, follow-through action. Note that *straight into wind*. The wind is not always blowing at right angles to the slope; sometimes it is at a relatively acute angle to it, so do not then launch the model straight out from the slope (superfluous advice, one may feel, but we have seen this mistake made, again and again!) but obliquely from the slope and *directly into the wind*. (Fig. 70).

As always, we must be ready to put in some down elevator as soon as the model is launched, and aim to keep the nose a little below the horizon until some headway has been made, out and away from the hillside. If the lift is good, it is quite possible that the model will start to ride up bodily—even though the nose is pointing well down from the horizontal. It often happens that the movement of air upwards is greater than the model's progress

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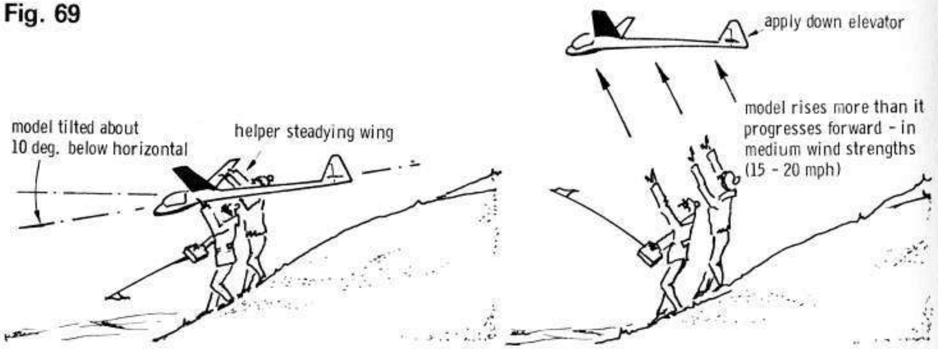
*A "tip stall" is when the tip of the wing stalls first, rather than the whole wing stalling at once, causing that tip to drop sharply. This can be very vicious on high aspect-ratio models with tapered wings, where the chord at the tips is often very small. When the stalled tip drops, the model will often begin to spin of its own volition—very dangerous if it happens near the ground.

To help reduce this undesirable characteristic, it is common practice to introduce "aerodynamic twist" to the wing—known to modellers as "washout"—whereby the angle of attack at the tips is reduced, or even becomes negative. Thus the tips become the last part of the wing to stall, so ensuring a "straight" stall.

Fig. 69



forwards (as depicted in Fig. 69), and we have to apply even more down elevator to gain "penetration" into the wind and out from the slope.

"Penetration"

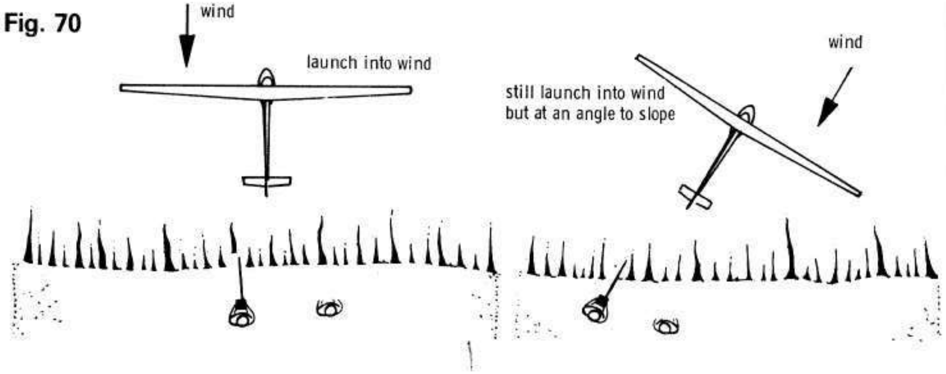
Some models have better penetration in these conditions than others. A higher wing loading will usually make for better penetration, and thin wings will often have a similar effect. The right combination of both will produce a model with very good penetration. Of course, we must be prepared for such models to fly unusually fast when the wind is not blowing so hard. The docile sportster will have a medium wing loading of around 10-16oz./sq.ft. and a fairly thick wing. The near-scale type will, of necessity, have a quite thin wing and, depending upon its construction, a loading of between 10 and 18oz/sq.ft. At the lower end of this range it will usually have fairly pleasant handling characteristics, which become more "interesting" as the weight goes up. (For "interesting" read "exciting"—or even downright hair-raising. It depends very much on the combination of wing-loading, configuration and general design.)

High speed landings

The higher the wing loading, as we have seen, the better the penetration, and we then have to pay the penalty of the resulting high landing speed. One must not attempt to slow these models down too much on the landing approach or, despite washout, one can engender a tip stall, which can result in a spectacular flick-roll at 6ft. altitude—not good practice unless one prefers building to flying. We must allow the model to come in at its natural flying speed, and only ease back the stick at the very last moment when it is within an inch or two of the ground.

Coming in fast, like this, it is desirable that our landing area is as smooth as possible and free from large bumps or tufts which could catch a wingtip or hit the tail. (When flying near-scale or scale gliders, it is a pity that we cannot all fly from a site near a golf course, where we could land on the green in virtually "scale" conditions! As it is, most of us have to set our models down in the scale equivalent of a forest of 4ft. high fir trees!) However, for our landing with the full-house sport or near-scale model, we can at least "pick up a wing" with our ailerons, much quicker and easier than we could with that rudder/elevator sport model, and thus can keep the wings lined up and level, and out of the way of any nasty looking tufts we may see looming up in the landing path.

Fig. 70

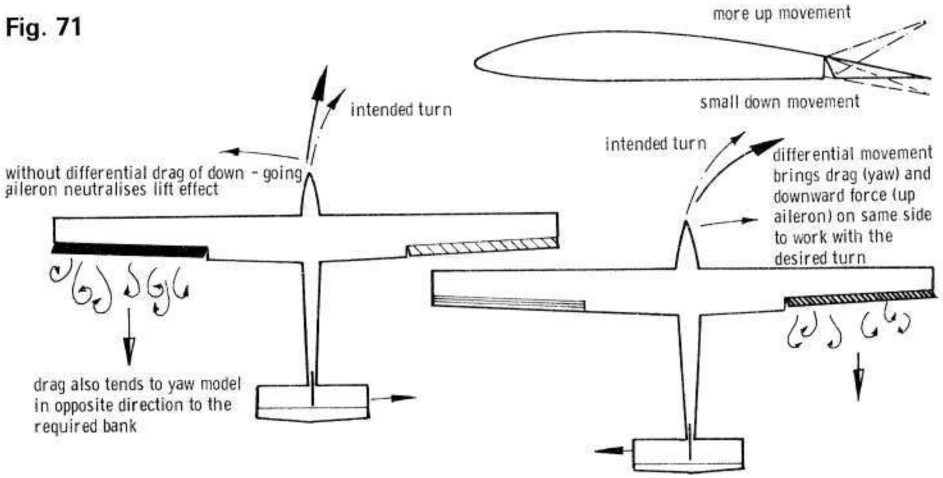


Ailerons and rudder

In turns, for general flying, it is usually preferable to use ailerons and rudder together, in a co-ordinated manner, just as in full-size gliding. While some high aspect-ratio near-scale types will turn well enough on aileron alone, much smoother and realistic turns can usually be effected by using both controls—plus, of course, elevator to keep the nose up and to tighten the turns in the usual way.

Many fliers find it difficult to co-ordinate the controls propertly at first. It is not the sort of thing one has to do in flying any other kind of model, except perhaps the powered scale model. To most, the knack comes, after practice. To some it never seems to quite "click." These will often prefer to have it done "automatically" for them, by means of "CAR" (coupled aileron and rudder) and more information, together with a typical linkage for this sort of system, is given in a later chapter. It is also suitable, of course, for those who only have two-function equipment, enabling them to operate three control functions. If at all possible, however, it is infinitely preferable to keep the control functions operating separately, and learn to co-ordinate them. To have ailerons and rudder coupled all the time *can* be an embarrassment, as the reader will realise, on mentally going through some manoeuvres.

Fig. 71



We find some odd effects with ailerons, on high aspect-ratio wings. If we have equal "throw" on these control surfaces (that is, the same amount of movement, upwards, as downwards), they may not have the effect we require. In fact, it is possible to have an aerodynamic reversal of the ailerons' effect. (Nothing to do with fitting the servo in the wrong way, either!)

What happens is this. The down-going aileron has more drag effect than the up-going one, so this tends to (a) neutralise its lifting effect and (b) to yaw the model to that side—*i.e.*

out of the intended turn. On moving the stick, say, to the right, we see a momentary yaw to the left, followed by nothing very much. Or we may come across a condition worse than this, where the wing with the down-going aileron stalls, and drops. That is to say, we move our stick to the right—and the left wing drops!

What we have to do to correct this rather alarming fault is to incorporate a differential movement of the ailerons, so that they move at least twice as far in an upward direction as they do downwards. A 3 : 1 differential is better still, if it is mechanically possible. Some designs even use a system whereby the ailerons move upwards only, alternately, thereby having the downward force and all the drag on the same side—the inside wing in the turn—so helping the turn rather than hindering it. Fig. 71 shows the differential aileron effect. (Details of the geometry and mechanics for obtaining differential movement will be found in *The Radio Control Guide.)*

As we said earlier, the sort of models we have been talking about in this chapter are usually very "clean," aerodynamically, and highly efficient, being capable in fair conditions of being flown to almost "out of sight" heights. Flying one of these graceful creations, well up into the blue, it is easy to have it mistaken (if only momentarily) by an onlooker, for the "real thing"—and on such occasions who will not forgive us if we indulge in a satisfied chuckle?

CHAPTER 8

THE PYLON RACING SOARER

FROM the "non-competitive" pleasure-flying model, we now turn to a type of slope soarer that has been evolved for the sole purpose—as its names implies—of competitive flying. (Why build a racer if not to race?)

Strictly speaking, most pylon racers could come under our "intermediate" category, in that they require only two controls. However, we have seen that the recognised intermediate controls are rudder and elevator, whereas *most* pylon racers, being largely derived from aerobatic models, use *aileron and elevator.* Indeed, the specialised pylon race soarer is one of the most recent developments in slope soaring and although, naturally, it is possible to fly an "ordinary" aerobatic model in a pylon race, the trend towards specialised designs means that, if one is to be competitive, then one must virtually rule out-of-the-running any compromise designs or dual purpose models.

Speed is the prime requirement here, with turning ability a close second. As we have seen, rudder is not required (this usually only being used for stall turns and spins with aerobatic models, not for turns). Neither are outside loops or inverted flying, so we see a return to the semi-symmetrical aerofoil section and, in many cases, to the flat-bottomed one. For a given area, the wing with the flat-bottom section generates more lift and, when "held down," as it were, by the pilot, that excess lift seems to result in increased forward speed instead of climb. We will not attempt, here, to discuss the reasons for this—though the more technically inclined reader may see some clues in Fred Duedney's technical section, later on—but if our description sounds too "un-aerodynamical" for you, then perhaps it will be more acceptable put another way. Let us say, then, that one can put the nose down further (thus increasing the speed) on the model with the more efficient (lift-producing) wing section, *without loss of height.*

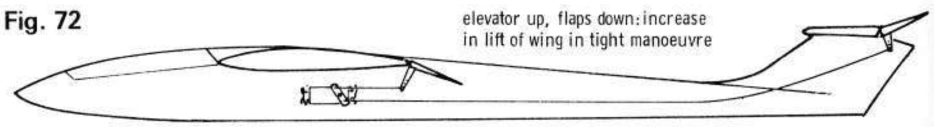
The wings will, however, tend to be *thin,* for low frontal area and low drag characteristics. Spans tend to be a little greater than the average aerobatic model, because aspect-ratios become higher (again, for greater efficiency, since rolling—at any rate past the vertical position!—is not required). The whole model is generally more sleek and cleaned up than the majority of aerobatic models, an increasingly common feature being the use of "V" or "butterfly" tail units, to give reduced wetted and frontal area (and being conveniently less complex, mechanically, for not having to incorporate a "rudder" action).

Perhaps not surprisingly, when one considers their clean lines, high aspect-ratios, and thin, flat-bottomed section wings, some true (that is rudder/elevator) intermediate models—notably the *Cirrus,* a near-scale type based on the full-size sailplane of that name—can be made to fly extremely fast, especially when their wing-loading is increased by ballasting, often making up in sheer speed any loss incurred in having to make wider turns.

Usually, the pylon racing models are constructed rather more solidly than their aerobatic counterparts, the higher wing loading increasing the flying speed (though this, as always, is a compromise, since the heavier models will not turn so tightly). Tightness of turn being a prime requirement, we also find models using the coupled-flap-and-elevator set-up that we described briefly when first mentioning the pylon racing model in Chapter 3.

This system was originally evolved by the control-line stunt fliers, in the 1950's, when their schedules started to demand very sudden changes in direction—square outside loops and so on. The flaps, at the trailing edges of the wings, are coupled to the elevator push-rod

Fig. 72



in such a way that when the elevator is made to go up, the flaps will go down (Fig. 72). Thus, at the very moment when most demand is put on the lifting ability of the wing, extra lift reserves are provided, to enable it to pull round those 'square' manoeuvres or, in our case, the very tight pylon turns, with little loss of speed.

There are a number of variations of the coupled flaps idea; some feature separate flaps, along the inboard half of each wing panel, while others utilise what have come to be known as "flaperons"—a combined flap and aileron. This, by means of one of a number of possible mechanical linkage systems, enables the aileron to act also as a flap (by drooping but still retaining its aileron action) and still be coupled to the elevator push-rod in its flap capacity. Such a system is shown in Fig. 73, which has the added attraction of a "knock-off" crash-proofing feature, so as not to damage the servos in the event of a crash or "heavy landing."

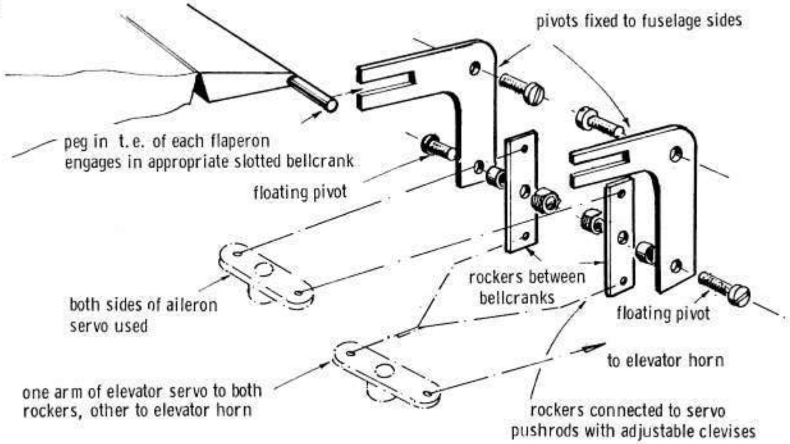
We have seen that some designers go to great lengths to produce aerodynamically "clean" models (no external rubber bands, or even control horns, in some cases), but the question of whether or not a very high surface finish helps does not really seem to have been resolved. We have known modellers produce a really beautiful mirror finish by spraying and rubbing down—and then polish the model with furniture polish, but turn in only a mediocre performance. The winning models, on the other hand, on many occasions have had only a mediocre finish—but a startling turn of speed. On the whole, we think it is probably the general configuration of the model, and the way in which it is flown, that count more than elbow grease at the workbench.

Pylon race flying

In slope soaring pylon races there are usually only two pylons, rather than the three used in powered racing. This, of course, is dictated by the fact that the course must be along the face of the ridge in order that the models can fly continuously in slope lift. The models race to and fro, and turn as they *pass* the pylons, *not* turning around them as in powered pylon racing. See Fig. 74.

There are differences in detail, around the country, some dictated by the nature of the slope (it's not possible to arrive at a standardised length of lap, as no two sites are the same) and others by the ideas of the organising club but, in general, the soaring pylon race is something like this. The two "pylons" each consist of two flags, forming two parallel lines, some 200 or 300ft. apart. A race is usually either six or ten "laps" (12 or 20 "legs"). With the flying start, one minute is given for the models to gain height, the last ten seconds of this being counted down (by the official starter or contest director) to zero. All the models must, at this instant, still be on the start side of the line. Any model having anticipated, even by half a second, the "zero," must turn back and re-cross the line.

Fig. 73



The "flying start" or "sail boat start" is the better and more correct way, but some organisers use a simultaneous launch (which can be rather hair-raising) or else a staggered launch, whereby models are launched one second apart (a better compromise). The flying start, however, is certainly more exciting and satisfying to pilots and spectators alike.

A "flagman" is stationed at the far "pylon" for each model taking part (usually three, but sometimes four in finals), and the pilots must first "identify" their models to their particular flagmen (noting the colour of the flag waved in response) by holding them up aloft, showing top and bottom surfaces, especially if these are coloured differently, or have some particular identifying mark. The winner of each heat goes forward to the next race until the final is reached, which decides first, second and third places.

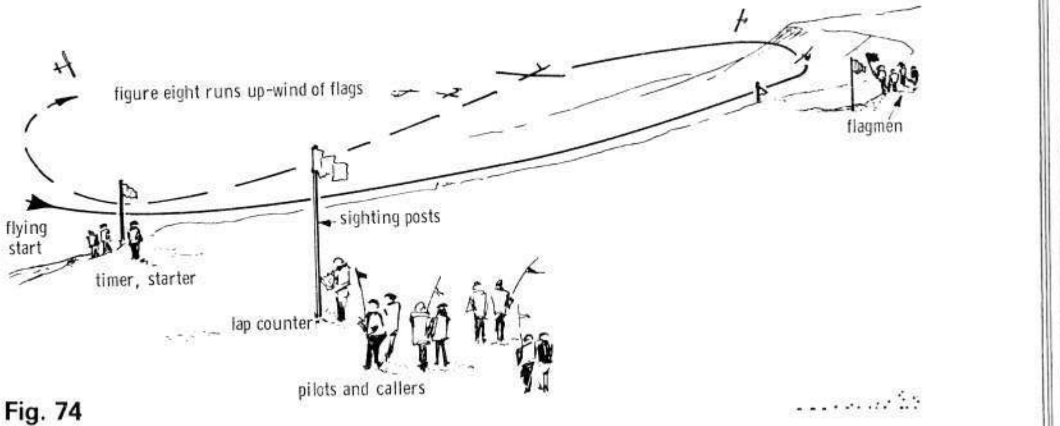


Fig. 74

After you have flown in one or two pylon races you will begin to develop your own technique, but for those just beginning, some general words of guidance. After the launch, search for the best lift and get your model as high as possible in the first fifty seconds. In the last ten seconds before the whistle, position the model somewhere near the start line (though, of course, a lot higher). At about three or four seconds from zero, start a near vertical dive to gain speed, keeping on the start side of the line, of course; if you go over it you must loop or otherwise manoeuvre to bring the model back and recross it.

Now fly straight to the far "pylon," with only the smallest possible control movements—we do not want the model swooping and swerving all over the place, or it will have to travel further. Have a caller by your side, ready to call out when the flag at the far pylon is raised. *You* will be far too busy concentrating on flying the model to notice this. Immediately he calls, do a very quick turn (a near vertical bank, followed by pulling in almost full up-elevator) and fly the model straight back to the "pylon" at your own end, then turn again when called. This is a lap, and is repeated six times (or whatever the particular organisers have decided).

Slight advantages can sometimes be gained by climbing in the turns and diving on the "legs," and it is possible to get into a certain rhythm of doing this—if not baulked and forced to take avoiding action by the proximity of another model. Avoid flying the model too close to the hillside as this tends to make it "crab" along (try to point into the wind), which induces drag and makes the model slower in response. Finally, be on the lookout for those other models; they can come "out of nowhere," and the risk of mid-air collision is very high in pylon racing, where the models are all racing up and down virtually the same narrow corridor of air in front of the ridge.

CHAPTER 9

TYPES OF CONTEST

THE newcomers to slope soaring will have seen references to a number of different types of competition, and will probably be wondering just how many kinds there are. The answer—in one sense—could be "infinite," since there are no standardised rules for slope soaring contests, and each organiser tends to improvise, depending often upon prevailing conditions, the type of ridge available and so on.

The contests, though varying in detail, do fall into a number of definite categories, however, and a list of these, with a general description of each, is given here.

Rudder only

Usually simply a "speed" event, with one model in the air at a time, flying along a slope face between two markers. The greatest number of passes wins the event. Sometimes this event is combined with points for a spot landing (landing nearest to a marked spot).

It must be noted that, with the now almost universal use of proportional radio control (and usually 2 or 4 functions), rudder-only as a competition class, has virtually died out.

Intermediate

This usually consists of a schedule of simple aerobatics, for the rudder/elevator type of model. It may include loops, spins and possibly rolls, with a "nominated manoeuvre" to gain points. (That is, some manoeuvre other than those laid down, but nominated in advance by the competitor.)

Full-house aerobatics

The schedules for this type of event are about as numerous as the events themselves. Sometimes the more "difficult" manoeuvres are given a higher possible score; on other occasions all are marked out of the same possible maximum.

Sometimes—usually as a second round of the same event—there may be a "lucky draw." In this, the pilot, while cruising his model to and fro to gain height, picks a sealed envelope from a pack and is then obliged to perform the four or five manoeuvres written on the card from the envelope. This can be very amusing—at any rate for the other competitors and spectators—as they hear the pilot's howls of anguish when the manoeuvres he has drawn are read out to him.

The other type of aerobatic contest is the "freestyle" event, where the pilot is asked to fly any number of manoeuvres of his own choosing, strung together in a smooth and flowing pattern, with each manoeuvre being called before it is performed. This is where "opportunism" and presence of mind count a great deal. Regular and continuous practice is, of course, required to achieve any degree of accomplishment in this or any other type of aerobatic event.

Aerobatics from the flat

This event really originated at the slope, when the bungee (catapult) launch was used because of completely calm conditions. With a bungee "Hi-start" launch (described fully in the Thermal Soaring section) it is possible to do a limited number of manoeuvres before the model is back to start level.

The idea has now been carried a stage further, to become an event in its own right, with the slope soaring type models being launched from a flat field, either by means of bungee catapult or electric—or even petrol driven—winches. This sort of contest has the attraction that it is completely independent of both wind speed and direction and, given suitable "tasks" in addition to manoeuvres, can be a most interesting and "different" event.

Pylon racing

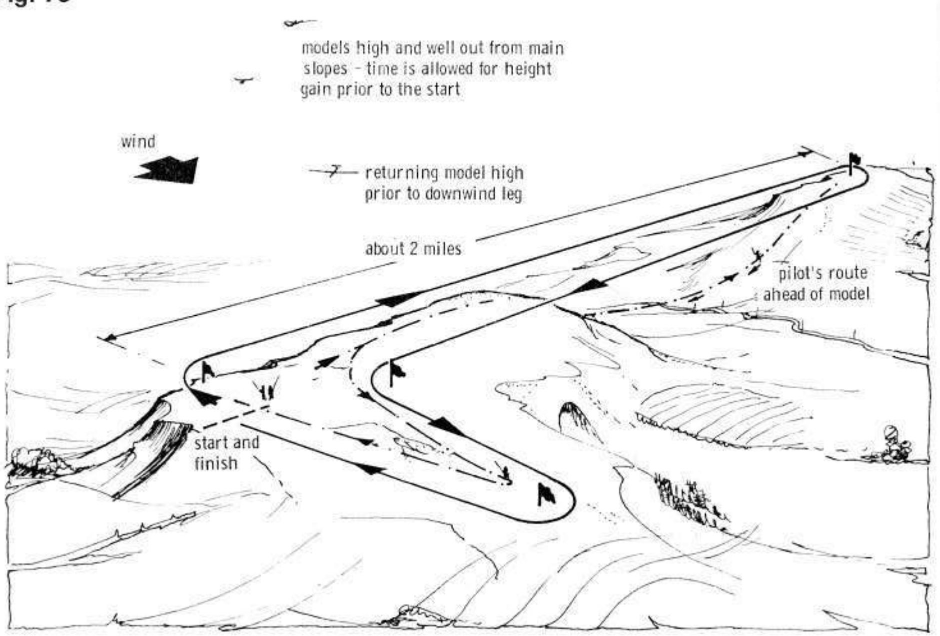
This type of competition has already been described in the chapter concerning pylon racing models. It is claiming more and more devotees so that, instead of being a secondary event to an aerobatic contest, as used to be the case, some organisers are now setting aside a complete day for slope pylon racing.

Cross country events

This comparatively recent addition to the contest calendar has lately been proving the most well supported event of all, with almost double the number of participants of other contests. Probably the reason for its general popularity is that it does not demand a specialised type of model. In fact, the specialised aerobatic or pylon models will generally be at a disadvantage. The cross country event favours glider models that look more like they did before specialisation became rife—fairly large, high aspect-ratio sailplanes, often of the semi-scale type, that are aerodynamically efficient and will gain height easily and maintain it. The sort of model favoured by the "sport" fliers, in fact. So, in many cases, the soarer who never dreams of entering any other sort of contest will take part in a cross country event. Added to this, there is the fact that, apart from the initial cruising about to gain height, most of the activity is carried on well away from the crowds of competitors and spectators, not under the spotlight of their gaze.

Basically a cross country soaring event requires the model to be flown over a course of perhaps two miles or so and, if possible, return to base. This is similar to what the full size gliding people call "goal and return."there will be a checkpoint—perhaps several—which the model has to pass over or turn at, to establish that it has been over the course. Fig. 75 shows a typical course. Each pilot is accompanied by a "co-pilot" or helper, to guide him over rough terrain (the pilot, remember, is trotting along while squinting upwards or over his shoulder to keep the model in sight!) or who is allowed, if circumstances demand, to take over the transmitter while the pilot jumps a ditch or negotiates a stile. The helper may also urge on the pilot with words of encouragement and advice, which are always a comfort during what may be quite an arduous journey! In fact, this type of event can be a test of physical fitness as well as piloting ability. Following by vehicle is not permitted, nor is this practical.

Fig. 75



Often the nature of the conditions will mean that models are virtually "thermal soaring from a hillside" but, of course, the wind may increase in velocity at any time, so the genuine "paper bag" thermal soarer, which is likely to do well in near-calm conditions, might well be put out of the running by its lack of sufficient flying speed, or "penetration."

Another of the attractions of the cross country event is that anything up to six models may be airborne together, and have up to 90 minutes flying time each—plus, perhaps, a fly-off if two or more complete the course. For the average r/c soaring modeller, such an event represents a most enjoyable day out and a chance to see, and talk to the owners of, many interesting models which would never appear at any other sort of meeting.

Scale

Competitions for scale model gliders and sailplanes have not exactly caught on like wildfire in this country—probably the world's leading proponent of the r/c scale power model. A very gradual increase in the numbers of those interested, over the past few years, however, shows that such events may well have a future, though they will certainly never have the mass appeal of the cross country.

So far the rules for static judging have been anything but stringent—in order to encourage a larger entry—the models being judged from a set distance (usually 10ft.). This is commonly known as "Eyeball" or "Standoff" scale, though published 3-view drawings of the prototype, and usually an authenticating photograph (for colour scheme and markings) are generally asked for. Some events add to their criteria "Workmanship and finish," though one could not be blamed for wondering how this is to be assessed at a distance of ten feet.

In flight, realism is the criterion, and models are usually required to perform a few basic manoeuvres in a "scale" manner. A demonstration of the effectiveness of each individual control function is sometimes also required.

There now only remain what we call the "novelty" events, for want of a better term. These are usually held after a main event, if there is sufficient time and daylight remaining. Also called "fun" events, it seems implicit that these events are organised and participated in purely for amusement, rather than any real means of competition and, although small trophies are often awarded, they represent no real "kudos" for the regular contest goers. We will outline them briefly so that our resumé of types of contest will be complete.

Limbo

The name is taken from the West Indian dance "contest" whereby the dancer manages to get under a tape, suspended between two poles, which is progressively lowered each time he or she performs the feat.

In the model flying world, the poles are much the same, the "tape" is usually a light wool or narrow crepe paper streamer—and it is the model which has to be flown under it. (Wits have, of course, suggested that the pilots should keep their models hovering while they themselves scrambled under the tape—something that the rest of us feel the wits ought to be made to try).

At one time, the tape used to be lowered progressively, between rounds, in the manner of the dance. It sometimes still is done this way, but it is more usual to have a set height for the tape with the winner the one who can make the greatest number of clear passes under it with his model in, say, two minutes—instead of the one whose model "survives" through the narrowest gap. All good clean fun—unless your model hits the pole. Depth perception can play a considerable part in this, as may be imagined.

Spot-landing—at "start" level

This is, as its name implies, a landing as near as possible to a predetermined spot on the ground, at the top of the hill, somewhere near the launching point. The spot is usually marked by a coloured disc or similar device, which will not damage the model should the landing be really "spot" on. This type of event is usually combined with a "spot time," so that the contestant has to gauge both speed and distance to a nicety on his landing approach.

Spot-landing—foot of the slope

As may perhaps be imagined, this is usually a "desperation" event, improvised by contest organisers when there is insufficient lift for anything else of a competitive nature to be practical. However, it can be very interesting as, once below the pilot, the actual height of the model from the ground below it can be very difficult indeed to judge, especially if there is no sun to provide a tell-tale shadow. Models will appear to "stop" when one thought they must be at least 30ft. from the ground—or, on the other hand, may keep going long after one thought they must be at ground level. There can be a risk of damage to models, of course, through "flying into the ground" in this way from, perhaps, a considerable distance away.

Most spins

This is fairly explanatory, and can sometimes be even more hair-raising than limbo flying. The contestant is given a specified time (usually one minute, depending on conditions) to gain height, then, at the given word or blast of the whistle, he spins his model and keeps it spinning as long as he dares. The one to do the most spins, without writing off his model, is the winner. Normally the winner, and many other competitors, are obliged to land their models at the foot of the slope, having flown below the lift area, or "point of no return," and it could well be for this reason that events of this nature are usually scheduled as the last of the day.

One piece of "gamesmanship" that can often work to the pilot's advantage (there do not seem to be any rules for "Most spins"!) is for him to go down to the foot of the slope first, then have a helper launch his model, and also call "go" when he is to start spinning it. This way he can much more easily judge when to pull out of the spin, as it will by then be very close to him, and of course, he will be able to land it safely, too.

Advance notice

If you are thinking about attending soaring contests, you should keep a close watch on the "For Your Diary" feature which appears monthly (from February to October) in Radio Modeller magazine. This will give the dates and venues of the meetings, and often also the addresses to which to send for entry forms and contest details. Many contests are becoming so popular that pre-entry is necessary (*i.e.* entry details and fee sent some time in advance of the actual contest) and, when this is the case, again details are given.

With a large entry, slope pylon races can run on until late in the day, as in the case pictured here. The flag man signals that the model has passed the line, when its pilot banks it vertically ("pylon turn") and sends it speeding back to the other end of the course. Another model may be seen, tail towards us, on the horizon line, also banked almost vertically.

Flying the model towards yourself, along the face of the ridge, is a good exercise to teach you your right from your left. Better to make mistakes with space to spare underneath than to give "wrong stick" when landing. Ken Binks, who writes about aerobatic contest flying in Chapter 10, here makes a speed run, pylon race fashion.

CHAPTER 10

APPROACH TO AEROBATIC CONTEST FLYING

By KEN BINKS

IF you attend any slope soaring competition around Great Britain, you will find a really friendly crowd who are really there for the flying and the chat, as much as for the contest itself. The competitive spirit is there, but without the ill-feeling and cut-throat undertones that one seems to find at power competitions. I really enjoy competitions at the slope, not only for themselves but because they present the opportunity, like nothing else does, to meet fellow enthusiasts from other parts of the country, and to see their models, discuss new projects and so on. It has always been like this, right from the very early days of r/c slope soaring, and I hope it always will be. It is aerobatic competitions that have come to be the major part of the British slope soaring scene, and I hope here to be able to give a few pointers to those who are thinking of joining in.

The model

Competitions tend to design models. That is to say, the increasing demands made by the "thinkers-up" of schedules have tended to reduce model design criteria to a fairly narrow spectrum. There was a time (it seems long ago now, though it is only a very few years!) when any soaring competition could be won with a rudder/elevator model; not any more. The 2-point and 4-point rolls, prolonged inverted flying, and so on, have demanded aileron control, so for "multi" competitions, 3-function equipment is necessary—and perhaps 4-function (for variable section, or flaps). We still have "intermediate" contests for the two-function model, but these are usually restricted to the beginner.

Once you have graduated from the beginner's model, then, you should, if you are intent upon flying in aerobatic contests, build one of the currently popular full-house aerobatic designs. (I will not name any names because, apart from its being too much of a temptation to name one's favourite (ahem!), books are made to last a few years, and model designs change almost monthly!) Build a proven design and, provided your model is warp free and trimmed out properly, with aerobatic practice you can be with the winners.

Practice

Now obviously you must practice your general flying and your aerobatics and, on this point, I would mention that it is amazing the number of people one sees letting the model "fly them," instead of controlling its flight path. One idea, to help you maintain strict control is, when you are doing your landings, do a nice rectangular approach and land on a pre-determined spot. Practice this all the time, so that you get used to putting you model just where you want to. Your approach does not always have to be right-handed or left-handed, but from either side, so that you can land in any situation of slope, on whatever sort of site you may be called upon to fly.

There is no standardised schedule for slope soaring aerobatics. This is a deliberate decision on the part of the various organisers, who maintain that, by not having a set pattern to practice at, the most versatile and adaptable fliers will do best. It certainly makes for more interesting competitions. Some schedules are published in advance, and you may find one or two in the monthly magazines to practice.

Firstly you can practice each manoeuvre on its own and, when you are proficient at these, try stringing them together. For instance a typical run of manoeuvres could be . . . loop, roll, stall-turn, reversal, 4-point roll, stall-turn, outside loop, reversal, half-roll, inverted circle, half-roll . . . followed by an approach and landing. Now, just bend down and switch the model off. Or, of course, "back to the drawing board." Well, it's not that bad, really! This stringing together of manoeuvres is the sort of thing that is required for what is called "freestyle" aerobatics. They should not follow one another in lightning succession, however—the judges must have time to write down the marks!

The contest

After putting in plenty of practice, it's time for your first competition—and there's no practice like the real thing. When you decide to go to a contest, make sure you know where the site is, so that you will be able to arrive on time or, preferably, a little early. When you get there, talk to the local lads, find out what the slope is like, see where the best lift is (you'll be able to try it out for yourself, if you arrive early enough), and what prospects the landing area holds. See where you will be flying from, and where the judges will be positioned in relation to the sun, and the slope, so that when you come to do your manoeuvres they are not too high, or in the sun.

If the judges cannot see your manoeuvres, they will score "0," so do them at head height in front of them; if a judge has to crank his head about too much or crane his neck, you must expect to get less points. If there is a choice of manoeuvres, make sure the judges know the ones you are going to perform. Before you go into each manoeuvre call it out, loud and clear. If, for some reason, a particular manoeuvre goes wrong, you must go on to the next one—no second attempts are permitted. Provided you had no spectacular failures, the overall impression of a flight counts as well. The placing of manoeuvres, the smoothness of in-between flying, how square your approach is—and, by now, you ought to be able to land it at your feet. It always gives a good impression if you only have to bend down and switch it off, instead of disappearing over the back of the ridge to find out where it has gone!

All the foregoing has assumed that conditions are perfect, or at any rate, good. If the lift is poor, you should pick the manoeuvres which are rated the highest, even if it means giving a very high powered launch and flying straight out over the valley, using all the height you have got to do the highest pointed manoeuvres, even though you have to land at the bottom of the slope. If, with generally poor lift, the odd thermal or two comes along, you may be very lucky to catch one and can utilise this to gain height to do, perhaps, the whole schedule on the way down. With practice there is no reason why you should not soon be picking up some of the prizes. Even if you don't, you will find you have had such an enjoyable day that you will come again, and keep coming, once you have been "bitten."

As this is essentially a beginner's article, I think it might be an idea to explain the way to perform and present some of the manoeuvres, with special regard to encouraging the judges to give you good marks.

The loop. First gain some speed with a shallow dive and then pull on up-elevator gradually. As you get to the top, reduce the elevator movement so that it flattens out slightly, then as it starts to dive, pull out more sharply and finish on the same level as you started. This way you will get a nice round loop. Now, for consecutive loops, since it is a glider, you have keep the speed up. So, in the downward part of the loop, *i.e.* the second half, you must allow the model to dive slightly to gain speed, then you can use this speed to do the next loop—and so on. This way, with practice, you will be able to superimpose your consecutive loops. Present them sideways on, to the judges, so that they can see how round they are, even though this is cross-wind.

The roll. This, again, is best started with a fair reserve of speed. From a shallow dive, pull up just past the horizontal and apply full aileron. As the model rolls towards the inverted position, apply slight down elevator to keep it flat. Then, as it reaches the vertical position again, let the elevator off, keeping full aileron on all the while. When the model has nearly reached the horizontal, release the aileron, finishing nice and level, fore and aft as well as laterally. This is standard practice for an axial roll.

For consecutive rolls this procedure is repeated, but obviously you must keep the speed up or the model will tend to wander. So you must start with more speed, because there is no way of keeping the speed up in horizontal rolls. It is sometimes an advantage to apply slightly more down in the inverted position so that the nose is raised, and thus your consecutive rolls will maintain a level attitude, instead of being all slightly "downhill." Do not overdo this, of course, as it can easily reduce that all-important speed. As with loops, the rolls should, ideally, be presented going *past* the judges, not away from them, even though it does mean doing them cross wind. We all do rolls *into* wind to start with, because it seems the natural way. But practice doing them along the length of the slope, and you will find, after a while, that this is not so difficult as you thought. It will certainly give you an advantage when you start flying for the judges.

Inverted straight flight. First half-roll to the inverted position and apply some down elevator to maintain level flight—not too much or you will stall the model—and keep it going nice and straight for, say, the 15 seconds that is usually required in competitions. Either the organisers will provide a counter, or you can have a helper who will call off the seconds. Sometimes, even, the judge will do this. When the time is up, half-roll out, rolling the same way that you entered the manoeuvre. (That is to say, if you half-rolled to the right to go inverted, do another half-roll to the right, to recover at the finish.)

Which way this manoeuvre is presented can depend a lot on the particular site. To do it along the ridge can mean that the model is going quite fast—and can cover a lot of ground in 15 seconds, so, if you do not feel there is enough room, then do it into wind. What the judges are looking for here is simply straight flight, directionally, with not too much swerving about, and with the wings level.

Inverted circle. This should be started in front of the judge, with a half-roll. Then, keeping on an angle of bank, do a round circle, using down elevator to maintain a level height. When you reach the entry point you must roll out in the direction of bank. This is obviously your shortest path back to an upright position.

Inverted eight. This is usually started at the intersection point, with a half roll to an angle of bank. Complete as if doing an inverted circle and, as you get the model back to the intersection point, aileron is applied *opposite* to the bank until a bank to the other side is started. When you have completed this circle, roll out the *same* way as your bank to complete the manoeuvre back at the intersection point. This sounds complicated on paper. It's not really all that complicated, but it does take a great deal of practice to produce anything like a recognisable inverted eight—let alone one that the judges are going to approve of. So get practising.

Outside loop. This should be started with plenty of height, then applying increasing amounts of down-elevator so as to build up speed in the first part of the loop. Then, as you start to climb back up the other side, gradually increase the amount of down-elevator all the time so as to level out at the point of entry. This manoeuvre relies on the fact that you *gradually* increase the down-elevator so as to maintain the speed for the last quarter, which is the usual point of trouble with the outside loop.

Again, as with loops, this manoeuvre should be done—when you can manage it—sideways on to the judges, to show them how nice and round you can make the manoeuvre.

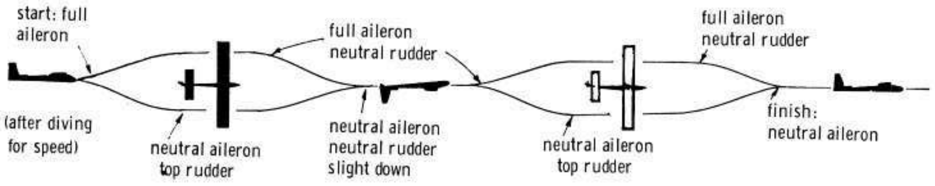
Three turn spin. This, it goes without saying, has to be started with a fair amount of height. Sometimes, if the lift is not good, and competitors can select the order in which they do their manoeuvres, it is as well to make this the last one, so that you can spin down below "the point of no return" and land at the bottom of the slope. (Only do this, however, if it will gain you more points than you could have scored with your approach and landing.)

The model is gradually stalled by applying up-elevator; as you see it drop a wing, apply full up and full left (or right) rudder. This will start the spin. On some models ailerons might be required to keep the model spinning. When you wish to stop the model spinning, release all controls. Usually it will then stop its spin, taking half to three-quarters of a turn to do so. If it doesn't—apply full *down* elevator, to unstall the wing, and then recover in the normal way. This tendency to continue spinning could be due to the c.g. being too far back, or to warped flying surfaces.

Presentation-wise, there is not a great deal one can do with the spin, to please the judges. The main thing is to do *precisely* three turns, and finish on exactly the same heading as you started, coming out of it nice and level, without any zooming.

Stall turn. Start with some excess speed and, from level flight, pull up until the model is vertical, then allow it to continue until nearly all the speed has gone, then apply full rudder to kick the model over. Sometimes ailerons are needed in the same direction to keep the model in the one plane. As the model comes back down, gradually apply up-elevator, pulling out at the same height as your entry.

Reversal. This is a half-roll followed by a half-loop. From level flight apply aileron to complete the half-roll. (This must be accurately done because, when the half-loop is executed, the model will not return on the same path, unless the inverted position was exactly horizontal.) Now pull on up-elevator to complete the half-loop. That's all there is to this manoeuvre.



Four point roll. This is an axial roll with hesitations at 90° stations. To perform it, we once again need excess speed, from a shallow dive. Then lift the nose, apply ailerons then release, apply top rudder*, release, apply ailerons, release, down-elevator and hold level, release, apply ailerons, release, apply top rudder, release and finally apply ailerons to return to level flight. Phew! you will really have to practise this one—study the illustration!

I have not attempted to cover all possible manoeuvres here, but I think the foregoing will give you a good basis for stick stirring, while bearing in mind what judges will most likely be looking for. Experience is a dear teacher but I don't think anyone has found a better one, so let us see you on the slope!

Unless you live only a very few miles from suitable slopes, so that you can practise in the evenings as well as weekends, and do so regularly, you cannot really expect to attain the high degree of precision now demanded to place high in these contests. Nevertheless, it is good experience to practise for contests, and certainly helps you to achieve disciplined, purposeful flying, instead of random, haphazard manoeuvres. Once you have got to this stage, then it is only a short step to getting into active competition soaring.

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* Top rudder is the term used when rudder is applied with the aircraft in a vertical or near vertical bank, when the rudder actually acts as an elevator. For instance, if we bank to the left, into a vertical bank, we then apply *right rudder* which helps to keep the nose up. As will be seen, the application of "Top Rudder" is called for twice during a four point roll. Without it, the model would describe a steadily descending path, due to the brief periods spent on its side, when the nose would go down quite steeply. The co-ordination of hand and eye required for the correct application of top rudder (also used during a slow roll) is of a very high order.

CHAPTER 11

KEEPING UP WITH THE BIRDS

There's more to it than a 15 knot wind and a good slope, say – PAT TEAKLE and TONY ELLS

IF you go to the slope in marginal lift conditions, you will often find that less experienced pilots have much more difficulty in keeping their models airborne than the older hands. The design of the model obviously plays an important part in success, but the model trim, piloting technique, and a general feel for "sloping," also have an important contribution to make.

Most clubs have a few members with "built-in lift," but you ask these chaps the secret and they will have genuine difficulty in explaining judgements and actions that, after a time, have become almost instinctive. Pat and I thought that, by putting a few thoughts on paper, ideas that have been slowly and painfully crystallised over several seasons' flying, these might provide a short cut for a few, provoke heated argument with most, and possibly bring back a few really worthwhile ideas.

We were originally asked to write an article on "where to look for lift" but we found this impossible to do, because the "where" is so much tied up with the "how." Therefore, we are going to put our heads on the chopping block and talk firstly about model trim. Most of this stuff will be obvious to you but, nevertheless, will, we are sure, bring a great many unwritten thoughts and prejudices into the open.

Model trim and flying technique

Before advantage can be taken of any light lift, the pilot must be thoroughly familiar with his glider's flight characteristics. Principally, he must be able to recognise the onset of the stall, which must not be too sharp. The minimum sink speed of the glider will be very slightly above the stall, whereas the minimum glide path angle will occur at a speed which is a fair margin faster again. It is this minimum glide path angle that you need, to move from a dead lift area to a possible lift area, with the minimum height loss. If you are lucky enough to find some lift, then you will settle back to minimum sink speed. The most common trap beginners fall into is to fly the model a crack too slow, even for minimum sink, and only speed up if they want to lose height. To their surprise, up to a certain speed, this is the very last thing that happens. With a draggy box plus wings, this minimum glide path angle will not be very far above the stall but, with a clean, reasonably high aspect-ratio model, this speed margin is much greater.

To achieve an accurate flying speed, apart from knowing the model like you know the back of your hand, you must have precise pitch control. Now pitch response is, to a certain extent, a matter of personal choice, but too forward a c.g. will result in excessive static pitch stability, and the model will "balloon" up with variations in windspeed. The fight is on, and you will not be as one with the model. The "feel" can be lost to such an extent that it could become impossible to hold the model on a smooth flight path.

In all light wind conditions one should use the minimum control surface movements consistent with the desired flight path—it can be likened to milking a mouse! A sneaky comment here about design. The incremental increase in drag, due to control surface deflections, may be further minimised by having very large control surfaces moving through small angles, with the model neutral trim carefully set so that the rudder and elevator are at zero deflection.

Turns are much more efficiently executed with some attempt at a co-ordinated rudder-and-aileron turn, to minimise the drag. This does not mean coupled aileron/rudder controls, as aileron is nominally used only to set up the bank angle and to terminate the turn, while the rudder is used throughout the turn, theoretically maintaining zero side-slip. As small slip angles are impossible to detect with models, the right order of rudder can only be found by trial and error, but it is quite small. Just a suspicion of rudder will enable you to execute the same rate turn with less bank angle than is required with the aileron-only turn. In light slope lift, entry into and exit from the turns, must be anticipated by using control movements and allowing time for their full effect to develop. Remember, of course, that the stalling speed in a turn will be slightly higher than in normal straight and level flight.

Where is the lift?

Naturally you should choose, if possible, a site with the wind drift normal to the slope and a long, open, windward approach. A preliminary assessment of the situation should be made, and this is best done as follows:

(a) Preferably watching models already struggling.
(b) Looking for any birds circling in thermal lift, or holding height on ridge lift.
(c) Looking for possible sources of thermals: ploughed fields, stretches of concrete, large groups of trees, broken terrain.
(d) Looking for those wonderful cumulus clouds building up.
(e) Using small bowls within the main slope, which may produce localised areas of stronger lift; keeping close to the hill contours for maximum advantage.

To make a practical assessment of the situation, it is best to have an assistant with a true and mighty heave. A single exploratory circuit-and-land can then be made, with only fifteen or twenty feet height loss. Several of these single circuits are a better investment for finding lift than over-optimistically hanging on, finally finishing up way down the hill. Not only can this result in a hazardous landing, not infrequently of the tent-peg variety, due to bad visibility, or stalling—or both, but also recovery of the model can be very exhausting. Nevertheless, a delicate touch and caution are required for these single circuits, otherwise damage to the model can easily be caused.

When the time is your own, you can often wait for weak thermals to come through. These may be detected by slight rises in temperature, which you can sense on your face, and they are often accompanied by a decrease in the air movement.

Flying the model near lift can cause an upset in the lateral trim. Advantage may quickly be taken of this situation by holding down the rising wing and gently turning into the disturbance. Thermal activity naturally gives turbulent conditions and often, prior to getting the lift, the model will fly into a small downdraught. This kind of situation makes it more efficient, overall, to increase the speed slightly so that an incipient stall is avoided.

One can spend many pleasant hours searching out lift, in this way, from the slopes, and it really does improve one's flying ability. After all, anything, and almost anyone, can fly a slope soarer indefinitely with a 15-knot wind up the slope. Don't be discouraged, therefore, if you reach your hill site to find hardly a breath of wind. This is the time when there is some real challenge!

The really gratifying proof of your having learned something about the business may come one day—when the gulls begin to follow and formate onto your model, instead of the other way about!

CHAPTER 12

CREATIVE SOARER DESIGN

By CHRIS FOSS

THE creative aspects of life give possibly the greatest pleasure of all, whether they are of a musical, artistic, literary or practical nature. The latter I would describe as including all those creations that can ultimately be put to some use, or made to perform a function, and this must surely cover, in principle, this hobby or pastime of ours.

The vast majority of us create or construct our own flying machines, if only from a box of pre-shaped parts which has been prepared for us. But how much more satisfying it would be to create our own model, right from its origin; to be our own master throughout, making our own decisions from start to finish.

The thought of designing a model from "scratch" is, I know, a daunting one for many, but no model is truly designed from so-called scratch. There is so much reliable and proven information already at our fingertips, and there are numerous magazines full of photographs of other designs that we can use for reference. We must all have had the opportunity, too, to study detailed constructional plans from time to time.

We therefore have a fair idea of what a model glider is, yet the biggest drawback, when it actually comes to producing a design of our own, is the lack of practical information to guide us along the correct path, which is so necessary if we are to be guaranteed a good degree of success.

In these following pages, I intend to lay out a path, commencing at the basic elements, running right through the various design stages and finally leading up to the building board, a path which can be used with some measure of confidence by any progressive modeller who has, up till now, been waiting for the opportunity to "go it alone," or whose past experience may lie completely with power models, and who wishes to explore this, yet another, branch of the sport.

One's powers of creativity are readily affected by numerous factors, not the least being one's particular frame of mind. Inspirations cannot be made to happen, they occur when they are ready, and impatience is the worst deterrent. Be prepared to produce a dozen futile designs for every one that possesses a glimmer of hope, and only be satisfied when one has come as near to the ultimate as is personally considered possible.

Basic components

In approaching any new skill that has to be acquired, one is always told not to try and run before one can walk. So, in the same context, and with the help of the imagination, there is no point in rushing off to design something if we do not know what we are to design. Now that makes sense, doesn't it?

Before gathering together paper and pencil, therefore, we should firstly try to visualise the general overall picture of the model we wish to design and, at the same time, consider the role that it should, or must, fulfil. We must ask ourselves whether we want a simple and stable soarer for fair weather flying, a high speed pylon racer, or a versatile aerobatic contest machine. In doing this we should bear in mind the type, size and weight of the radio control system to be used, and fully appreciate any limitations it may impose on the scope of the design. Quite obviously it is pointless to rush off and proceed with a sophisticated full-house soarer, if the only radio available is a set of two-function equipment!

The vast majority of potential designers are probably fully experienced in building models from kits or from plans, but are at a complete loss when confronted with a blank sheet of paper. Therefore, what would be valuable, at this stage, is a complete analysis of the individual components and their recommended values, to act as a foundation on which to base our design. Such material may also be of use in clearing away any doubts over particular items (and will, without doubt, spark off criticism and laughter from the "experts" who should not need to read this chapter anyway!).

The wing

1. Span. More often than not, practicalities take priority over all other considerations, and the wing span may simply be determined by the size of the car boot! Practical implications aside, however, it is a generally accepted view that, whilst the smaller and more compact model has a greater chance of surviving the occasional (or continual) mishap, the larger model is invariably much smoother and more pleasant to fly, being less affected by irregularities in the airstream (another way of saying turbulence!).

The resulting influence of these factors has been a slow, but continual, reduction in the extremes of model sizes, until the situation has now been reached where, upon carrying out a survey of all the most popular and successful designs at present being flown throughout this country, it would be the exception rather than the rule to find many soarers smaller than 4ft.6in., or larger than 6ft. in span. Four-feet-six, because models much smaller tend to find themselves bounced about in anything other than ideal conditions, and six feet probably because that is the length of two 3ft. pieces of wood!

Popular opinion and choice being the most reliable, it makes good sense to point our design somewhere between these two figures.

2. Aspect-ratio. If we want, basically, a good stable performer with pleasant flying characteristics, then we cannot hope to achieve aspect-ratios comparable with those of full-size sailplanes. Although scale models with 1 : 20 or 1 : 25 aspect-ratio wings will fly and, indeed, have flown, they are invariably plagued with the unpleasant vice of tip stalling*, or flick rolling, at the slightest provocation, a characteristic which is further accentuated by the use of a sharply tapered wing. It must be remembered that a soarer has no source of power on which to rely in order to maintain a safe flying speed, but is required to fly in a varied range of conditions at a similarly varied range of air speeds and, at times, often very near the stall.

However, if we are interested in maintaining a semi-scale appearance, we could aim for an aspect-ratio around 1 : 12 to 1 : 14, remembering that, if ailerons are to be used, the control response will become comparatively poor and, indeed, "aileron reversal" may be experienced at times.

On the other hand, if less importance is attached to producing a model resembling a full-size machine, the aspect-ratio can be reduced to a more practical level of between 1 : 7 and 1 : 10. Certainly the trend in aerobatic contest soarers, where a good rate of roll and crisp levelling qualities are essential, is towards this more compact wing form. However, criticism is often levelled at this modern breed of soarer, insofar as they no longer resemble gliders. Using the same argument, it can be said that the typical competition class aerobatic power model bears little resemblance to anything one might expect to see at the local aerodrome! Such models are designed for a specific purpose—to perform the functions required of them in a particular type of contest, and perform them as effectively and efficiently as possible. They should be regarded solely as model aeroplanes and viewed comparatively with one another, rather than with full-size machines. However, I am not condemning any attempts to add a degree of realism to a design, far from it, for what I have just said only applies to thoroughbred contest models, where flying performance is the chief factor.

3. Wing loading and wing area. Before a final decision can be made on the span and

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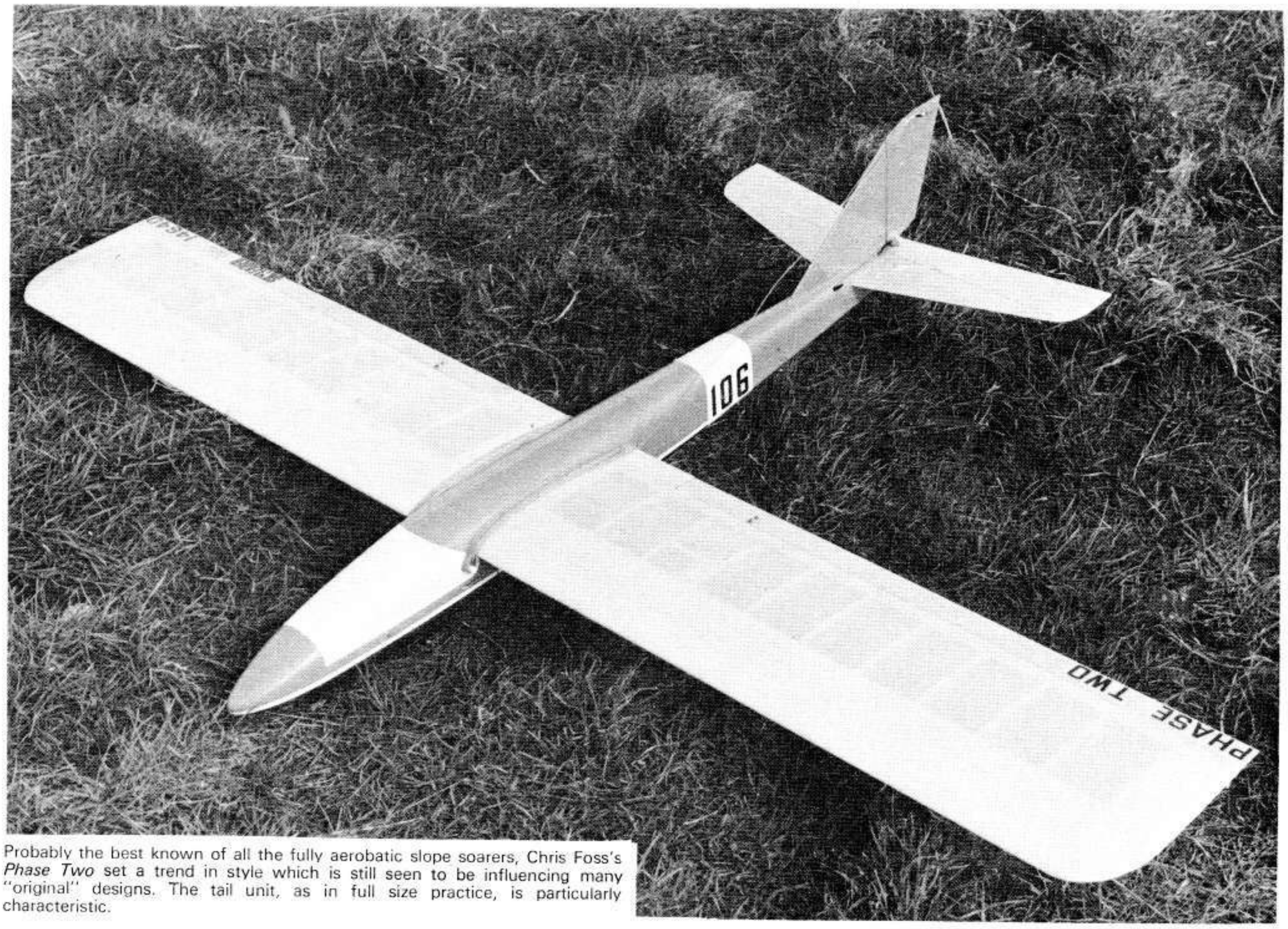
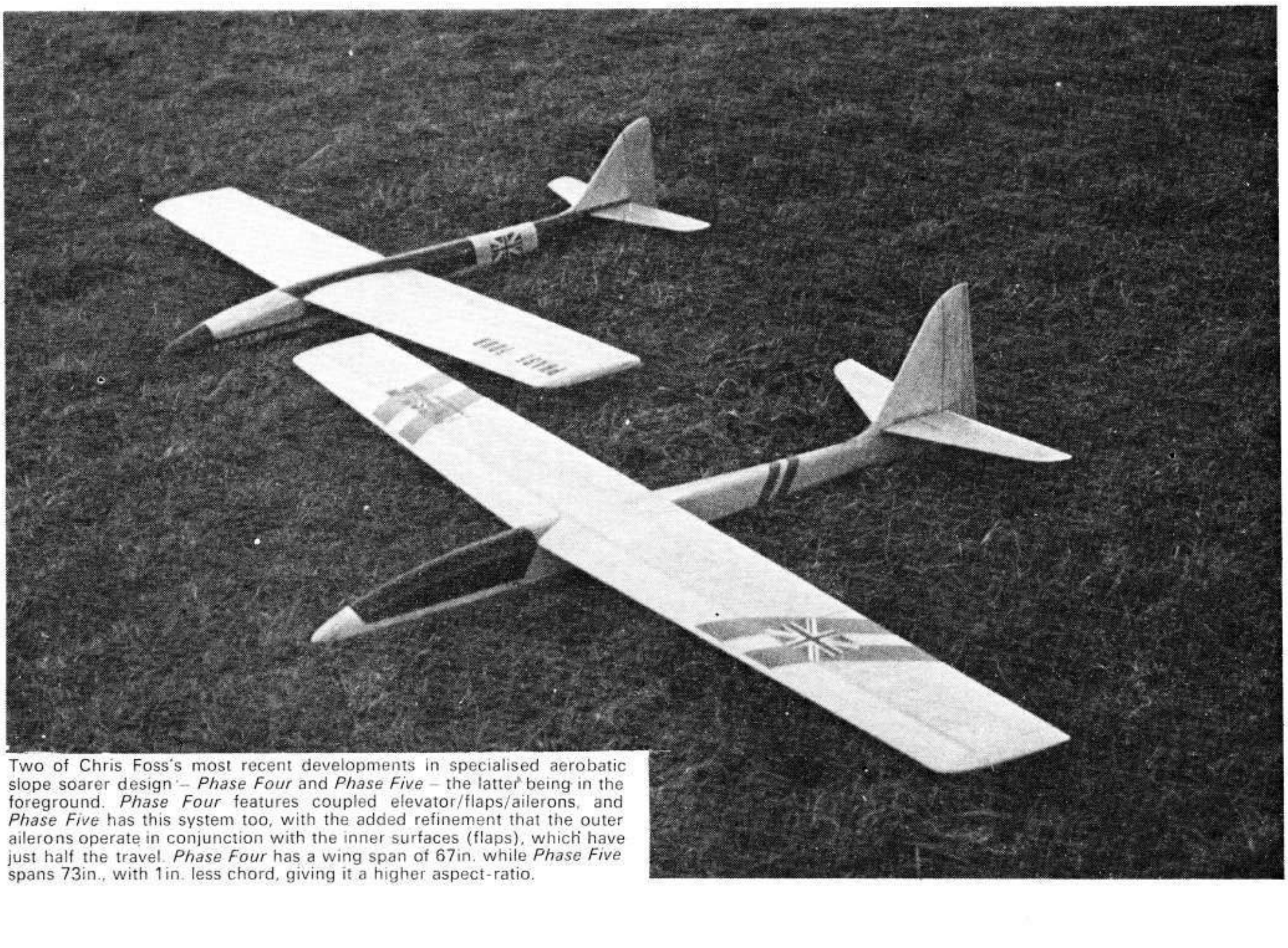
* Here some "washout" at the wingtips, as described in an earlier chapter, can be helpful, but it will not altogether prevent the tip-stalling tendency in models with *very* high aspect-ratios and *very* tapered wings. One low aspect-ratio aerobatic soarers, of course, it is neither necessary nor desirable since, when the model is flown inverted, it would have the opposite effect to that intended.

Quite a breakthrough in design concept for rudder-only models (previously often "boxes with wings") Chris Foss's *Force Four* showed early evidence of a keen eye for line and form, as well as a firm grip of the practical essentials. The model has a thin wing for good penetration, and an adjustable semi-elevator.



Probably the best known of all the fully aerobatic slope soarers, Chris Foss's *Phase Two* set a trend in style which is still seen to be influencing many "original" designs. The tail unit, as in full size practice, is particularly characteristic.



Two of Chris Foss's most recent developments in specialised aerobatic slope soarer design – *Phase Four* and *Phase Five* – the latter being in the foreground. *Phase Four* features coupled elevator/flaps/ailerons, and *Phase Five* has this system too, with the added refinement that the outer ailerons operate in conjunction with the inner surfaces (flaps), which have just half the travel. *Phase Four* has a wing span of 67in. while *Phase Five* spans 73in., with 1in. less chord, giving it a higher aspect-ratio.

Elegance and efficiency are the keynotes of *Phase Lift*, Chris Foss's high aspect-ratio design for cross-country slope work and flat field thermal soaring. It features ailerons, plus a variable camber aerofoil ("trimmable trailing edge") which affords a wide range of speeds – desirable in both these aspects of soaring.

aspect-ratio, consideration must be given to the wing area we require, as well as the wing loading we may hope to achieve. The latter is a factor, the importance of which is not perhaps fully appreciated in the world of slope soaring, and it can quite often be the sole factor determining the success or failure of a given design.

As a fairly broad statement, I would suggest that the wing loading of the typical all-weather soarer, with which we are mainly concerned in this article, should be somewhere between 10 and 18 ozs./sq.ft. A fairly wide variation indeed but, in fact, it can be narrowed down at a later date, when we know the type of aerofoil to be used, a topic that will be explained in detail in the aerofoil department. It is not to say I am suggesting that models with loadings outside these limits are impractical, for soarers over 20 oz/sq.ft. are fine, provided that the wind is blowing well, and the models of the thermal soarer variety with 4 or 6 oz loadings are quite happy on days when there is just sufficient breeze to move the grass. As it is our aim to concentrate on designing one model and not two, then we must produce one that will operate in the widest range of wind speeds possible.

Returning to the question of wing area, bearing in mind what I have just said, and being consistent with the previous material, I would suggest setting 2½sq.ft. as a minimum and 4½ as a maximum.

The tailplane

The general shape and aspect-ratio of the tailplane seems to be a matter of personal choice, rather than of any real aerodynamic value but, what is of vital importance, is the area in relation to that of the wing. An unnecessarily large tailplane is perfectly all right from an aerodynamic point of view, but may spoil the appearance of the model, whereas an undersized tail will certainly impair the longitudinal stability of the model, even to the extent where controlled level flight is impossible, however skilful the pilot.

Ideally, the tailplane should be just sufficiently large to provide a safe margin of stability, as a surplus of area will only create unnecessary drag and weight. As a general rule, on a conventional and sensibly proportioned layout, the overall tail area should be 15%-20% of the wing area.

Nose and tail moments

The nose moment, measured from the tip of the nose to the leading edge of the wing, should, ideally, be sufficiently long to accommodate the bulk of the radio equipment, so as to virtually, or entirely, eliminate the need for nose ballast, therefore reducing any unnecessary dead weight. On both practical and aesthetic grounds, a nose length of between 1 and 1½ wing chords seems most desirable.

The tail moment, or the "moment arm" as it is more commonly known is, in simple terms, the distance between the trailing edge of the wing and the leading edge of the tail, and is quite often referred to in terms of so many wing chords. The moment arm and tail area are inversely proportional to one another—a larger moment arm requires less tail area than a shorter moment arm, to provide the same degree of stability.

In practice, the moment arm may often be decided on the "if it looks right, it is right" principle and, if viewed in conjunction with the tailplane area and relative to the wing, can frequently lead to the most satisfactory result. However, for the purpose of this design exercise, it is not going to be a great deal of help to simply state "design it to look right" as most of us have differing standards of what is "right"!

Therefore, to conform with the tail area already specified, we should aim for a moment arm of between 2 and 3½ wing chords, and bear in mind the relationship with the tail area, as already stated, when determining the final length.

Dihedral

On a model using rudder as the only directional control surface, a fair amount of dihedral, in the region of 5°-8°, is required under each wing panel, to provide an adequate degree of control response. Alternatively, to save messing with protractors and adjustable set squares, it could be stated as 1in. of dihedral at each tip for every foot of span.

Reducing the angle also reduces the effectiveness of the rudder, until we reach the completely flat wing, where the rudder becomes entirely useless for normal flight. Conversely, an unnecessary amount of dihedral, whilst increasing rudder response, will also result in the model wallowing, or "Dutch rolling," as it is sometimes known, when rudder is applied, thus giving a rather unattractive flight pattern.

With ailerons as the major control, the less dihedral the better. A completely flat wing is most desirable on a fully aerobatic soarer, thus giving equal stability (or lack of it!) both upright and inverted. However, criticism is often levelled, from some quarters, at the "droopy" appearance of a non-dihedral layout, so it is quite in order to add a degree or two to eliminate what is purely an optical illusion.

To relieve the need for the reader to refer back through the foregoing material I will now set out a summary of the recommended values relating to the basic components:

Wing span:	54″—72″
Aspect-ratio:	1:7—1:14 (up to 1:10 max. for aerobatic soarers)
Wing loading:	10—18 ozs./sq.ft.
Wing area:	2½—4½sq.ft. (360-648 sq.ins.)
Tail area:	15%—20% of wing area
Nose moment:	1—1½ wing chords
Tail moment:	2—3½ wing chords
Dihedral—rudder only:	5°—8° under each panel
Dihedral—aileron:	no dihedral necessary

AEROFOIL SECTIONS

Before we all go racing off to the drawing board, there is a little more reading to be done, for it would be as well, at this stage in the proceedings, to run briefly through the types of aerofoil sections, noting their suitability for our particular application. There are two ways of approaching this subject—armed with either (a) a library of technical information, or (b) a shoe and a pencil. The latter method seems to be by far the most popular!

Seriously though, I admit to being rather ignorant on the theory of aerofoils—I get up and leave the room when the discussion turns to Reynolds Numbers and lift coefficients—so the following is written in plain and simple language.

Wing sections

1. Undercambered. This is most suited to a lightly loaded model and produces good lift at slow speeds. As the flying speed is increased, so is the drag, and the net result is that you get nowhere fast! Such models are normally more suited to thermal soaring, although they can be valuable on those few calm days when the grass is barely moving, and most of the models are rapidly descending to the foot of the hill. Conclusion—*not* suitable for the average slope soarer.

2. Flat bottom. Any section, based on the well-known *Clark Y*, with a maximum thickness of between 10% and 12%, will perform well in a varied wind range, although there are definite limitations in its use in the higher wind speeds that are quite often experienced in this country. It is invariably the wing loading of the model that determines the actual upper operating limits (sheer weight and brute force!) and a fairly high loading of around 16 to 18 ozs/sq.ft. is desirable, if one intends to fly in winds much over 20 m.p.h., without the constant threat of "losing it over the back," whilst still permitting a useful performance in marginal conditions due to the excellent lifting qualities of this type of section.

As regards rigging angles, it is most common to set the underside of the wing at 0°, and rely on the slight upsweep or radius at the leading edge to produce an *actual* incidence angle of one or two degrees.

Conclusion—most suitable for all slope soarers that are not required to achieve "fully aerobatic" status. However, it has not been completely unknown for some models to have performed quite satisfactory bunts and limited inverted flight using this type of section, although I suspect there have been other important, but subtle, factors involved to have permitted such antics!

3. Semi and fully symmetrical. These are an essential ingredient for all fully aerobatic soarers, and can be remarkably efficient at low speed in marginal conditions, whilst, at the same time, capable of clocking up a fair rate of knots when required to do so in strong winds. The semi-symmetrical *Eppler 374* section has become a favourite amongst contest fliers in recent years, although increasing use is now being made of fully symmetrical wing sections, as practical experience has shown they have a comparable performance to the semi's, even in marginal lift, whilst offering superior aerobatic capabilities. In contrast to the flat bottom wing, which, as mentioned, requires a substantial loading to cope in high winds, it is advantageous to keep the loading down to 10 or 12 ozs/sq.ft. if possible, as this will ensure a good "marginal" performance, whilst relying on a clean low drag design to fight the gales.

The recommended longitudinal dihedral is 0°, relying on a small degree of "up" trim on the elevator for normal upright flight, therefore only requiring a similar amount of "down" when inverted.

Tail section

There is little that need be said about this—after all the tailplane is only there to keep the fuselage level in flight!—other than that the simplest and most popular section is a flat plate, with a radiused leading edge and a tapered trailing edge, or elevator. An elaborate built-up tailplane, using a "proper" aerofoil, seems to offer no significant advantage.

Initial design work.

The enthusiastic readers who have thoroughly read and inwardly digested all of the foregoing material should now have a clearer picture of what should, and what should not, be incorporated in the design of a slope soarer. Having reached this stage, it is not completely unknown for some modellers to actually start building. No pencil and paper or nicely thought out plans to work from, just a few random lines scratched on to the building board, and they are away! Needless to say, more often than not their method of approach is borne out in the end product. The darn' annoying part of it is when a model produced in this manner actually flies, although apparently most things will fly after a fashion, even bricks.

If any of the readers are "cut and hope" modellers, then may I politely suggest they turn quickly to the next chapter, as the following material is going to be of no use to them whatsoever!

Right, with the room now two-thirds empty, I shall continue and try to explain the most satisfactory procedure to adopt in tackling actual design work. Unlike the previous sections in this chapter, where it only entailed commenting on specific items and recommending maximum and minimum values for the various components, the task I am now faced with is somewhat more complex.

The plan form or layout

The first and relatively painless step is to gather together a pile of scrap paper and a newly sharpened pencil. Proceed to sketch out, in freehand and roughly to size, ¼ or ⅛th scale plan views using all the previous data as a basic guide, bearing in mind any individual requirements, and the rôle we wish the model to fulfil, particularly when determining the aspect-ratio. Don't be afraid of wasting paper; cast aside the designs that are leading to nothing, for a lot of time can be wasted labouring heavily over one poor drawing, rubbing out, re-drawing and so on until a hole eventually appears in the paper. The secret of success is to explore every possibility, to sketch away furiously at all conceivable variations and combinations of shapes—try a tapered wing, possibly with the taper on the leading edge, then try it with the taper on the trailing edge, do the same with the tailplane, and vary its aspect-ratio as this can have an interesting effect on the overall appearance; juggle with the moment arm and, in fact, try everything!

There is nothing to lose in doing this, apart from paper and pencil lead. As the pile of

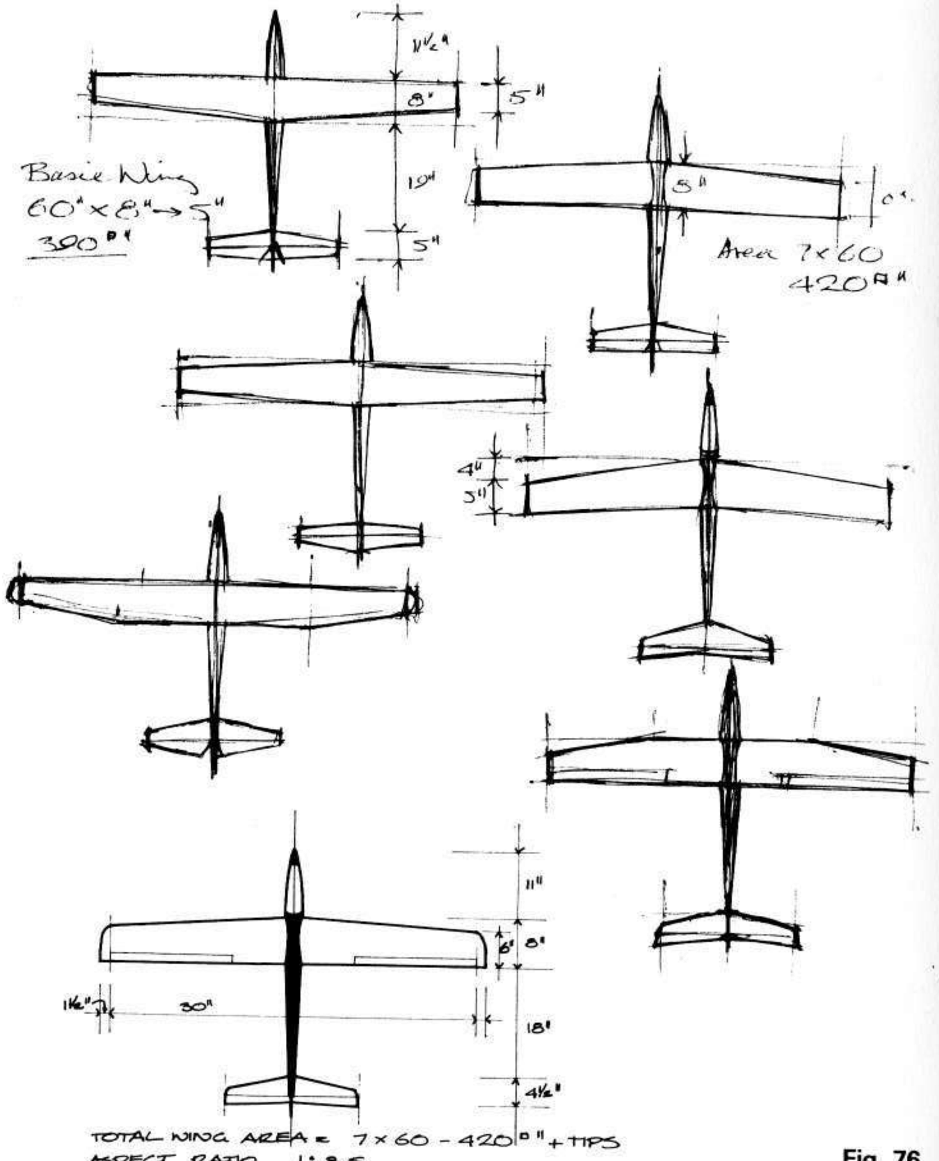


Fig. 76

sketches increases in volume, we will, or should, begin to pick out certain features which are particularly to our liking, so that we can then bring them together on one drawing, thus producing the final layout sketch on which to base the remainder of the design work.

Although I should stress the importance of making full use of the "Basic Components" data, even doing so religiously does not necessarily guarantee that the result will be a winner.

On the contrary, it would be quite an easy matter to create an absolute freak, whilst still working within the suggested limits! This statement is not intended to shatter the confidence as much as to warn of the possibilities.

By far the greatest asset one can possess is an "eye" for the right shapes—all my own designing is basically carried out on the "what *looks* right must *be* right" principle. This is something that can only be acquired through experience, by observing other designs, looking at photographs in magazines, studying plans, and watching and relating the performances of other models in action. When we observe a particular model performing significantly well, or maybe badly, an impression is created in our mind, and a detailed picture of the model is "filed" away subconsciously, together with any favourable or unfavourable impressions that it has created. As time goes on, we enlarge our "library," until it is sufficiently well equipped to enable us to use it as a reference in order to produce a design of our own, which we are confident will fly and fly well.

Let us now assume that we have finalised our sketch plan view, so the next step is to work it up to an accuratge scale drawing to which can be added a few detail items such as rib-spacing, spar positions, areas of sheeting, and the outlines of the horizontal control surfaces. The whole operation of working up the basic plan-form of a design is summarised briefly as a series of illustrations, in Fig. 76. Let us now proceed to the question of tapered flying surfaces.

Wing taper

A wing which tapers in plan form towards the tip is considerably more acceptable, from the visual angle, than a constant chord wing. There is, however, a certain constructional drawback, insofar as all of the wing ribs are slightly different in size. The small degree of additional effort involved is often the reason why there are so many parallel chord wings in evidence these days! From a flying point of view, provided the taper is reasonably gentle—the tip chord is no less than ⅔ rds of the root chord—there is little harm to be done. If one tries tapering the wing to the extent that the chord at the tip is reduced to ½ or less than that at the root, the same unpleasant characteristics, in the form of tip-stalling or even, in a more violent form, flick-rolling, will quite probably occur. Sharply tapered wings can be, and have been, quite acceptable on power models, but we must remember that a slope soarer is a different kettle of fish, as it does not rely upon an engine to provide adequate flying speed at all times.

Tailplane taper

As most tailplanes on slope soarers are of the simple flat plate variety, the actual shape does not normally present any constructional or, for that matter, aerodynamic, problems. In fact, there are few models possessing tailplanes that are not tapered, and the way the taper is handled can have a considerable bearing upon the overall visual effect. A carefully proportioned tapered tail can do a great deal to offset the plain look often afforded by a constant chord wing, as is shown in Fig. 77.

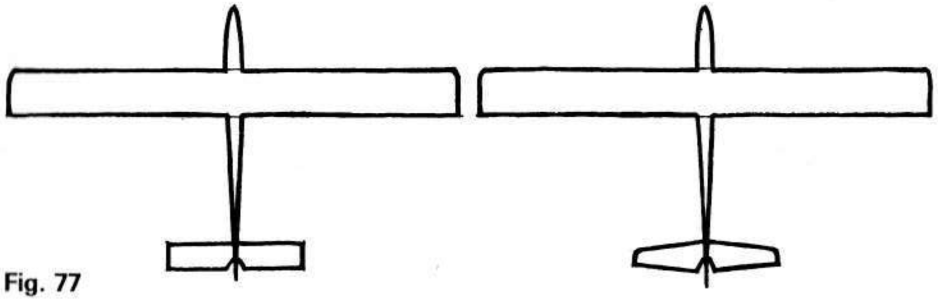


Fig. 77

The fuselage profile

With the plan form of our model finalised and, thus, the major factors of aerodynamic and performance value determined, we can now concentrate on producing an attractive fuselage profile, a task which, unlike the previous operation, has few significant restrictions. Now is the time to let our hair down and allow the imagination to run wild. Sounds great, doesn't it!

The idea is to produce a shape that is personally satisfying, which is worth admiring, has character, clean flowing but purposeful lines, and all that. It is a great mistake to sit down and simply plot methodically and with great accuracy a side view of the fuselage, for the chances are the result would show little inspiration and appear quite insignificant "in the flesh," as it were.

What we must do is to set to with a big soft pencil and some large white paper and eagerly sketch out the wildest variations of shapes that the mind is capable of conceiving. As I suggested when tackling the plan view, explore every possibility. Leave no stone unturned, and do not be afraid of consuming large quantities of paper. Fig. 78 shows the sort of sketches that I mean. The chances of finally obtaining a shape with some interest and character, that is a step above the rest, are substantially greater by aiming the sights high and then "watering down" the design into a practical proposition later, than by starting with a "tame" and mediocre shape that results in a nonentity.

It is so easy to picture in our mind the ultimate design, yet it is another matter to be able to convert it, with the aid of pencil and paper, into reality. However, by making a concentrated effort to investigate every possibility, we should sooner or later strike a "theme" that is to our liking. It can be a long and sometimes frustrating process but, when the lines begin to fall into place and we see at last some of our dream model appearing in black and white, then the sense of satisfaction and achievement is ample reward.

Before going any deeper, I must point out that we should not completely lose sight of the planform of the model which has already been established. Sooner or later the fuselage has to be mated with the wing and tail, so consideration must be given to the compatibility of these items. There are obvious cases where models possess the influence of one designer throughout, whereas others give the impression that the wing, tail and fuselage were each the work of separate individuals.

Once we have found the "shape" that, in our opinion, is compatible with the overall planform, the next step is to relate it dimensionally to this. This is best achieved by setting up a "grid" consisting of a horizontal datum line, crossed by verticals which indicate, to scale, the nose length, wing chord, moment arm and tail position. The idea now is to transfer our shape onto this grid, to produce an accurate scale fuselage profile that can then be enlarged to produce the full size drawing. It may be found that, in redrawing, some of the character or meaning is lost, and the shape may become distorted as a result of making it conform with the dimensions already fixed. For example, the rear of the fuselage may become disproportionate to the whole, or the nose a little deeper than expected in order to accommodate the radio equipment. Don't despair, for it is quite probable that the layout will tolerate a small amount of pushing and pulling along the fuselage to help rectify any discrepancies that have appeared.

With the layout and the fuselage profile drawn accurately to scale, the basic design is complete, so the scaling-up process can now commence to produce the final full-size "shapes" into which we can begin to work the construction. And this is where we might begin to regret some of the fancy ideas. . . .

Detail design

With the basic overall design put to bed, the time is now ripe to investigate and consider carefully the small details, the finishing touches if you like, that can have a considerable influence on the final product. By small details, I mean such items as the tip shapes, fairings, canopy, and rear-end treatment. In practice, these are the items often given little or no prior consideration and which only come to light as the balsa knife is travelling through

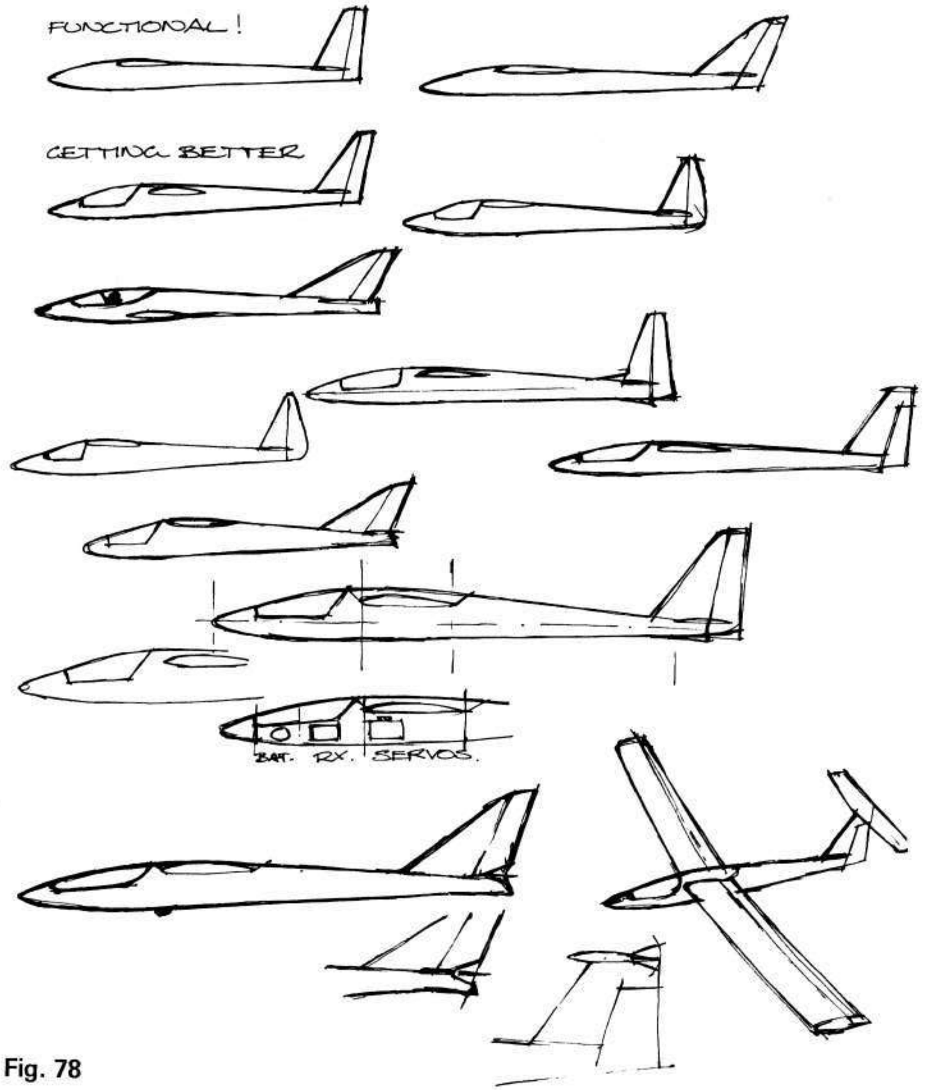


Fig. 78

the wood! Just to illustrate what I am driving at, I have made a couple of sketches (Fig. 79) showing a simple design before and after the "treatment." Let us now take a look at each of these items in turn. . . .

Tip shapes

Remembering my remarks earlier about some models giving the impression of being designed by three individuals rather than by one, the wing, tail and fin extremities should be related to one another in order to provide some continuity, throughout the model. With that in mind I have made another group of sketches, together with appropriate comments, which may provide some food for thought. (Fig. 80).

I read somewhere that the elliptical wing-tip shape is aerodynamically superior to all others but, to be quite honest, such theories are difficult to prove in practice, particularly on slope soarers, where ultimate efficiency is never the prime factor, so the choice of tip shape can be left entirely to the individual.

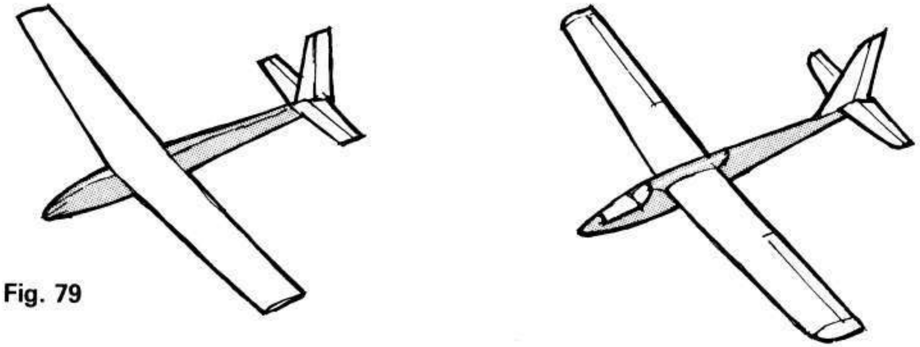


Fig. 79

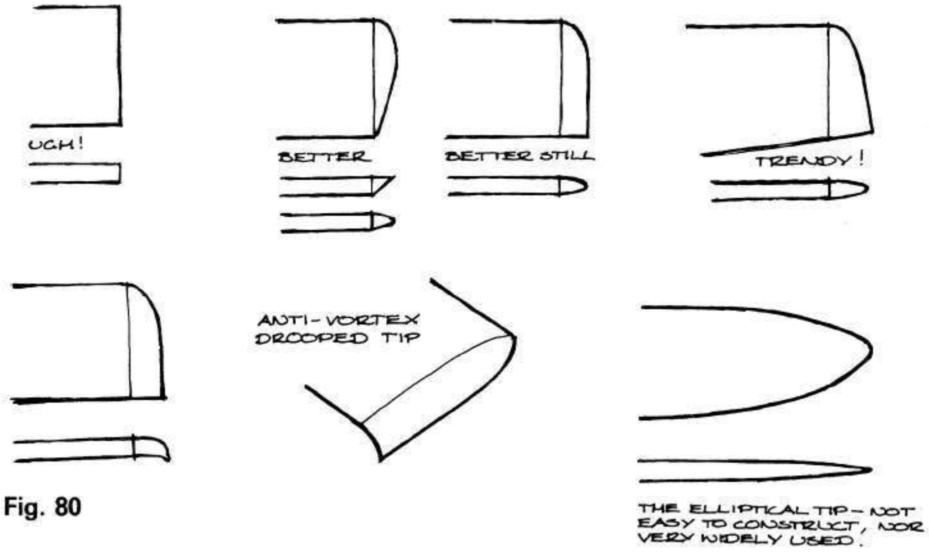


Fig. 80

Front-end treatment

You get blunt noses and pointed noses on people—and the same applies to slope soarers. The choice is up to you, whether you like your model to bounce or stick in! What does enhance a model more than any other individual feature is a cockpit canopy, preferably transparent but, if all else fails, at least a painted area to suggest where the canopy should be! Break off for a quick illustration. (Fig. 81).

The main problems with a transparent canopy, if it is other than the pimple variety, perched on top of the nose, are that it invariably exposes a tangle of wires and electrical workings that are not very pretty to look at and, being a fairly large non-structural component, can cause a weak nose just where additional strength is required. The above is, of course, most apparent on the smaller variety of soarers, with slim minimum area fuselages of just sufficient volume to accommodate the radio equipment. On the larger models, the radio can easily be tucked away, thus allowing considerably more scope in positioning the canopy.

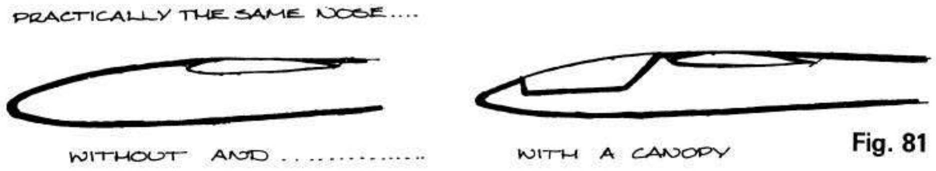


Fig. 81

Also under this heading, wing fairings deserve a mention. The simplest way of positioning a wing is simply to strap it to the top of the fuselage, which can give the appearance of the whole thing's being an accident. With a little more imagination and effort, we can set the wing down into the fuselage and continue the top of the fuselage over the wing, in the form of a fairing, thus creating the impression that the wing and fuselage actually came together by design. Incidentally, wing fairings serve a practical use, indicating whether the wing is correctly aligned with the fuselage—a useful check to make before "chucking off."

With the wing secured by the time-honoured rubber band method, it should be free to knock off cleanly in the event of an accident and, therefore, we should be certain to ensure the wing fairing does not foul the proceedings. Just how many models have you seen with a vertical bulkhead directly in front of, or behind, the wing? Quite a few, I bet, and I need not explain about what happens in a crash. One should always provide an angle no steeper than about 30°, in front of the wing so that, if the model does have an argument with the hillside, the wing is free to shoot forward without taking pieces of the fuselage with it. (Fig. 82). The angle at the trailing edge is not so critical, but it should ideally be 45° or less, thus allowing the wing to slew round should one attempt to land "one wing low" (there, somewhere, is the beginning of a joke about a Chinese pilot.)

Rear-end treatment

However painful the heading may seem, the relationship of tailplane to fin and the associated details, deserve considerably more thought than is often given. Firstly, we must decide whether the tailplane is to be detachable or not—if it is, then the fin must be kept clear of it. A detachable tail is preferable, if one's piloting skill gives cause for concern, but it is rather prone to be knocked and misplaced, causing an elevator trim change and, in addition, limits the design possibilities around the tail feathers. The sketches will, I hope, speak for themselves. (Fig. 83).

Constructive suggestions

Having spent so much time expounding upon the techniques and procedures involved in designing a slope soarer, to conclude at this stage would leave the story incomplete, for there ought to be some mention of how to construct the thing once it has been designed.

Here then, is a brief, and I mean brief, run through of the popular and proven constructional methods widely used on slope soarers.

Wing

Foam wings aside, a sheeted leading edge is considered most advisable, preferably top and bottom and, together with vertical main spar webbing, forms a "D" shaped box section.

Fig. 82

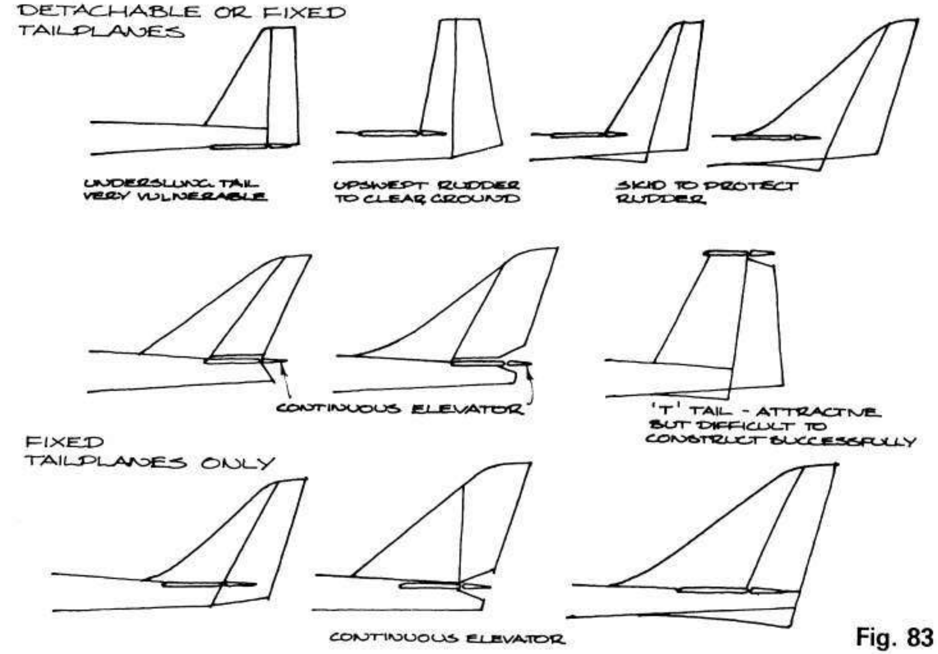


Fig. 83

which is very resistant to torsional loads. Spruce main spars are widely used, although hard balsa can be considered quite adequate, if using the type of construction outlined above. In the interests of economy, weight, and ease of repairing, an open structure behind the spar is recommended, using capping strips over the ribs to provide extra strength with negligible weight penalty.

Ailerons can be dealt with in two different ways, depending on the type used. Strip ailerons are the simplest, and also seem the most effective, as they do not affect the basic wing construction, and can simply be cut from solid wood. If inset ailerons are used, it is most satisfactory to build them in with the wing and cut them away when the basic wing structure is complete.

Fuselage

My own preference is to use fairly generous quantities of light wood, rather than thin and hard material, using 3/16in. sheet for the fuselage sides and underside with triangular longerons in the lower corners, and a fairly generous 1/2in. block top, again with longerons if desired. With this type of construction a fair amount of wood can be removed from the corners to produce an attractive near-round cross section and, when covered in nylon, which I thoroughly recommend if one intends to keep the model, produces a very strong but reasonably light structure.

If the wing is to be faired into the fuselage, 1/16in. ply facings should be used on both the fairing and fuselage where the join occurs, to provide protection when the wing shifts. It is worth while to add a small amount of fibreglass reinforcement around the inside of the nose, mainly in the form of corner fillets, to strengthen the joints between the formers and the fuselage sides, preventing the nose from "spreading" upon heavy impact.

"Tail feathers"

The tailplane and fin, together with the elevator and rudder can be straightforward,

3/16in. or 1/4in. sheet balsa, although one may experience some weakness in the tailplane, if it is permanently fixed, unless great care is taken over wood selection. If a fixed tailplane is contemplated, I would play safe and use a built-up structure, consisting of a basic 1/8in. by 3/8in. or so framework, with perhaps a small amount of spruce reinforcement around the centre, covered both sides with 1/16in. sheet. The result is still a 1/4in. thick tailplane, but one which is many times stronger than the solid version.

Now that I have reached a convenient clearing in the woods, it is an opportune moment for me to draw this chapter to a close. I hope I have covered the important aspects in sufficient detail—any obvious holes in the text are either an oversight on my part, or the result of the editor being over enthusiastic in his editing! If this article fulfils the task that I hope it will, then we should soon be witnessing some new and enterprising soarers on our slopes.

CHAPTER 13

T-TAILS, V-TAILS – AND DETAILS –

including all-flying tails, coupled flaps, flaperons, variable camber aerofoils, airbrakes and spoilers

THERE are certain configurations used on gliders which are not commonly found on any other type of model. For this reason and because, therefore, one is unlikely to come across them in any other volume on modelling, we are going to look at some of these here. The idea of this is simply to familiarise ourselves with them, and "what's the object" of them, which is what most newcomers to this branch of the hobby ask.

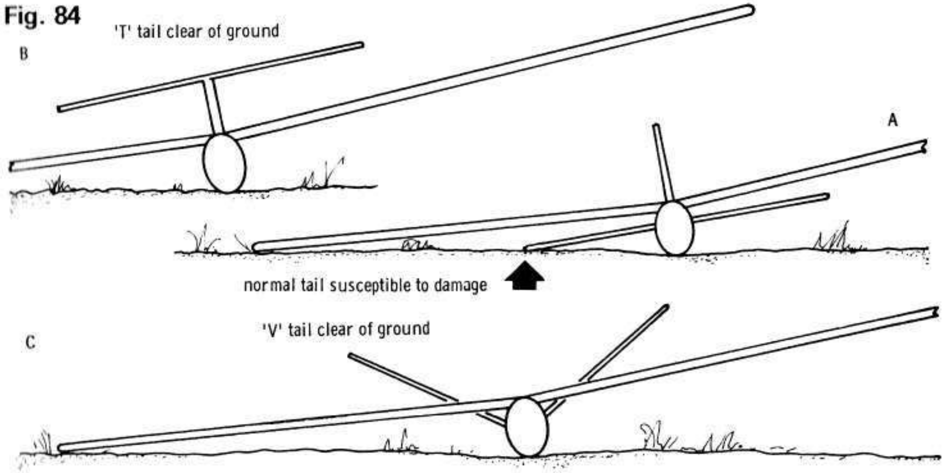
It is not intended to show in detail how to build or install such items—the former will come under the scope of another book, some other time, and the latter is dealt with exhaustively elsewhere*—but simply to show the sort of innovations that are made by r/c modellers, soarers in particular, with various specific aspects of their models in mind.

Ground clearance!

Many gliders, but especially slope soarers, use either a "T" tail—where the tailplane is mounted on top of the fin—or a "V" tail, instead of the usual configuration. No matter how one's aesthetic or aerodynamic senses may be offended, let us be clear that the main reason for this is to keep the tailplane clear of tufts and stones which are a common cause of damage every time the model lands—Fig. 84. The tail is also kept clear of the ground when the model is at rest.

There may be an aerodynamic bonus and there certainly is artistic satisfaction to be obtained from such layouts but, nonetheless, the main reason for their use is practical!

Fig. 84



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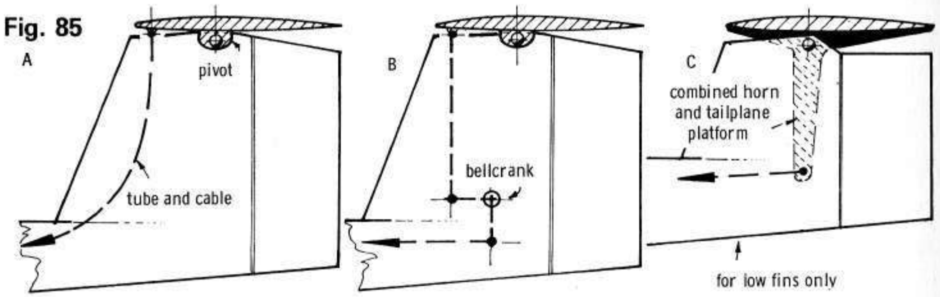
* **THE RADIO CONTROL GUIDE**—this publication has already been mentioned several times but it should again be emphasised that studying it closely will provide all the answers about installing equipment, linking up to control surfaces—including "T" and "V" tails and so on—that are not dealt with in detail in this book. As a bonus, the *Radio Control Guide* also advises on the choice of equipment at the outset, and how to maintain it in first class condition throughout its life.

Fig. 85



All-flying "T" tail

The "all-flying" or "all-moving" tailplane is one that does not have elevators. The whole tailplane changes its angle of attack instead. Theoretically, this is a more efficient way of doing things, of course, and undoubtedly is so in terms of "full-size" gliders. There is some doubt about there being any real aerodynamic advantage in model sizes. However, it is an interesting way of producing a tail unit and, of course, necessary on some scale subjects.

Probably the most commonly used all-flying tail configuration is in conjunction with a T-tail layout where it is probably easier to produce than an elevator version *provided the mechanics of the pivot and the linkage are properly and accurately made.* Many modellers do seem to have difficulty in producing accurate and slop-free tail-assemblies, however, and this is probably the main reason why, after enjoying an initial vogue, the all-flying tail has rather fallen out of favour with slope soarers. Unless properly made, an all-moving tail can develop "flutter" when the model is subjected to steep dives and other violent aerobatics. Such tails have even been known to lock in a "down" position, through poor geometry of the linkage arrangement. (Thermal soarers, on the other hand, are not subjected to such extreme aerodynamic pressures—not intentionally, at any rate—and the all-moving tail has therefore become quite widely used on these more sedate fliers.)

Fig. 85 shows some examples of T-tail layouts. The variations on this theme are numerous, of course, but about the most extreme version we have seen is that of one kit manufacturer, who has arranged for the whole fin and rudder to pivot and lean backwards or forwards in the fuselage, to provide the change of elevation. It works very well.

Fig. 86

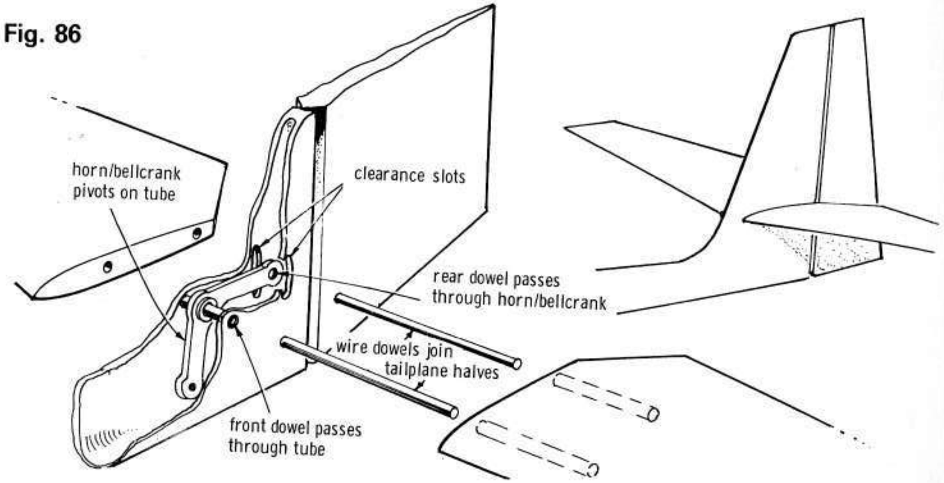
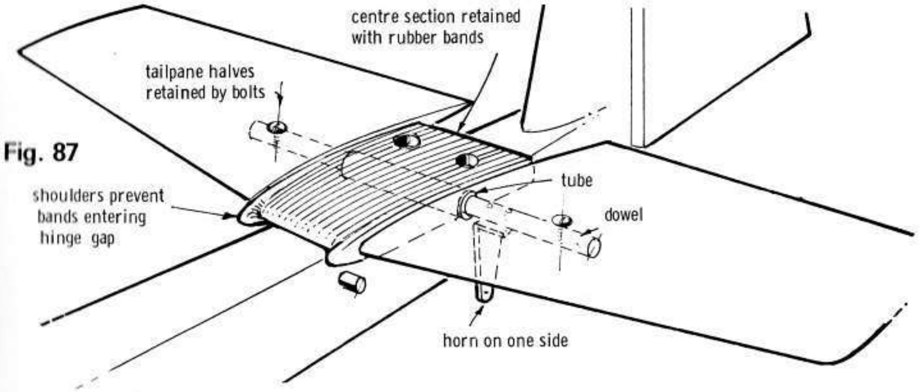


Fig. 87



All-moving semi-T tail

This tailplane is situated lower down the fin, and is usually in two halves, threaded onto each side of the fin with a wire support. One of the wires—the front one—simply rotates in a metal tube or bearing, and the rear one passes through one end of a bellcrank located inside the fin. Fig. 86 shows this arrangement.

All-moving tail on fuselage

These are most common as a modification to an existing design, when the simplest method is to have a separate centre-section through which the bearer rod goes to mount the tailplane panels. They are a good tight push fit. One of the tailplane panels (whichever side is convenient) has an ordinary elevator control horn mounted in a suitable position, and operated by a push rod in the normal way—Fig. 87.

Another method, rather more elegant, and likely to be used in a new design rather than as a modification—uses a bellcrank inside the fuselage with the tailplane (or "stabilator" as an all-flying tailplane is called) panels fitting each side in the manner of the "Semi-T"—Fig. 86—except that the panels are, in fact, fitted to each side of the fuselage.

V-tails

The V-tail, like the T-tail, is another way of keeping the tail out of harm's way. This time, however, we go one better, from the point of view of "cleaning up" the design, in that we dispense with the fin and rudder. The "V" angle formed by the tailplane is itself

Fig. 88

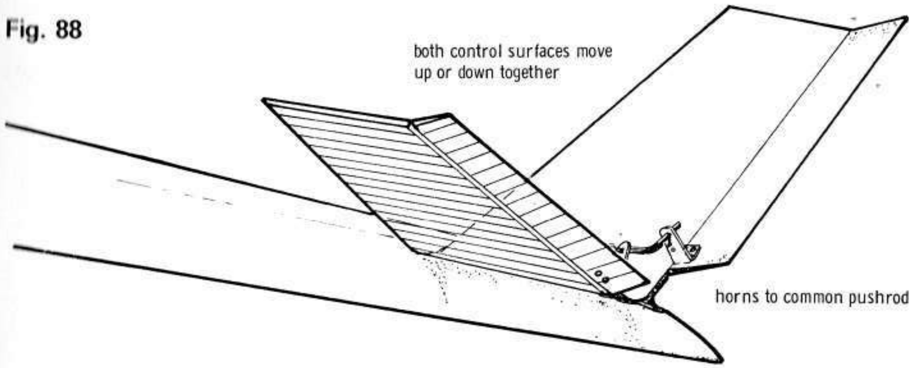
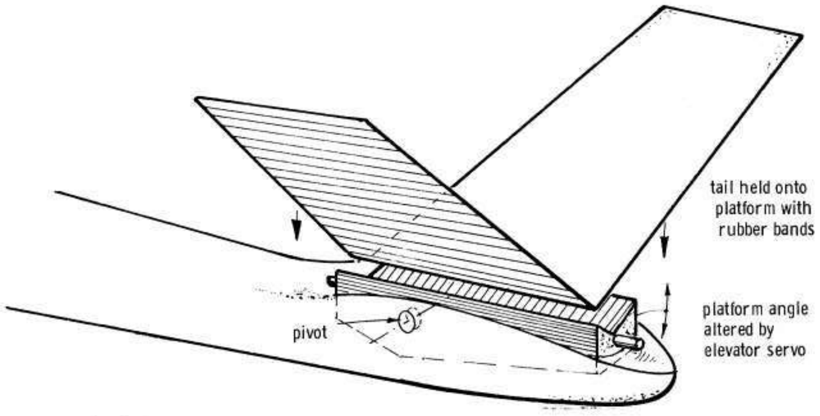


Fig. 89



presenting enough side area to make up for this. The V-tail is sometimes called the "butterfly" tail—a name, of course, derived from its appearance.

The simplest version of the V-tail is one whose control surfaces have elevator action alone. This is the sort of tail used on pylon racing soarers, that only require elevator and aileron action for all the manoeuvres and tight turns they may be called upon to make during the course of racing. Fig. 88 shows this type of V-tail.

An all-flying V-tail can be simple and elegant. As will be seen from Fig. 89, it can be of the knock-off variety—a good idea when used with pylon racers! The tailplane seats in a moving block which is pivoted in the fuselage and connected to the elevator push-rod.

Interesting things begin to happen, however, when modellers start to work on methods of achieving *rudder and elevator* effect with a V-tail! Fig. 90 shows the general principle but there seems to be no limit to the mechanical variations dreamed up to achieve the correct action and each modeller will, no doubt, choose the one that best suits his particular model, equipment or workshop.

Fig. 90

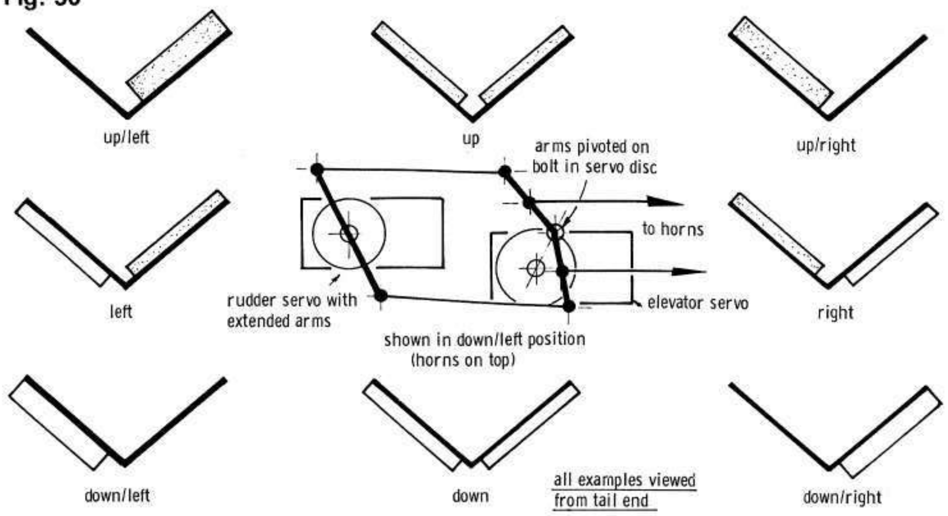
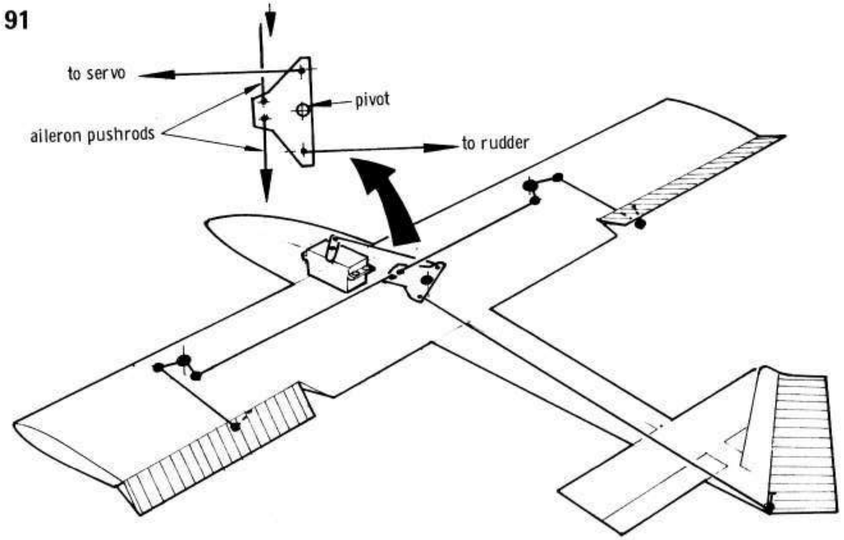


Fig. 91



C.A.R.—coupled ailerons and rudder

This is not exactly a part of a model's "configuration"—to look at a model one would not know it was being used—but more a "configuration of control."

As we have seen in the earlier chapters, some models—usually the scale or semi-scale type—perform best with rudder *and* ailerons. While this is no problem to those of us with "full-house" outfits, many soarers normally use only two-function equipment. To get the best out of these more sophisticated models, therefore, it is necessary to make a mechanical coupling, as in Fig. 91, so that both rudder and ailerons may be operated by just one servo.

The best proportion that the rudder should move in relation to the ailerons will only be found, on each individual model, by trial and error but, as a rule, it is necessary for the rudder to have considerably more travel than the ailerons. For instance, one model we know of, has "normal" aileron movement ($5/16$in. "up" and $3/16$ in. "down") and the rudder deflection is some 40° to tie in with this, for nicely co-ordinated turns. Each model varies, however, and trial and error is the only sure way.

We have heard of C.A.R. being used by full-house fliers who could not seem to manage

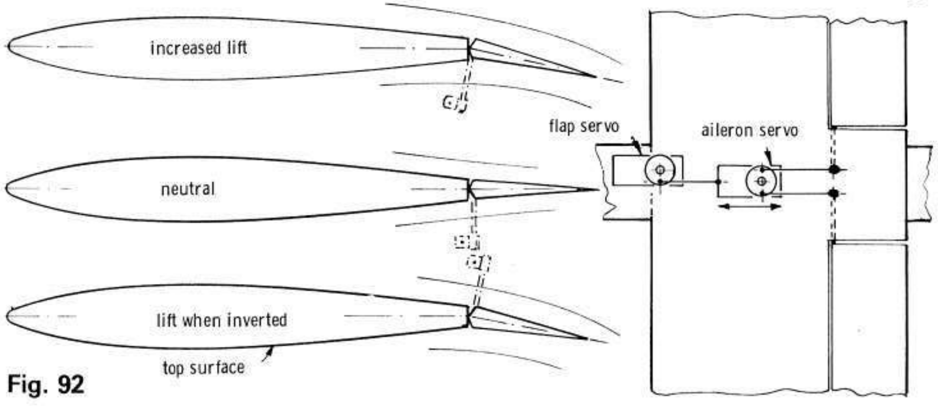


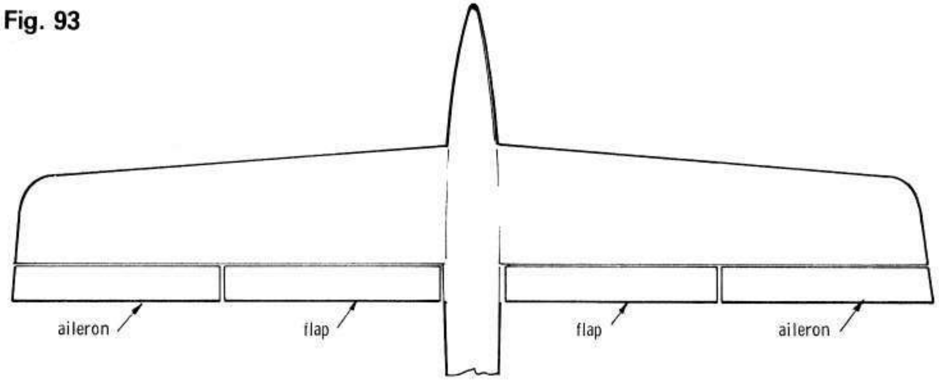
Fig. 92

the correct co-ordination of rudder, aileron and elevator. By coupling rudder and aileron, they say, they can at least be sure that all the controls go in the right direction! Usually, on a model with a relatively small ("scale type") dihedral, quite a large degree of rudder movement will be required.

Flaperons

The word "flaperon" is a composite of "flap" and "aileron" and it means, naturally enough, part flaps and part strip-aileron. The idea of an aileron usable as a flap is twofold. The flaperons can be drooped so as to give the trailing edge of the wing a downward curve, thus giving the wing an increased lift coefficient, in order to maintain—or gain—height. They can then be neutralised for general aerobatic flying, or *raised,* to once again increase the model's lifting properties—*when inverted.* Fig. 92 shows this, and also that two servos are required—one operating the ailerons in the normal manner, and the other driving the first so as to effect flap control. This is achieved with a similar servo link-up to that shown in Fig. 90. The flap and aileron controls operate independently and simultaneously.

Fig. 93



Flaps/ailerons

Another practice is to use wider control surfaces, and to arrange the outboard part as ailerons and the inboard part as flaps. This probably has advantages in that the effectiveness of the ailerons is in no way impaired, and the increase in overall lift coefficient will probably be greater than with flaperons. Fig. 93 shows roughly the proportions of flap and aileron used.

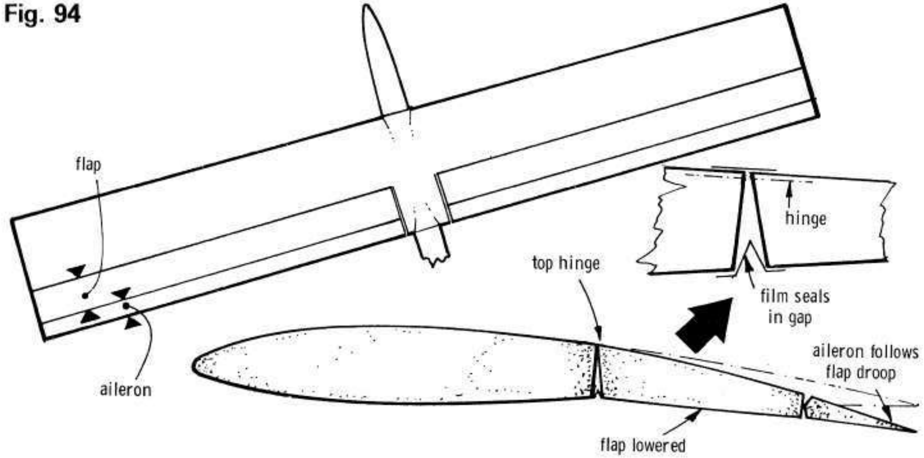
Variable camber aerofoils

Following on from "flaperon" the logical development was a really variable geometry wing section. Not many have so far been produced in this country—only those by the more dedicated contest protagonists. They require a great deal of painstaking care and attention and much experimentation.

Those systems tried so far have been of two types. First, the definite two-stage, changing-section wing, then the less complicated "wide flap" type. As seen in Fig. 94 the two-stage type changes its section from about one-third of the wing chord. It involves considerable mechanics for the linkages—and big problems arise with the necessity to seal the gap on the undersurface of the wing. Without sealing, serious vibration problems develop, due to turbulence around the edges of the gap. Power to move it becomes the problem with the seal in place, however!

Whereas it seems necessary to seal the gap which occurs, in the two-stage unit, at some one-third of the chord, there seems no such necessity to seal that on the "wide flap" unit, which occupies something less than a quarter of the chord—not really such a great deal more than the normal strip aileron, as seen in Fig. 95. Instead of sealing, a knuckle hinge is used for the flaps and ailerons, which allows a very close fit. This type of variable section has proved very effective in marginal wind conditions, but seems to have little if any advantage in "good" contest weather.

Fig. 94



Coupled flaps/elevators

This system, whereby the flaps go down when the elevator goes up—and vice versa—gives a greater coefficient of lift to the wings at just the moment this is required—that is, in tight turns. The subject has been more fully dealt with in the chapter on Pylon Racing models, since it has been developed specifically with pylon racing in mind.

Spoilers

Many of the larger and more efficient models find difficulty "losing" height for landing. In fact, on some sites where one is obliged to land *into* lift they can pose definite

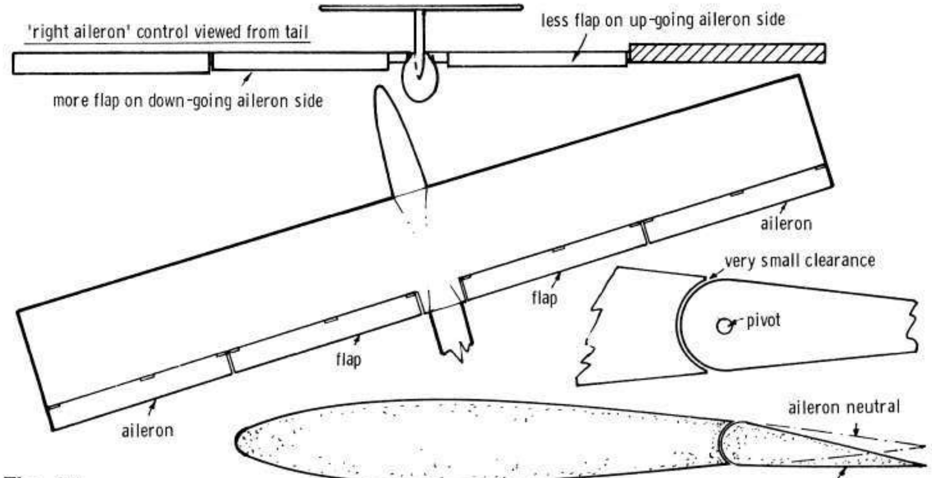
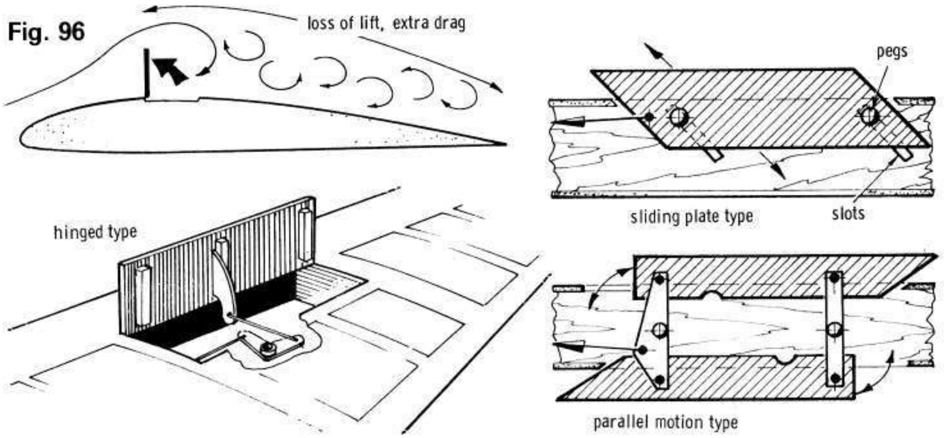


Fig. 95

Fig. 96



problems, unless some sort of lift "spoiling" device is fitted, so that they can make a steep approach without too much build-up forward of speed.

Mechanically, spoilers take a number of forms and, as always, the modeller will select that best adapted to his particular model. Fig. 96 shows a few of the variations. Choice could depend on the spar depth, or even the type of output of the servo it is planned to use. The position of the spoilers, chordwise, is usually at the maximum depth point, for both efficiency and structural reasons. Spanwise, they should not be sited too near inboard, as the turbulent airflow caused by them could reduce the effectiveness of elevator control, as shown in Fig. 97.

No one seems to have arrived at a formula for determining the appropriate size for spoilers on any particular model. In most cases it seems that a strip of material roughly ½ × 6in. long, placed at about the main spar position (maximum thickness of the wing) and parallel with the spar, will have the desired effect! These are often made from thin ply, but tend to warp, so Paxolin or Formica have been more often used.

If you have fully proportional control on the spoiler servo, then so much the better, as it may be raised by degrees, noting the effect, and correcting as you proceed. As a rule, when the spoilers are raised a little, the nose of the model drops slightly. One corrects this with a little back stick and the model starts to sink. More spoilers, more nose-down pitch . . . more back stick . . . more sink—and so on. So, in fact, the approach may be steepened considerably without increasing the forward speed because we are, in fact, now only using some three-quarters of the wing, having "spoilt" the lift on the other quarter or so. Fig. 98 shows the effect on the glide angle.

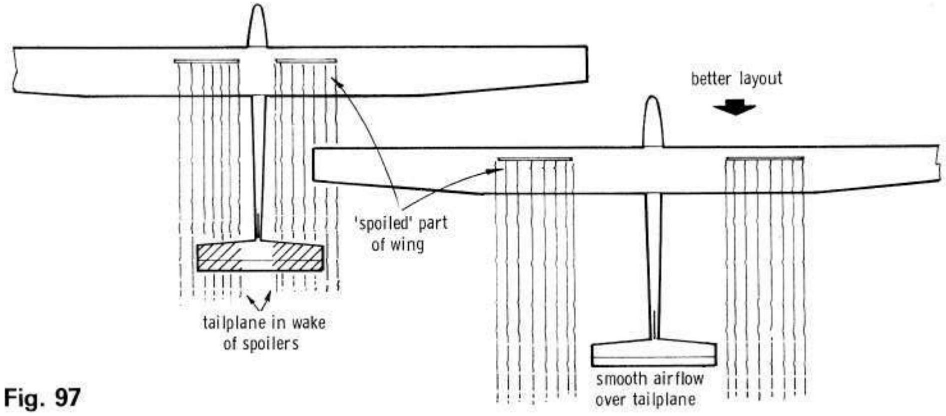
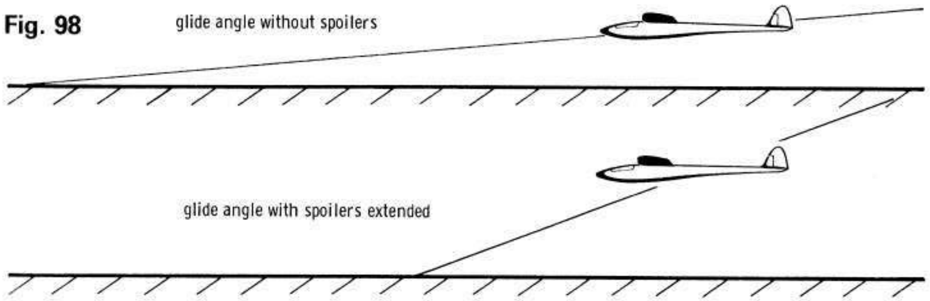


Fig. 97

Fig. 98



Some modellers, who do not have extra servos available, operate a "once only" system, whereby the spoilers are fully extended by a take-off from the extreme position of one of the other controls. For instance, the spoilers could be actuated by rubber bands, but held closed by a pin which was pulled by a thread attached to the servo output, in such a way that it would not operate unless "full down" were applied—very briefly, one should add. The brief moment of down-elevator will hardly affect the model's equilibrium, but sufficient movement has been given by the servo to pull out its locking pin and release the spoilers. Crude, perhaps, but effective—and certainly light.

However effective the "once only" system may be (it is probably ideal for thermal soarers) it is really best to have a separate servo for the job. In this way, not only is it possible to "inch" the spoilers up, by degrees, but also to retract them fully and "go round again," should your approach not have been shaping up to your liking.

It is usually the larger types of semi-scale or sport models that benefit by being fitted with spoilers. The smaller aerobatic models are generally manoeuvrable enough to be able to land in confined spaces without such aids.

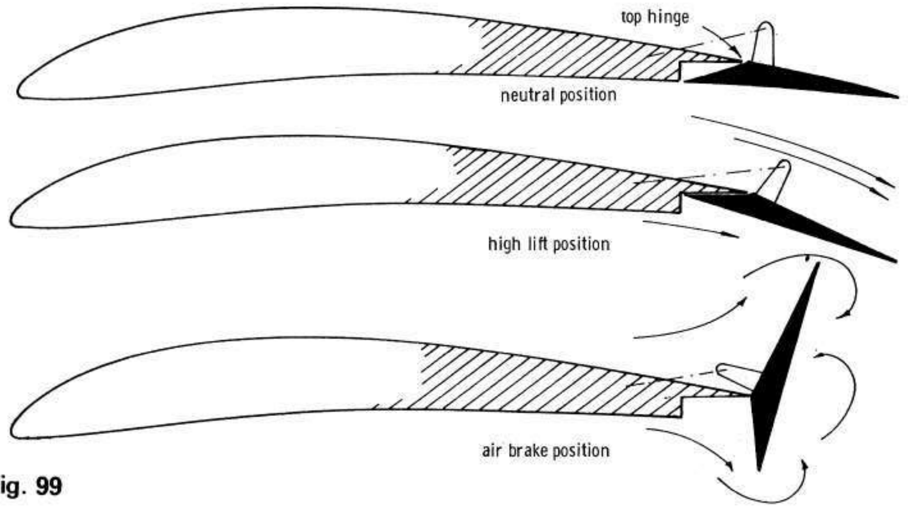
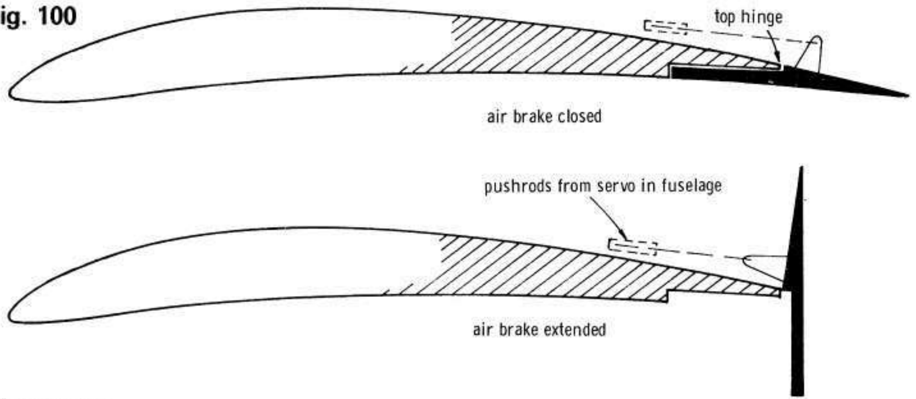


Fig. 99

Fig. 100



Flap/brakes

An unusual and ingenious idea from Norway, shown in Fig. 99, is that of dual-purpose flaps-cum-brakes. Bear in mind, however, that the sort of models flown there are more like the "thermal soaring from the slope" models seen in Germany and the rest of the Continent—not like our own slope models, which are more often of the aerobatic type.

The idea behind these devices is to have a flap which may be used as a lifting surface for slow flight and, using the same servo, with the secondary rôle of serving as an effective airbrake/spoiler. The diagram shows how the system works in theory, but it will need careful structural design to give the necessary strength and rigidity in practice.

Although we have not yet seen these interesting devices in operation on a model in this country (and they could well be more suited to thermal soarers than slope soarers) the Norwegians claim many advantages. These include a much lower landing speed, steeper descent at lower speeds, increased longitudinal stability (as compared with ordinary brakes), improved thermalling performance, permitting safe turns of much smaller diameter without stalling—and improved efficiency, by virtue of the elimination of air leakage and contour breakaway at a critical location on the wing.

Trailing-edge airbrakes

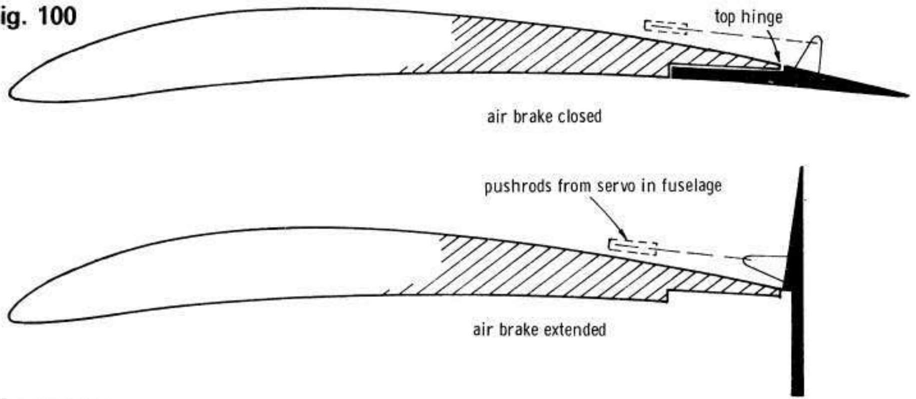
The trailing-edge flaps, as used in Germany, are really a simplification of the Norwegian idea, dispensing with the higher lift position, as will be seen from Fig. 100. Again, these will have a wider application on thermal soarers, but could be used, with advantage, on slope soarers which have to be landed in confined spaces, into lift. When they are deployed, the model may be pointed at the ground, at something like 60° to 70° and will lose height at something less than its normal flying speed. Any tendency to "float" on the landing approach can be killed, and excess height can be lost at the correct moment, by their adroit use.

There are many refinements, both in configuration and in mechanical detail, that have been—and will be—devised by the keen and ingenious soaring modeller. The foregoing, however, are probably the most significant, and are certainly those which seem to puzzle the newcomer most, as to their whys and wherefores.

SECTION TWO

THERMAL SOARING

Fig. 100



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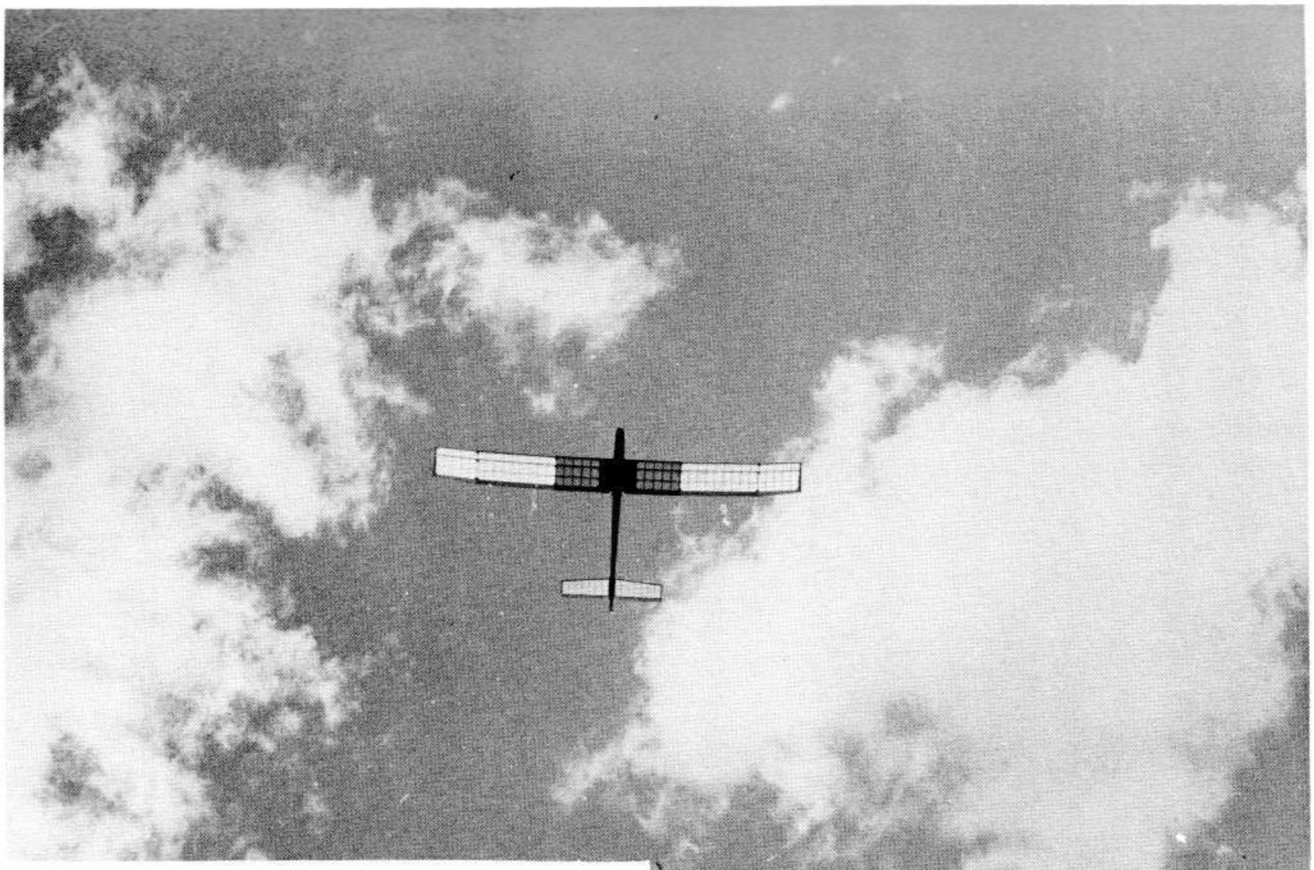
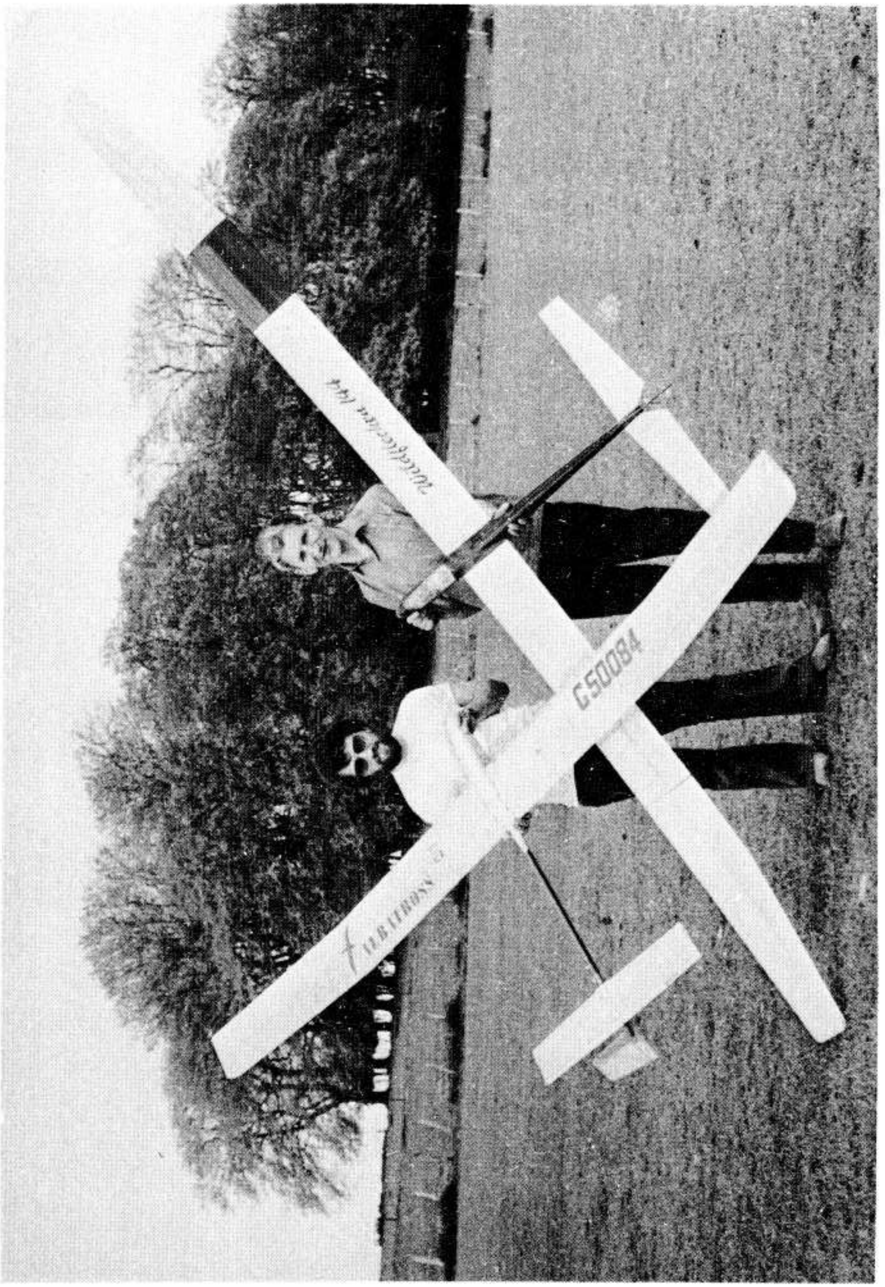


"Overhead release" – a picture which brings to mind all that's most enjoyable in thermal soaring. A warm summer's day and the model rising towards the fleecy clouds in good lift.



Co-authors of our introduction to thermal soaring, Dave Dyer (left) and Geoff Dallimer.

CHAPTER 14

AN INTRODUCTION TO THERMAL SOARING

By GEOFF DALLIMER and DAVE DYER

A WARM summer day, bright pillars of white cumulus cloud drifting across a clear blue sky, birds circling over the treetops. . . . Climbing quietly up to join the birds comes another winged creation, circling in the warm summer air. Soon it out-climbs the birds and rises eerily towards the clouds, for this bird is man-made and embodies his scientific knowledge to produce wings more efficient than those of our feathered friends; this, then, is a thermal soaring glider.

This idyllic scene is how any enthusiast of soaring flight will visualise his Sunday flying. Above, the air buoyant with warm thermal currents to sustain his model's silent flight; below the peaceful countryside. Not for him the hot concrete runways, the sickly smell of alcohol fuel, or the raucous noise of the soulless engine. But wait!—not always does our elegant model climb swiftly on a summer thermal—often it sinks dismally as though invisible hands were clutching it out of the sky—now nature adds a challenge that will increase man's enjoyment of his hobby!

The simple facts

How can a model—or any other aeroplane for that matter—fly without an engine? Firstly, one might ask, what is the purpose of the engine? We can say it is a means of providing power for movement, and this forward movement is translated into lifting flight by the aircraft's wings. There are, however, other means of propulsion; gravity, for instance, will provide power for movement, as anyone who has chased a ball downhill will testify.

A glider is continually flying "downhill," using the potential energy of its height, to create the forward motion needed for its wings to sustain its weight. The wings create lift by means of their reaction with the air through which they are passing; we say that an aircraft has "airspeed" and moves "relative to the mass of air surrounding it." Thus the glider, in *still air,* will fly steadily forward, sinking down at a constant angle until it reaches the ground. This angle is known as the "glide angle" and is a measure of the model's efficiency. The more efficient the model, the further it will glide for a given height loss.

But did you notice we said "still air"? Herein lies the key to long gliding flights and the ability of a glider to climb instead of sinking. *Always* the glider is sinking, relative to the air surrounding it, but what if this air is *rising* relative to the ground? Fortunately the air around us is very rarely, if ever, completely still. The heating effect of the sun causes masses of air to rise vertically, while other masses are sinking.

A good indication of how the air behaves can be seen in autumn, by watching the smoke generated by your local farmer burning off the stubble from a cornfield. Columns of rising air are known as "thermals" and are caused by some air becoming warmer than that surrounding it. Flying in these columns of rising air is therefore known as "thermal soaring." Later on we will discuss in more detail how thermals are formed and how to find them.

Thermal soaring gliders . . .

Thermal soaring is not new in itself, since both full-size gliders and free-flight model gliders have been flown in thermals for many years. However, with the advent of radio control systems light enough—and, incidentally, reliable enough—to enable the glider to be fully controlled, a whole new field of possibility has opened up to the model glider enthusiast.

The design of models for thermal soaring is still in the developing stage and, although at first the models used for r/c thermal soaring were fairly heavy ones, designed for slope soaring, but adapted for flat-field launching by the fitting of tow-hooks, the current trend is towards a much lighter "free-flight" type of glider, usually of around 8ft. to 12ft. wing span. The evolution of specialist models is bringing a steady improvement in performance, with an "all-weather" flying capability. How much influence the weather environment has on the design of thermal soaring gliders may be seen by comparing the very large (12 to 16ft. span) models flown in the United States, with the smaller (8 to 12ft.) models flown in the quite different climate of the British Isles.

This difference in climate also makes the formulation of acceptable International competition rules more difficult, since the flying techniques and models' performances are somewhat different, too. The larger models are able to circle and "work" a thermal as it drifts downwind, and then return upwind to the starting point; the smaller models, however, are less able to penetrate upwind, so remain near their starting point and only "work" the thermal as it passes by.

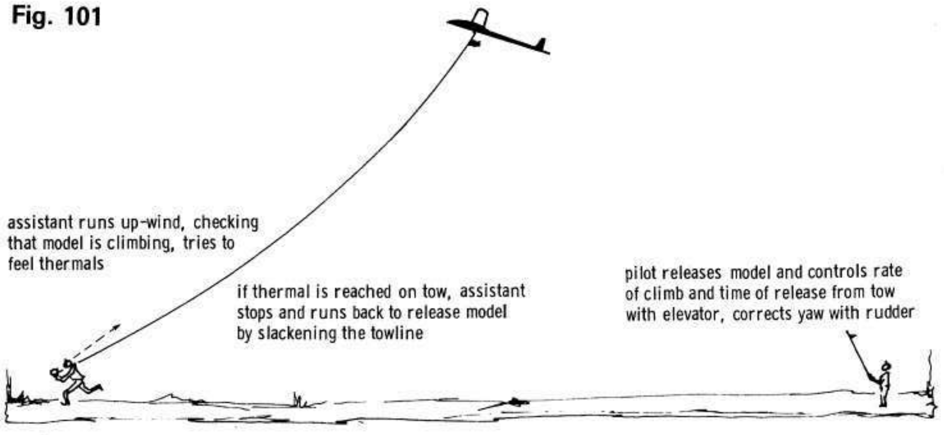
Thermal soaring, then, consists of launching the model over flat land (as distinct from a hillside), either by means of a tow-line or catapult, to a height of about 500ft., and then seeking out areas of rising air to sustain the model's flight—and even gain height. Sufficient height is often gained to allow the model to perform aerobatics, such as loops or spins, although the more efficient, high-performance, type of thermal soarers are not generally suitable for this purpose.

Getting started

By now we hope to have fired the reader with our enthusiasm for thermal soaring, to the extent that he is already thinking about building a suitable model. There are a number of excellent kits available, both of Continental origin (thermal soaring is very popular on the Continent) and from British manufacturers. Alternatively, the modeller may, if he wishes, choose from the wide variety of plans published by the modelling press. Building from a plan is probably the most economical way, although it will, of course, require rather more work on the part of the constructor.

To some extent the choice of model will depend upon the type of radio control equipment the modeller is going to use. The controls required for a thermal soarer are basically rudder and elevator, and these may be operated either by proportional radio

Fig. 101



equipment or by single channel systems—or even the old-fashioned "reed" outfits, or "galloping ghost." *(For details of the development of radio control systems, the reader is referred to* The Theory and Practice of Model Radio Control, *published by the publishers of this book.)*

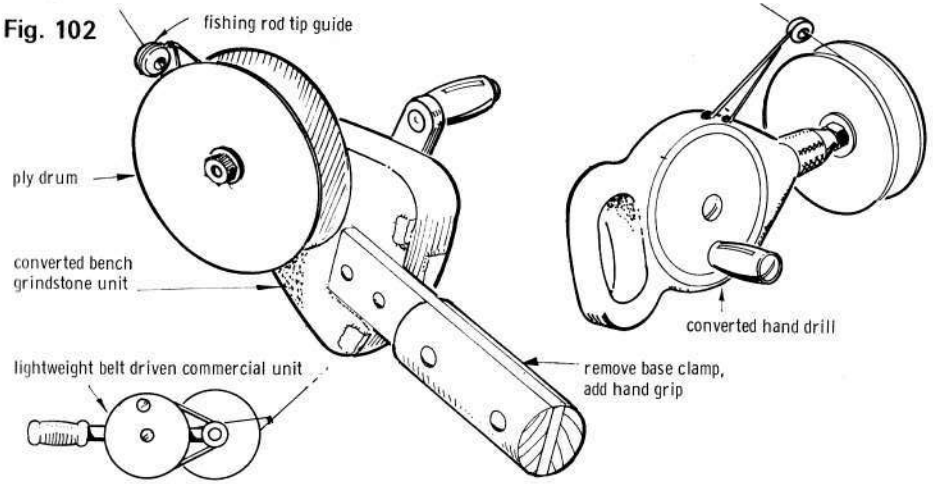
One cannot deny that the modern proportional systems are by far the most satisfactory, but this should not discourage those considering using simple single channel outfits, since these can still give excellent results on a cost/enjoyment basis. Being able to steer proportionally—and point the nose up or down—however, does make a whole world of difference, so proportional is really to be aimed at, if at all possible.

Launching technique

There are two main methods of launching thermal soarers, these being the tow-line and the Hi-start. Other methods, such as powered winch or pulley, have been used but have not gained popular acceptance, in this country, at least.

Hi-start, or Bungee launching, as it is more commonly called, is dealt with in another chapter, so here we will only say that, for competition work, it is now generally accepted that the tow-line is the more practical and efficient. Basically, this is simply a length of line, attached by means of a ring, to the model's tow hook, and by which the model is pulled along and into the air, in much the same way as a kite is flown. (See Fig. 101). The difference is, of course, that when the model reaches its maximum height (this often being vertically above the head of the man doing the towing) it is released, by the ring on the tow-line sliding from the hook, to fly where the pilot directs it.

Fig. 102

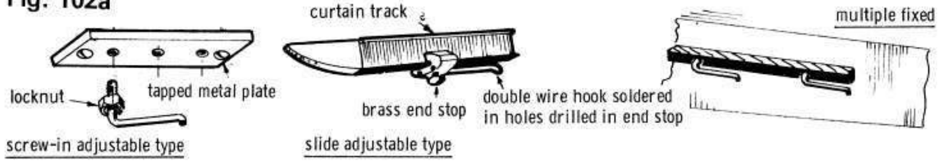


The most commonly used line length is 150 metres, although International rules call for a *maximum* line length of 300 metres, at the time of writing. For models of up to approximately 800sq. in. wing area and weighing up to, say, 3lb. the use of a line of about 22lb. breaking strain would seem to be the best choice, and the material used is almost universally nylon monofilament (fishing line). For models of greater area and weight, the breaking strain of the line used should be increased accordingly.

Care must be taken, when choosing a line, to have a fairly low cross-section area in order to minimise drag, and thus height loss. When in use, the tow-line must be regularly inspected for flaws, as the 3 Kg pull test used in contests will quite easily break a line if it has been chafed or cut, or even badly kinked.

To house the line, some form of drum is required, fitted to a geared hand-winch. By this means, the line can nearly always be fully winched in, after release of the model, before it touches the ground at all, thus avoiding its snagging or becoming tangled. To this end, a gear ratio of a fairly high order can be of great help. There are a few commercial winches on the market, but most modellers prefer to make their own. These can either be made up from scratch, or based on existing mechanisms such as small workshop hand-cranked grindstones—the stone itself being replaced by a drum of suitable proportions. Fig. 102 shows some typical examples, while Fig. 102a shows some methods of arranging for different tow points on the model. Fig 102b shows the method of determining the optimum hook position.

Fig. 102a



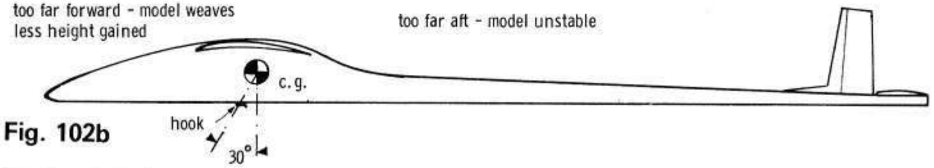


Fig. 102b

Towing technique

Here one has the choice of either towing the model oneself or finding a willing (and able) assistant to tow the model, while one concentrates on controlling it. Ideally, it is better to tow your model yourself but, as usual, there are snags. Quite apart from the obvious difficulty in running with the transmitter in one hand and the likelihood of bending the extended aerial, and the virtual impossibility of giving any form of precise control while on the run, there are other considerations. For competition flying, especially, where one has to land the model in a specified area, there is a definite disadvantage in towing for oneself. If you are flying the model in calm conditions, quite a long towing run can be involved and the result of this will be that the release point will be perhaps 300 to 400 metres upwind of the landing/launch area. Most modellers will agree that trying to control the model will be difficult while running or trotting back to the landing area. (If your landings are accurate at 300 or 400 metres, then you can ignore this point, but you will probably be unique!)

Another disadvantage of towing your own model is that, when the pilot is immediately beneath the model it is difficult to effect accurate pitch control—because he cannot observe the model's behaviour in that plane easily from this viewpoint—so several seconds are easily lost because of a non-optimum trim, or even a severe stall. It will be seen, therefore, that if an assistant tows the model, the pilot can relax and assess the wind and lift conditions while the model is gaining height, and he can also ensure that the model does not deviate from the desired straight tow, by giving any necessary correcting control. At the same time, the assistant can concentrate entirely on towing and, if necessary, run to his limit (boundary and physical) in the all-important search for lift, while the pilot stays in the launch/landing area and concentrates on the moment of release for the model.

For launching the model should be held up high, with its wings level and its nose well up, as shown in Fig. 103. As the line tension increases, due to the assistant commencing to run, the pilot begins to run with the model for a few yards, not letting go of it until he feels that it has reached flying speed.

Towing itself is not difficult, once one has mastered a few simple techniques. At first one

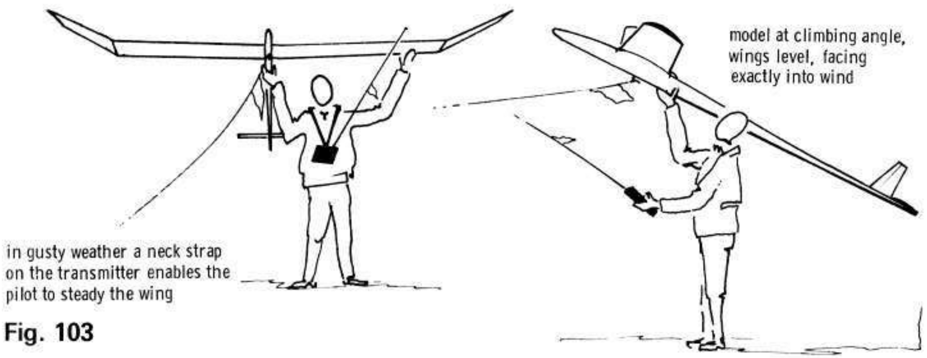


Fig. 103

has to run fairly fast to take the stretch from the line and to achieve the model's airspeed. Once the nose of the model lifts and it starts to climb at 30° or 40° to the horizontal, the speed of tow can be reduced and the model held in a steady climb until the "top" of the line is reached. Allowance must be made here for the wind component, in that, if calm, one must run faster and *vice-versa*. In fact, in strong winds it may even be necessary to run *towards* the model part of the time, to relieve the wing of what could otherwise be an excessive load.

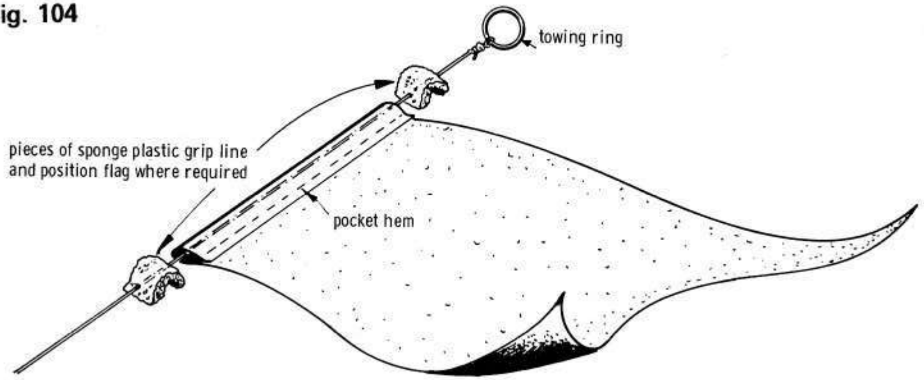
Some models tend to yaw and pull away to one side while being towed, due to either a shortcoming in the design, or to warped flying surfaces. If the model does veer, then a reduction in the towing speed should help the model to swing back naturally onto a straight climbing course, with the minimum of assistance from its pilot. (In fact—to revert to the "other end" for a moment—it is generally better to under-control than over-control while the model is being towed, as over-controlling can result in the model's oscillating wildly from side to side, if the pilot gets just a little bit "out of synchronisation" with his correcting commands.)

Once the model has reached its maximum height, on tow, one should be able, by slow running, to hold it there and wait for it to show signs of being in lift. However, as contest rules may call for a maximum allowable time spent on the line, there may not be many seconds left in which to do this. On the other hand, if you are only flying for your own pleasure, rather than in a contest, the man towing may "walk" the model around for several minutes until he feels it pulling, telling him it is in lift. To be able to launch a model straight into an area of strong lift is, of course, a great benefit, and should result in a better flight than simply trying to find lift "on the way down." The model is released (if the pilot is not using a radio controlled tow-hook release) by simply stopping and releasing any remaining tension on the line by jerking or shaking the line towards the model, being careful not to jerk (and so possibly stall) the model itself in the process. To aid both the release of the line, and the timekeeper's chance of starting his stopwatch at this precise instant, a pennant is used on the tow-line. In contests, a certain minimum area is laid down for this pennant, namely 2·5dm^2 or approximately 39sq. in. A suggested method of fixing the pennant to the line, so that it may be positioned as required, is shown in Fig. 104.

One of the biggest problems for the beginner to thermal soaring—or, rather, his helper, is in deciding just exactly how fast or slow the model should be towed, in a given set of conditions. Many people new to it, simply tear off across the field at a constant speed, irrespective of the strength of the wind. As a result, the model may, at best gyrate madly and perhaps even barrel roll on the line—and, at worst, the wings could fold up. Some helpers, however, are less energetic and do not run fast enough, when (especially in near calm conditions) the model simply follows behind them, about 15ft. up, and eventually gains on them, slipping its tow ring as the tow-line sags.

If at all possible, it is really the best plan to secure the services of an experienced glider flier—either radio or free-flight—to tow your first model up for you. By doing this you will know that it is being given a good launch—much better than having inexperienced men at

Fig. 104



both ends, no matter how enthusiastic! After a flight or two, ask your own helper to go along with the experienced man, and get the feel of the towing end of things. After that, it is simply a question of practice, practice and more practice.

Flying

The model will be quite some distance away from the pilot, at the point of release—the length of the tow-line plus the distance covered by the man towing—but this should be no cause for concern. It is, in fact, easier to detect thermal lift when the model is some distance away, than when it is near, since one is more easily able to detect any rising-up of the model, relative to the ground.

Old-hand power fliers tend to become a little disconcerted at the necessity for this long-distance control—and, indeed, sometimes find their control movements "out of step" with the model's requirements. If one is to continue thermal soaring, however, one should practise flying the model around the release point and some way *up-wind* of it, since it is here that often the best lift is to be found. More will be said about thermal lift and how to find it, a little later on.

Judging the landing approaches of thermal soarers can be quite difficult for even the most experienced power fliers since, of course, their rate of sink is very much lower and the glide angle a great deal better. They tend to float on, and on, and on, in fact, when only a few feet from the ground. The beginner can expect to make many "overshoot" landings before he gets the measure of his model. For that matter, this can apply almost equally to the experienced thermal soaring enthusiast with the first few flights of his latest (and best!) model. In this case, however, he does have the encouraging thought that, if it *does* overshoot, then it must be better than his last model.

THERMALS AND THEIR DETECTION

The use of thermals, as a method of prolonging soaring flight, is a well-established practice. Both full-size and model gliders have been doing it for years—and birds, of course, have been doing it since the dawn of life on earth.

First we will discuss the formation of thermals and then give some information on thermal utilisation. A generalisation of thermal shape and airflow is shown in Fig. 105. It will be seen that the overall shape is that of a ring doughnut, with the central core of the thermal moving upwards and the perimeter moving downwards.

On most sunny days more heat is supplied by the sun's radiation to a piece of ground than can be carried away by convection and wind turbulence into the air, and by conduction into the ground. Consider, then, a parcel of air thus heated. The air in this parcel becomes very unstable and thus, either because it is slightly warmer than its immediate surroundings, or because of its buoyancy and turbulence, this parcel begins to rise. As this formation moves upwards more air is encompassed and so the thermal grows in size. It follows that, because this parcel of air is rising, then other air must take its place, and this is how down-draughts (negative thermals, if you like!) are formed. A point which should be realised here is that, on some days when very strong thermals are abundant, there must also be very strong down-draughts existing, so flying becomes a matter not only for contacting lift, but also of avoiding down-draughts.

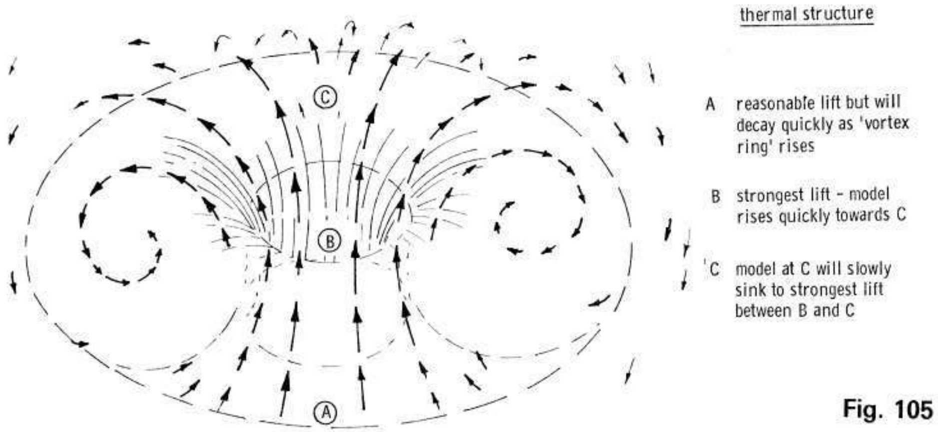


Fig. 105

As we have seen, some areas must become slightly warmer than their immediate surroundings to produce a thermal; such areas are called "heated thermal sources." The strength of such a source is dependent on two factors: the rate of temperature rise of the ground surface and the length of time an amount of air is resident over that particular area, before moving in the general wind flow.

The rate of temperature rise is dependent on several factors, namely (i) moisture content of soil—more heat used to heat damper soil; (ii) reflection of sunlight by the surface. For example:

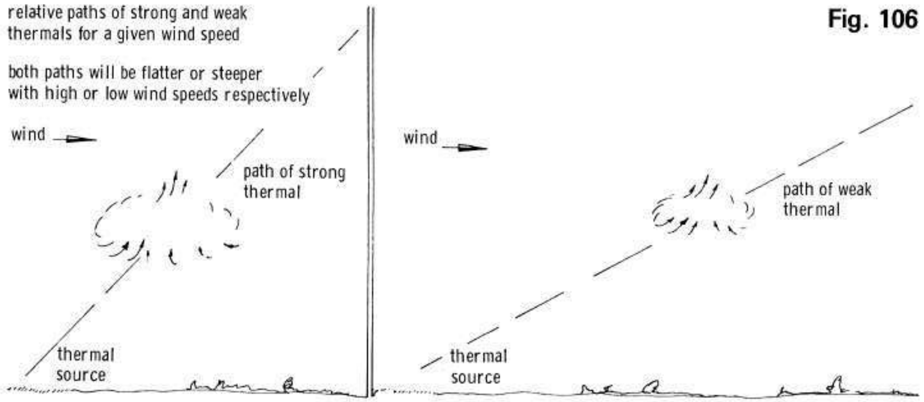
Surface	Wasted sunlight
Crops	3—15%
Bare ground	10—20%
Grass fields	14—27%
Snow, ice	45—85%

(iii) angle of incidence of the sun's rays and (iv) foliage cover. (This causes a reduction in ground heating due to the foliage using the heat for transpiration.

The period of time for which a parcel of air is in the vicinity of a thermal source, is dependent on wind strength and the degree of sheltering present. It follows that if an area is downwind of an obstruction, the air behind that obstruction will reach a higher temperature than that which is unprotected. This effect is even more pronounced if the area protected is in direct sunlight and that surrounding it is not. The effect of obstructions, for example, trees on a field boundary, can sometimes be to cause turbulence *and* have a sheltering effect, thus increasing the probability of thermal production. Another point is that thermals of different strengths will have proportionately different ground speeds—see Fig. 106.

Whilst the foregoing should be used as a guide to possible location indications, it should also be realised that what is normally a poor thermal source—for example, a wood or group of trees—can become a very reasonable area of lift production at a different time of

Fig. 106



day, since, in the evening, the woods become reasonable sources when most normal sources have ceased to be active. Combination effects of all the aforementioned phenomena make accurate prediction of thermal sources difficult, so it is necessary to study carefully any particular area and notice the location and frequency of any lift produced.

Thermal shape and form

In all gliding circles there is still much discussion and argument as to the actual form that thermals take. Because of the many different factors involved in the actual formation of the lift, it is very difficult to predict exactly what type of thermal emanates from what type of surface.

A general form of thermal can be considered as a vortex ring (the ring doughnut shape described earlier and shown in Fig. 105). However, this is not the complete story. Peter Goldney has described* a series of experiments he undertook with a heated plate in a wind tunnel, where a jet of smoke was allowed to drift over the plate. At first only a dome of smoke formed but, as the temperature and wind speed were increased, the smoke formed first a rising plume, which later became small clouds (or vortex rings?) building up into the phenomena known as "cloud streets."

It should be remembered here that we are only interested in relatively low level lift, and so most of the thermals are of the plume or continuous type we have just mentioned. Occasionally one encounters a low level bubble, or vortex ring. The situation here is rather a case of "swings and roundabouts" since, for these bubbles to form, a breeze is normally required. It follows that, because of the relatively short distances we fly our thermal soarers up- and down-wind, their usefulness is small.

Thermal detection

The detection of thermals by instrumentation has been much investigated in free-flight model circles, even to the extent of fitting chart recorders to sensitive temperature detectors. These detectors usually take the form of simple units comprising a d.c. bridge with a thermistor as one arm. Bridge detection is by means of a meter (or recorder, as mentioned). Results from these devices tend to be inconclusive in that, as only small differentials of temperature exist in and out of lift, it is very difficult to discriminate between an actual thermal and changes in direct sunlight and cloud screening. A circuit of this type of detector appears in Fig. 107.

The most sensitive of practical lift detectors seems to be the one using soap bubbles (the children's type, sold in small tubs with a ring to form them on). Devices have been tried for automatic bubble formation by means of a unit suspended from a helium balloon, but it is not known whether any appreciable success was achieved with this method.

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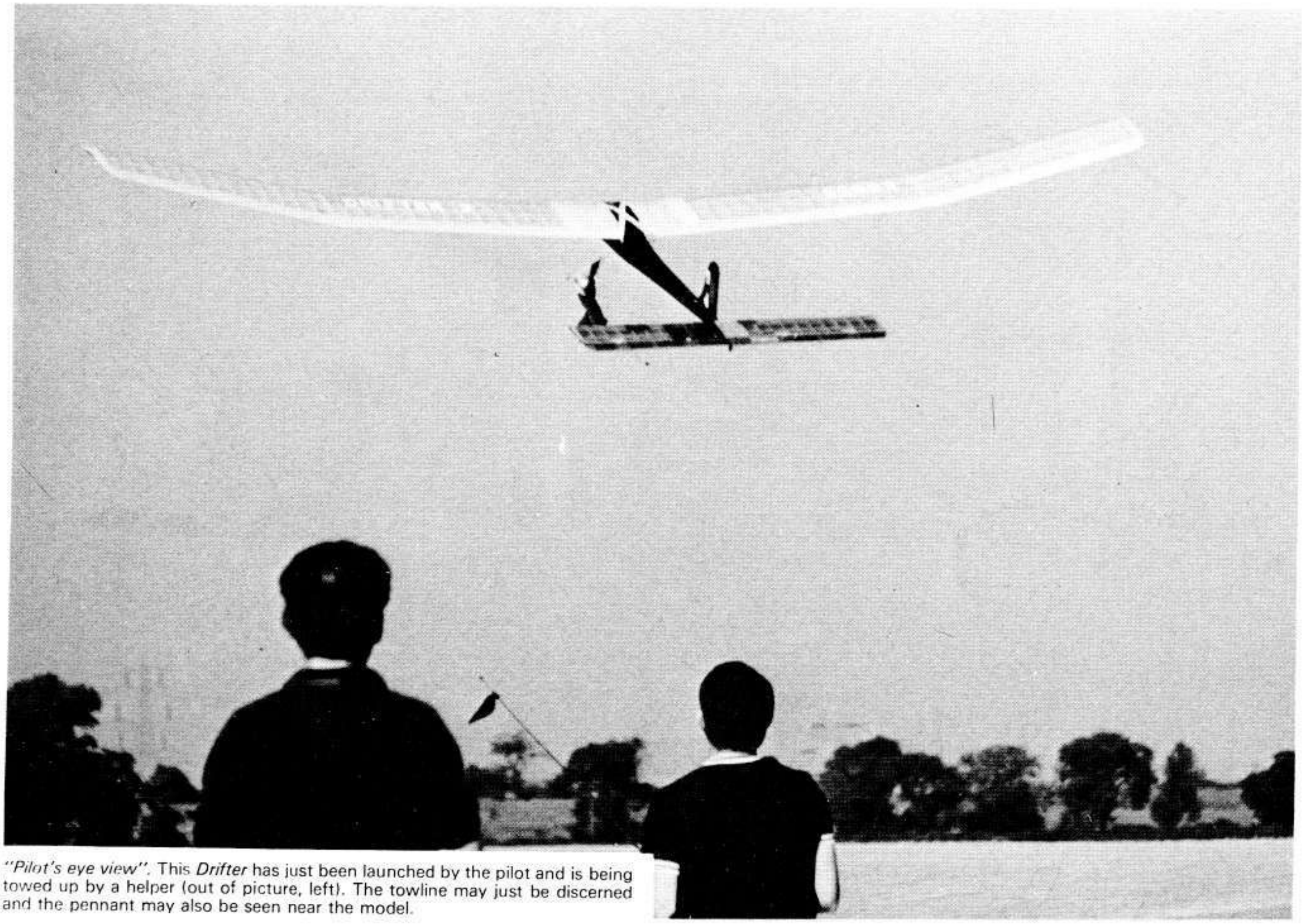
* *Sailplane and Gliding*, journal of the British Gliding Association.

"Up and away". Pilot releases a thermal soarer whose design obviously owes much to its builder's previous free-flight experience. A towline pennant hangs from the line, which may just be seen going out of the picture, right.

Lightly loaded models like this sometimes need support at the wingtips if the weather is at all breezy, to keep them level for a good straight launch.



"Pilot's eye view". This *Drifter* has just been launched by the pilot and is being towed up by a helper (out of picture, left). The towline may just be discerned and the pennant may also be seen near the model.

This V-tail model is typical of a breed of relatively heavily loaded (9oz./sq.ft. in this case) models that are being developed to fly the international "triple task" events.

Coming down to ground level, so to say, the use of bubbles is not, in practice, very helpful, due to the effects of ground turbulence.

A device which has been used in other countries is a miniature version of the electronic variometer, currently used in full-size sailplanes. There is great scope here for direct model rise/descent to be detected, the only problem being that of getting the information back to the pilot, since the use of airborne R.F. transmission would be illegal in the United Kingdom.

One of the most useful everyday methods of thermal detection is simply to study the visible signs. Birds are naturally very good thermal detectors and, if one sees a group circling, it is pretty certain they are in lift. By noticing where any birds start to circle when they are fairly low is also a reliable method of locating a thermal source.

By watching smoke emanating from a chimney it is often possible to see when lift is present, because the smoke starts to rise unnaturally fast. It should be realised that the lift produced is *not* from the chimney smoke source, but usually caused by heating of the surrounding buildings by incident sunlight.

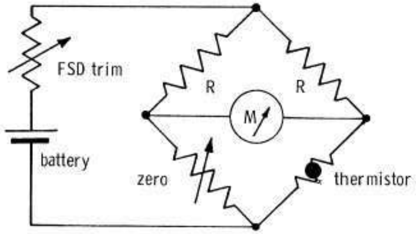


Fig. 107

Clouds are good thermal indicators. The subject is fairly complex, but here it is sufficient to say that the formation of cumulus type cloud indicates the presence of a thermal. The clouds are formed in the following manner. The thermal reaches condensation level and a cloud begins to form, which continues growing until the thermal activity ceases. Decay of the cloud begins when the air ceases to reach condensation level and the cloud slowly collapses at approximately the same rate as growth. As a hint, the decaying clouds are usually darker owing to the larger droplet size.

When locating lift below clouds, the best method seems to be up- and down-wind travel at the approximate crosswind location of the cloud-indicated thermal. Again, because of wind strength, thermals feeding cloud will tend to lag behind that cloud, and it is thus necessary to notice the usual time lag on one particular day—or at any site—as this figure will then usually hold good for that day, provided the wind strength remains fairly constant.

About the most helpful method of lift location for models seems to be the phenomena surrounding thermal formation. Usually one feels a cool breeze or, perhaps, just a lull in the normal windflow. This is the cool air moving into the thermal base. Following this, one feels the passing of warm air, and one is then at the approximate centre of the active thermal.

When towing a model it is possible to sense thermal pull by line tension, though this is not very easy, especially with longer lines, which tend to damp out any small fluctuations, due to their elasticity. As the model enters the start of a lift area, it first starts to sink; the pull then increases slowly until it is at a maximum when at the core of the lift. When flying in very calm conditions it is best to launch the model in the core of the thermal to enable the pilot to use the strongest lift by circling the model. However, when conditions are more normal, that is to say, with some breeze, then it is better to keep the model heading upwind all of the time that lift is present. As soon as the model begins to sink, then it is best to move away from the area, to avoid the down-draught after the thermal.

The most difficult part of thermal detecting seems to be that of discriminating between gusting and true thermals. Once free of the tow-line, lift detection with the model is not so easy. By careful flying, in order not to disturb the model's flight path by coarse control, it is quite possible to detect the model gently oscillating as it enters the swirl of the thermal.

It is also possible to sense lift by noticing if the model lifts one wing tip sharply as lift passes that side. The immediate reaction should be to turn the model towards the lifting wing in order to try to find the strongest lift.

TYPES OF CONTEST

While there are probably many modellers who enjoy the flying of thermal soarer models simply for its own sake, the high performance thermal soarer has usually been developed as a competitive machine. In fact, one tends to think of a "thermal soarer" as a contest glider, whereas a large proportion of slope soarer designs are "sport" or "fun" models.

Despite this contest-specialisation, however, there has—until quite recently—only been one type of contest for thermal soarers in this country, namely the "duration" event. In this, the competitors endeavour to keep their models airborne for as long as possible, up to a "maximum" fixed by whatever rules are being used. Flight times in excess of this are not recorded (*i.e.* the excess is not recorded, the flier being said to have scored a "max"). As a rule, the models are also required to be brought down within a specified time (usually a minute) of having reached this maximum, penalty points being deducted from the score for further excess time. In addition, the model must land within a prescribed area for the flight to count at all, but bonus points are awarded for a landing in a small circle within the main landing area.

Two, three, or sometimes four "rounds" are held, so that each competitor is called upon to fly a number of times during the day—he does not take his flights consecutively. This is supposed to even out the chances, and reduce the possibility of one flier having all his flights in "good air," while another has his all in "sink." The results are usually based on an aggregate of times, though sometimes a system is used calling for the "best two out of three" or "best three out of four" flights only, to be counted. This, also, is in an endeavour to avoid handicapping those who, though generally flying well, have found "sink" on one flight, resulting in a very poor performance, which would put them out of the running were all flights to be totalled.

Eliminating the "luck" element has occupied many modelling minds, especially in r/c thermal soaring, and various statistical systems of doing this have been devised, including some very ingenious—and complicated!—ones. We do not propose to go into details of these here, because, as with any developing art or science, they are constantly changing.

That, then, is the basic "duration" event, with its variations and trimmings. We said, earlier, that it was, until recently, the only type of competition, in this country, for thermal soaring fliers. On the Continent, however, there have been for quite some time, contests which put the accent less on flying the glider in thermals, and more on simply flying an r/c glider.

These contests are the "Fixed Task" or "Multiple Task" events, in which the models are required to perform certain specified operations, or "tasks," with precision. The triple task event, now favoured internationally, comprises (a) Spot time/spot landing, (b) Distance covered in a specified time and (c) Speed over an out-and-back course of a set distance. (Again, we are not quoting actual figures, as these may be changed several times in the lifetime of a book such as this—and a set of the current rules is normally available from those organising contests).

It will be seen that these task events call for models with perhaps more speed and manoeuvrability than is required for the duration events—and not necessarily the out-and-out glide efficiency. Models which can combine all three attributes, therefore, are to be desired, and it may be that variable camber aerofoils (*i.e.* flaps and their variants) could play a large part in achieving this.

The multiple task contest is now finding a much greater place in British thermal soaring, and is certainly an interesting and stimulating way of helping to rule out the luck element. However, there is an "organisational" problem, in that these events require a relatively large number of officials, flagmen and so on, so that it is unlikely that they will ever completely replace the simple duration format for "domestic" (club and inter-club) events.

CONTEST TACTICS

To the casual onlooker, thermal soaring competitions may seem simply to be a matter of keeping the model in the air for as long as possible. This is, perhaps, the case but, since we are flying in a contest, it is as well to make the best effort to win. This can be achieved without necessarily having the best model on the field, provided one is effective in applying a practised contest technique.

In some ways, the development of tactical flying in any competition class spoils the atmosphere for those who take a less serious attitude to contest flying. In the long run, however, it is often the tyro competitor who gets most enjoyment from his competition flying, since he has nothing to lose and everything to gain! Tactical flying has become the order of the day in free-flight competitions, so that it is now a highly specialised part of competitive flying, the model being used simply as a "tool of the trade" in achieving a contest score. Unfortunately this has led to free-flight contests being more a trial of one's patience, than a test of the model.

Radio controlled thermal soaring may eventually become similarly "cut-throat," but it is certainly to be hoped that this will not be the case, and perhaps the restrictions imposed, due to time and frequency limitations, will prevent this situation developing. In the meantime we can but make use of all our knowledge to record as high a score as possible and keep ahead of the other "pot hunters." If, on the other hand, you are one of those in the enjoyable position of entering a contest simply because you enjoy flying in the company of fellow modellers, you may happily ignore the rest of this piece. . . .

Use the rules to your advantage

The first essential is to be fully conversant with the rules to which the particular competition is being run. How important is this understanding of the rules? Well, it is obviously undesirable to be towing with a 300ft. tow-line when the rules allow 600ft., but how about using 300ft. when the rules allow 100 metres? Now, 100 metres is 328ft.—approximately 10% longer. In still air this means the model's flight time would be reduced by the same amount, so that you would lose 6 seconds of every minute flown, which of course, can make a lot of difference to your total score.

Can you choose the time that you fly? If so, you will be able to choose a favourable time, when the biggest thermal of the day is about to develop. If, on the other hand, times are allocated by the organiser (tending to be the rule rather than the exception these days) but with the option of going to the end of the queue, then if it is pouring with rain when your turn comes up it might be prudent to put off the flight until later!

At one time, two attempts at each flight were allowed, since landing outside the square records no score. This rule, however, has largely been dispensed with, as it tended to be "used to advantage" when the model was turning in a poor time, with pilots deliberately "dumping" the model outside the square, and thus gaining another attempt. The main reason for dispensing with this rule—apart from those who consider this "use" of the rule to actually be abuse—has probably been due to the time factor involved, since, if a large number of fliers elected to try for a better flight in this way, the length of the contest would be considerably extended. There may be some local contests which still incorporate this second attempt rule, and, if so, there is no reason why it should not be taken advantage of in this way. It is as well to have a helper calling off the time towards the end of the flight, to enable you to make the decision of whether or not to abort the flight on the approach to the square. This tactic must, however, be used with discretion, especially on windy days, as no room for error is left on the second attempt. If you miss the square accidentally the second time, then you are virtually eliminated from the contest. The decision to abort should not be left too late since, if the square is large, you might not be able to fly out of it.

Remember local conditions

It will soon be realised that no two contest sites are alike, and advantage can be taken of local conditions that prevail around the particular site at which a contest is held. Often this will mean a particular area that initiates thermals, or perhaps avoiding turbulent air downwind of a nearby building. At one site we know of, it is advantageous to tow some 400 yards upwind, since this point is higher than the normal starting point. At another it has been found possible to make a flight of 30 minutes plus, without thermal assistance! In this particular case a convenient building was used as a "slope" and the model soared back and forth along the "ridge" of the roof, making use of slope lift. (Unfortunately, this was only discovered after the contest had taken place!).

In approaching the landing square, there is always the danger of overshooting and losing the flight by touching down outside the square. For this reason it is useful to make the approach towards the pilot, so that height and distance may more easily be judged. (One is tempted to say "so that if all else fails, the pilot can catch the model"—but this would not be allowed in most contests today!) Usually it is advisable to land into wind in the normal manner; however, for rudder-only models, when conditions are calm and the landing area has a pronounced slope (not all contests are held on flat airfields), then it is as well to approach "up" the slope to avoid overshooting. Obviously if the slope has a fall of about 1-in-15 and the glider has a glide angle of 16-1, a landing *down* the slope is not possible without elevators!

A proper "square approach", as practised by the power fliers, is by far the best and safest method of landing approach for thermal soarers, too. By flying the model through the four sides of an imaginary square, it is far easier to judge its height, speed and rate of descent, than when simply bringing it in willy-nilly. One often sees thermal fliers bringing their models in, near to them, in ever-decreasing circles, but this is not good practice, as it means that it is most likely to touch down cross-wind, on a wing-tip, then cartwheel and overturn. Far better to judge your model's rate of sink on the square approach, and then land *into wind,* straight towards the spot—not in a stalled side-slip!

Draw the line somewhere

Please remember that this is only a hobby. By all means win if you can, but the first essential is to enjoy your flying. Don't let thoughts of tactics, thermal hunting and so forth, obscure the real pleasure that comes merely with competing in the company of fellow enthusiasts of silent flight.

CHAPTER 15

BASIC DESIGN FOR THERMAL SOARERS

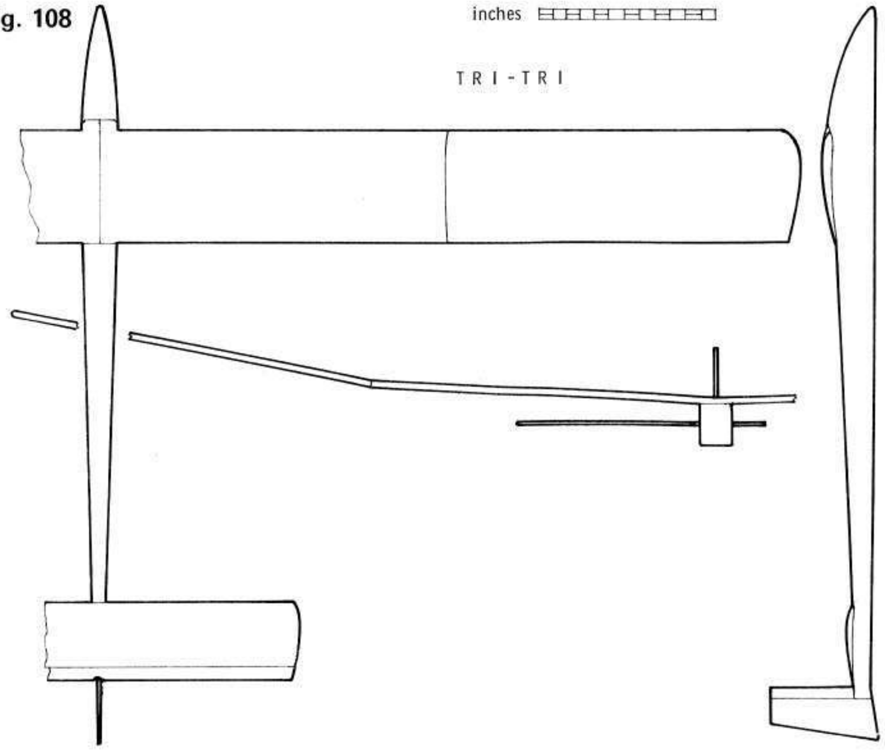
By GEOFF DALLIMER and DAVE DYER

THE design of gliders is far from difficult, and most keen modellers will wish to try their hands at this aspect of their hobby. It can be said, with some certainty, that any "design" will fly with at least some measure of success. It is a matter of degree, however, and this can only be improved with experience—and experiment.

Since gliders, generally, fly slower than powered models, they are usually more tolerant of design parameters and although, of course, the most efficient designs are to be preferred for contest flying, the designer has a wide range of possible configurations within which to create his own particular aircraft. Figs. 108-111 show some typical designs.

As with all designs, one must have at first some idea of what the finished model is to look like. That is to say, size and shape—high-wing, low-wing, T-tail or V-tail and so on. Once this is decided it is possible to work out the other proportions. It is convenient to start with the wingspan which is, commonly, between 6ft. and 12ft. At the same time, the

Fig. 108



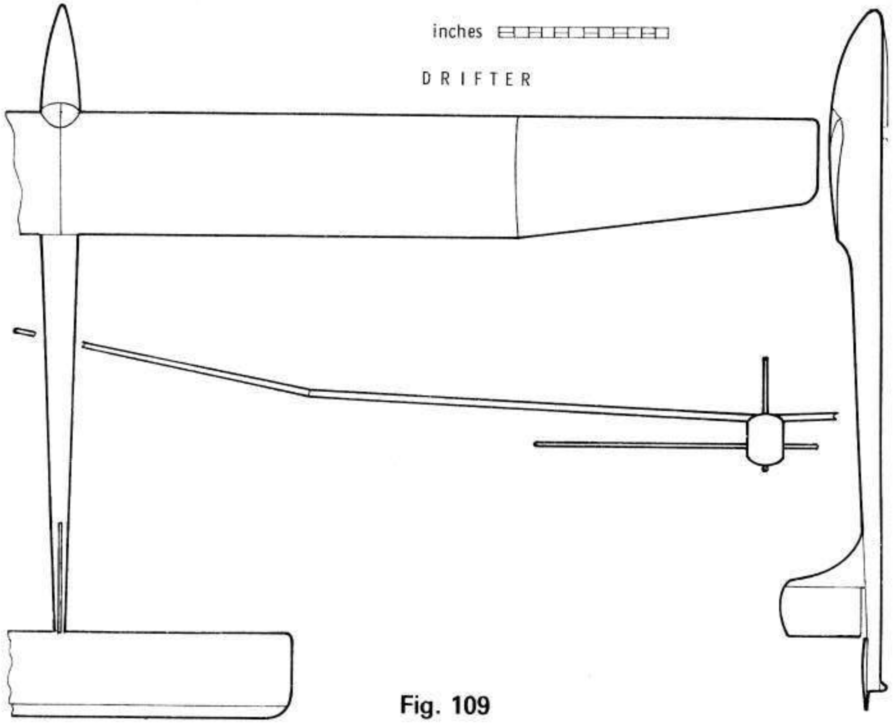


Fig. 109

intended wing-loading should be chosen, since this will determine both the model's flying speed and the total flying weight of the model. The wing-loading is arrived at by means of a simple sum; the wing area in square feet divided by the model's weight.* Loadings of between 4½ and 9oz. per square foot are usual, though it is usually preferable to aim for the lowest possible loading consistent with reasonable strength. With the wing loading chosen, the wing area can be calculated.

The aspect ratio of the wing is the next consideration. Again, a simple sum—$\frac{\text{Span}^2}{\text{Area}}$—or mean chord divided into span. The aspect-ratio will, for thermal soarers, lie typically in the range of 10 : 1 to 14 : 1. The higher the ratio, the more efficient will be the wing, although, for practical considerations, higher aspect ratios are not often used, since it becomes more difficult structurally to prevent wing flutter, due to twisting under stress. How stiff the wing can be made depends somewhat on the aerofoil section chosen.

We will read about the aerodynamic considerations of aerofoil sections in another part of this book, and each designer usually has his own ideas on the subject—indeed, often his own "pet" section—which may be either based on full-size data, or a hand drawn "zip-zip" shape. Variations of the good old standby, Clark-Y may be used for flat-bottom wings (easy to build), or perhaps NACA 6409 for an undercambered wing. (The model with an undercambered wing will tend to fly more slowly, though perhaps will not have the degree of penetration afforded by the flat bottomed wing). The type of section to use may possibly be best decided by looking around at contemporary designs, since the performance of the section at model size may then be observed. Full-size wind tunnel data is not very relevant to model applications, due to the extremely low speeds at which our models work.

Having now "designed" (for want of a better description!) the major component of our model, the proportions of the other parts may be worked out. The tailplane area should be between 15% and 20% of the wing area, and again we may have a flat-bottomed or undercambered aerofoil section. It is not unusual to use the same aerofoil as on the wing, but "thinned" by some 20 or 30%. The elevator area will be about 10% of the tailplane area.

The fin area is rather more difficult to decide, since it depends upon the length ("moment arm") and the frontal side-area of the fuselage, together with the dihedral used on the wing. "Cut-'n'-try" is a good method! However, a fin area of between 12 and 15% of the tail area is a good average. A large rudder is usual—about 40 to 60% of the total

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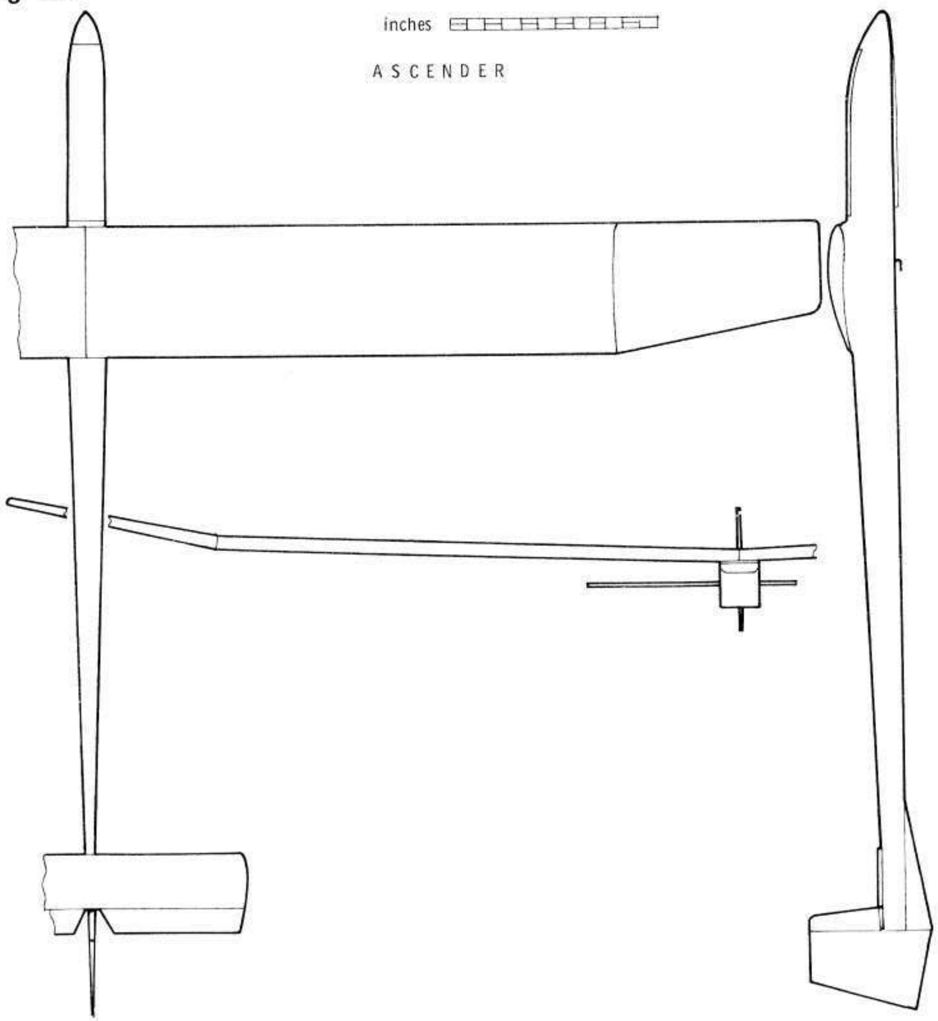
* See also wing loading nomogram page 32.

Fig. 110



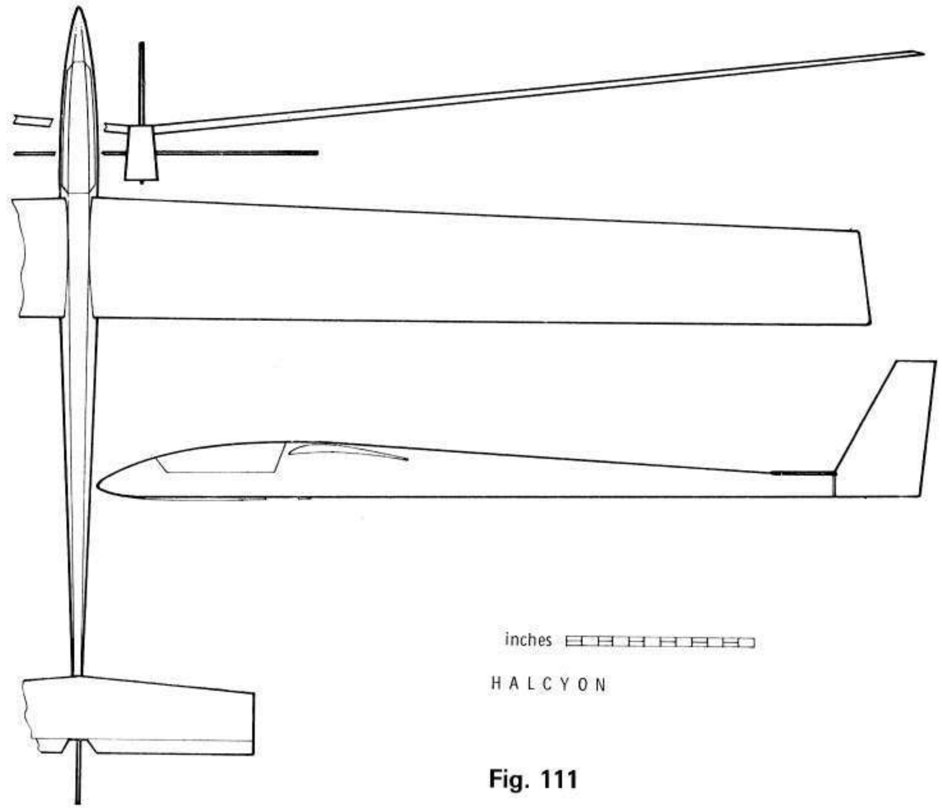


Fig. 111

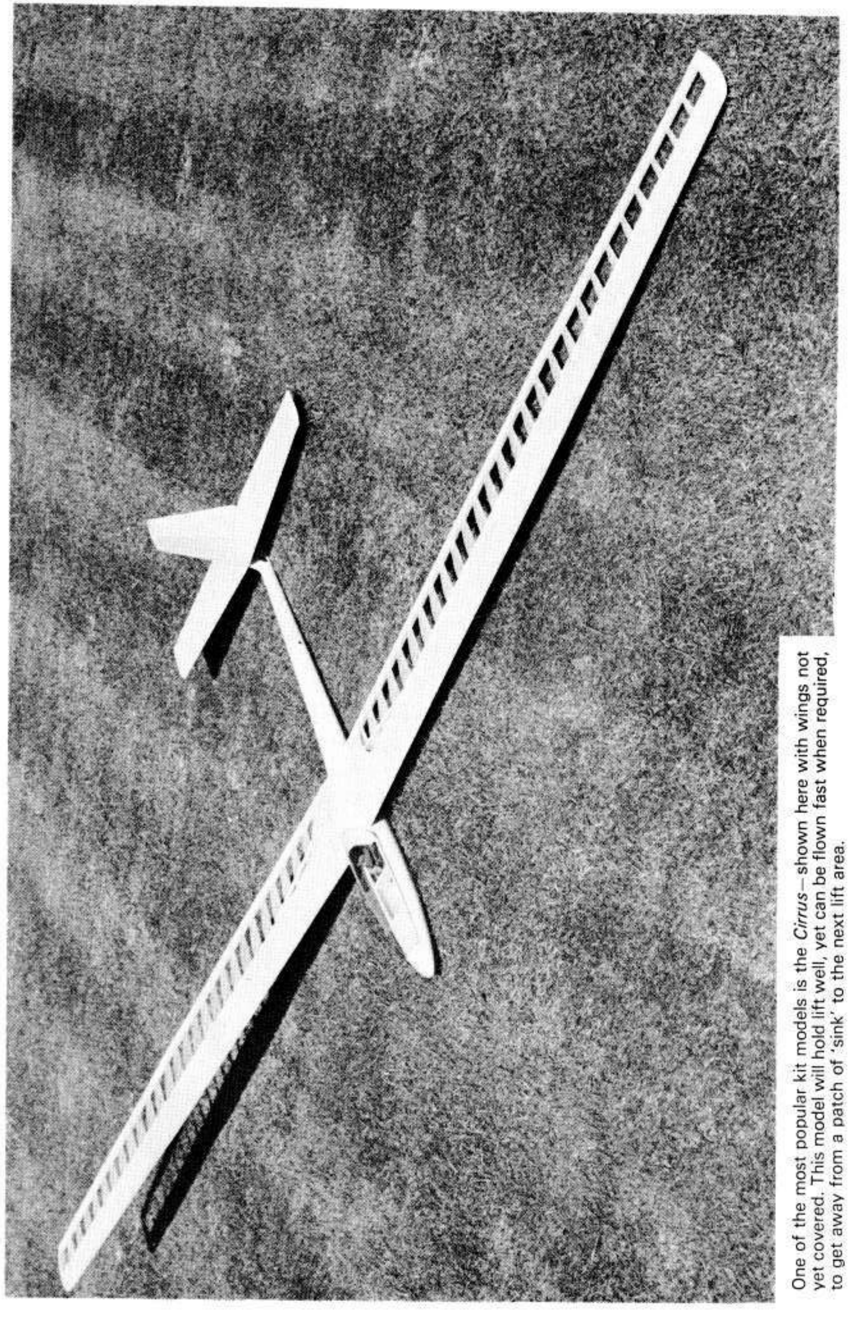
vertical stabilising area, or even greater. Some thermal soarers, in fact, feature "all-moving" vertical stabilisers, with no fixed fin at all.

The term "moment-arm" was mentioned earlier, and this is the name given to the distance between the wing and the tailplane, and of course, largely governs the overall length of the fuselage. It is convenient to express this length in terms of the wing's chord (width) and, from this, it can be said that a moment-arm of about 3 to 3½ times the wing chord will be satisfactory. The length of the nose should be about equal to the wing chord.

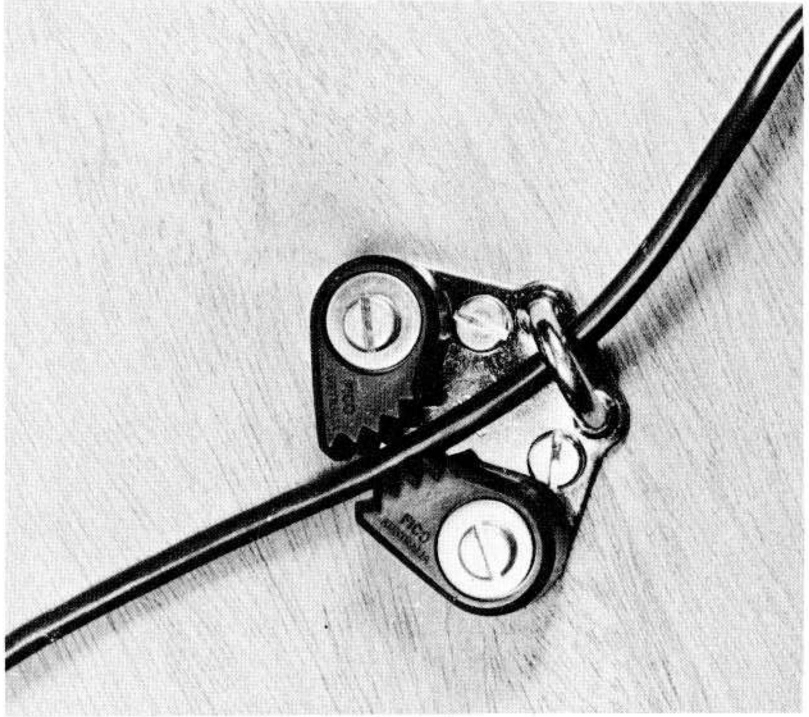
At this point, the model should be drawn out to scale and the shape of the various parts sketched in (perhaps elliptical wing-tips, or swept-back fin, and so on) and, when doing this, one can make small adjustments to the sizes calculated earlier. A good axiom, used by all the best designers, is that "if it looks right, it will fly right." Obviously one will try and make the model look "different"—although this is not easy since most models—particularly contest models—will tend to have rather similar proportions.

Finally, the centre of gravity should be positioned at about 50 to 70% of the wing chord, aft of the leading edge, and the wing set at about 3-5° incidence from the fuselage centre line.

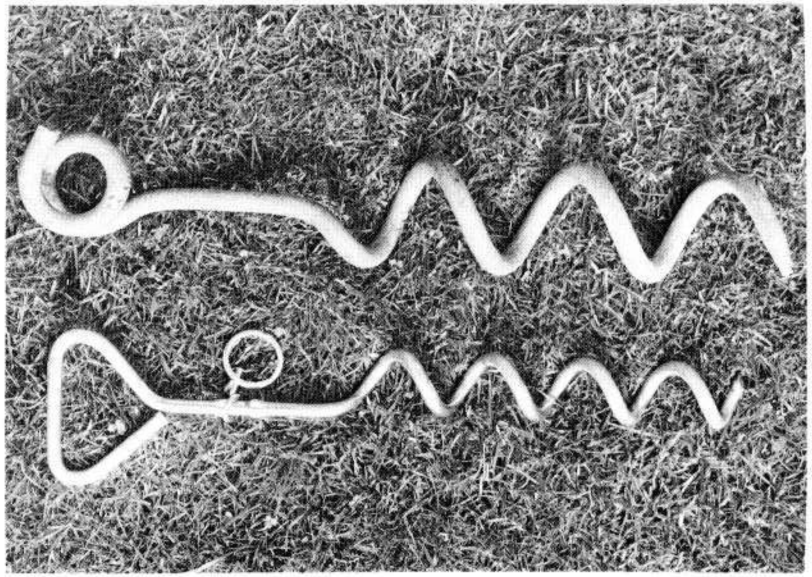
This, then, is the "basic design." Of course, experience will enable one to improve on each model, and enable one to choose the best parameters. We have not mentioned "washout," tow-line stability, turbulators, underfins, down-wash, etc., but then, if you do not know about such things, you will not worry about them! We would, however, like to say a little more regarding the controls and control surfaces used on thermal soaring models.



One of the most popular kit models is the *Cirrus*—shown here with wings not yet covered. This model will hold lift well, yet can be flown fast when required, to get away from a patch of 'sink' to the next lift area.



The cam-cleat, mentioned in Chapter 16, is a useful device, obtainable from marine suppliers, for locking the bungee cord to the required length, according to wind strength. The spring loaded cams allow the cord to be pulled through in one direction only. *(Note: plastic cord is shown here, not bungee.)*



Preview of the next Chapter. For Hi-start launching, a good anchorage for the bungee is essential. Here we show two types in general use. The more substantial one is a galvanised boat mooring screw-stake, while the other is a dog tie-out stake – available at pet stores – much lighter and really quite strong enough. Length is 16in. and weight just under 1lb.

Controls

Control of the thermal soaring glider is required in pitch and turn; the pure "roll" and "yaw" functions are not required for all practical purposes.

The consideration here is that the model is only required to be tow-launched, circle or fly straight, and land. At no time are aerobatics called for and, in fact, indulgence in these may well result in a bent model—unless so strongly constructed that it must have a high wing loading, in which case it will not be a very good thermal soarer anyway!

Because of the limited requirements, it should be possible to control the model efficiently with two functions, as we have said—pitch and turn. For pitch control, either a conventional elevator or an "all-flying" tailplane may be used. At first sight it would appear that the all-flying tailplane is the more efficient of the two, but experiment has shown that, unless the tailplane section has a "steep" coefficient of lift and a "shallow" coefficient of drag (as seen on a graph) then the advantage is lost. Elevators, on the other hand, seem to be very effective for small deflections, thus rendering them most useful. From a practical consideration, elevators are easier to fit, and allow a simple form of attachment of the tailplane, with rubber bands.

For the "turn" control, either a rudder or ailerons may be used. From an efficiency and structural point of view, ailerons are not very useful, as they tend to cause drag where they are hinged, disrupting the airflow over the wing's surface, and they also add extra outboard weight to the wing, which is not desirable.

From experience, it would seem that the best answer is a large rudder of approximately 70% total vertical tail area which, when coupled with adequate dihedral, produces a fast and reasonably efficient turn. The advantages of a rudder are that it is light in weight and simple to fit and adjust.

Auxiliary controls

Whilst not imperative, it can be helpful to use flaps and/or spoilers to assist during the landing phase of a flight. The most commonly used spoiler is the type which extends above the top surface of the wing approximately at the point of maximum camber. Its purpose, as its name implies, is to "spoil" the lifting properties of the wing. When the spoiler is extended, the airflow over the wing is disrupted, causing virtually complete loss of lift in the spoiled area. In doing this, the model's sinking speed is increased, thus enabling a steeper approach to be made to the landing area—without recourse to putting the nose down, which would increase the model's forward speed.*

The use of wing flaps (usually of the split trailing-edge type) will enable the model to fly at reduced airspeed and thus make a *slower* approach to the landing area. One is thus given more time to position the model for landing and consequently one should be able to make a more accurate approach. (Against this, in windy weather, the slower flying model is more easily upset by gusts of wind, and can be less readily corrected, whereas the model with spoilers will get the whole landing operation over quicker, with resulting lessened likelihood of being upset by gusts or turbulence. It is a question of "horses for courses," as it were).

The flap functions by increasing the lift coefficient of the wing (also the drag coefficient!) thus enabling a lower airspeed to be maintained before the stall occurs.

It is doubtful whether flaps have any real applications in "pure" thermal soaring. Our reason for saying this is that, at present, models of 6-8oz./sq.ft. wing loading are used, and their flying speed is already low enough for all practical purposes. On a more highly loaded model—perhaps of a type developed on the Continent for flying speed courses, or "multiple task" events—these devices could well be used to advantage. Now that the latter are becoming more numerous here, however, flaps may yet come into their own.

The main argument against fitting either of these additional controls is, once again, the penalty of weight and drag, which must always be assessed very carefully before their incorporation into a particular model design.

An auxiliary control which can be well worth while, and has seen virtually universal

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*Shown diagrammatically in Section One, Fig. 98

adoption in competition thermal soaring, is the tow-hook release. This can take various different forms (Fig. 112) but, basically, is a means of releasing the tow-line from the model by a mechanical means fitted to the tow-hook itself. Thus, the actual moment of release is decided by the *pilot*, and not the man towing the model. It is also helpful on occasions when the model is already in strong lift before it can be released, and is stretching the tow-line to such an extent that the man towing the model is unable to release it in the usual manner—by paying out a little extra line held in reserve for this purpose.

The use of a tow-hook release mechanism does not necessarily entail the use of an additional servo. It can be made to operate on the brief application of "full-down" elevator, for instance. As this amount of control is unlikely to be used under any other circumstances, it is not liable to be used inadvertently—and the brief application of the down control required will not upset the flight pattern nearly so much as the stall that would be induced were the model to be suddenly released when pulling upwards under strong lift conditions.

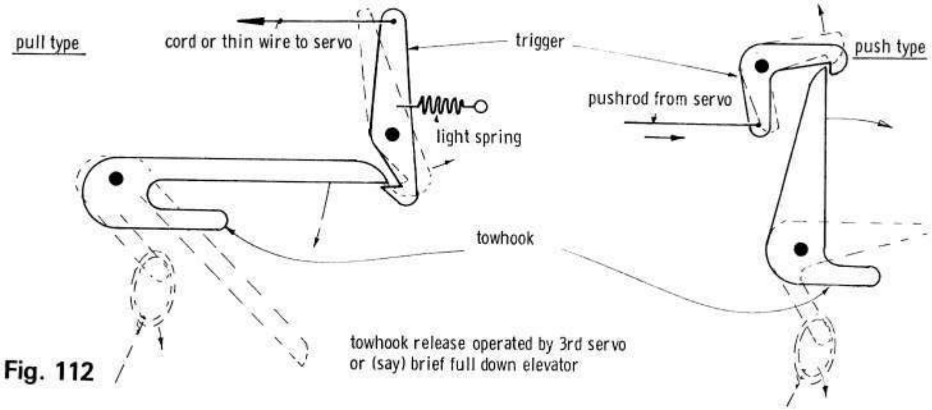


Fig. 112

Those with three or four function equipment will often opt to use an additional servo, however, for complete reliability—the additional weight of the modern proportional servo (say 1½ to 2oz.) hardly increasing the wing loading of a large model by any very significant amount.

THE DESIGN OF STRUCTURES

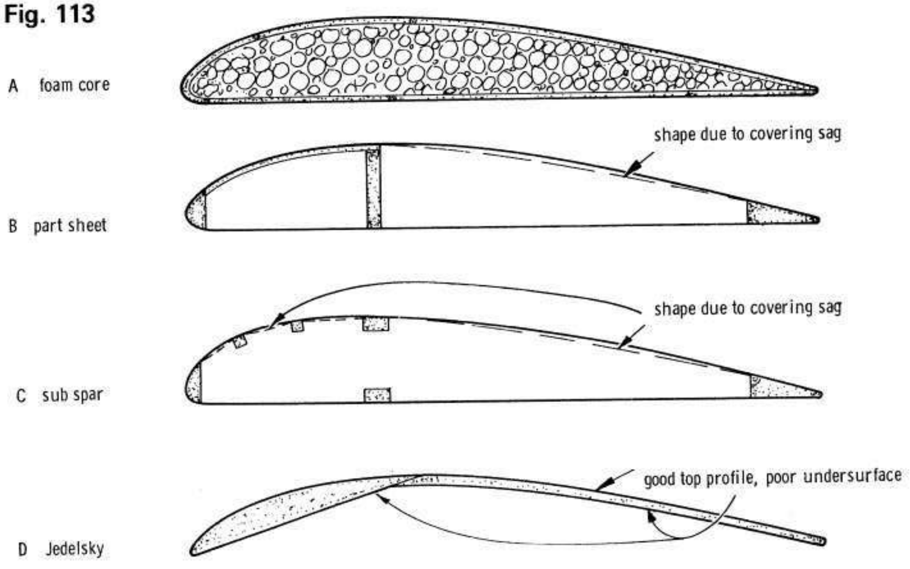
Although considerable attention is often given to the aerodynamic features of a model, it should be realised that the structure of the airframe can not only play a part in the mechanical strength of the model, to enable it to resist the rough and tumble of all-weather flying, but may affect significantly its aerodynamic performance. In this respect, three factors are of particular concern. These are: *(a)* effect of its structure on a wing's profile; *(b)* resistance to incipient warping; *(c)* inertia-destabilising effects.

Along with so many other aspects of model aerodynamics, these factors can only be discussed in general terms, since a detailed analysis is not possible, due to there being so many indeterminate variables. Rather one must pose the question, "I wish to achieve *this* feature," and then look at the model to ensure there is no clearly conflicting constructional feature, whilst endeavouring to reach a reasonable compromise in balancing the pros and cons to one's satisfaction. Let us now look at the aforementioned factors in turn.

Effect of structure on wing profile

How well will the chosen aerofoil section be reproduced on the model? It is clear that a foam-core wing will most accurately reproduce the section, provided it is accurately cut. Equally a sheeted leading edge surface will be better in this respect than a wing with

Fig. 113



sub-spars to support a shrunk tissue or nylon covering. These effects are illustrated in Fig. 113.

It is perhaps relevant at this time to include the covering as part of the structure, since the surface finish will certainly have some effect upon the airstream past the model. *How* relevant is, again, a matter for conjecture, since we cannot tell whether the airflow across the wing has laminar or turbulent conditions in its boundary layer—*i.e.* that part of the airflow nearest the wing surface. If the designer expects laminar flow, then a polished finish might be expected to produce least drag, so that the choice for covering would be one of the adhesive-backed iron-on Melinex/Mylar films, which are on the market under various trade names. However, if the aerofoil is expected to be operating with a turbulent boundary layer, then the ridges obtained from a rougher surface, or sub-spars (as in Fig. 113c), might well prove beneficial in propagating the required turbulence.

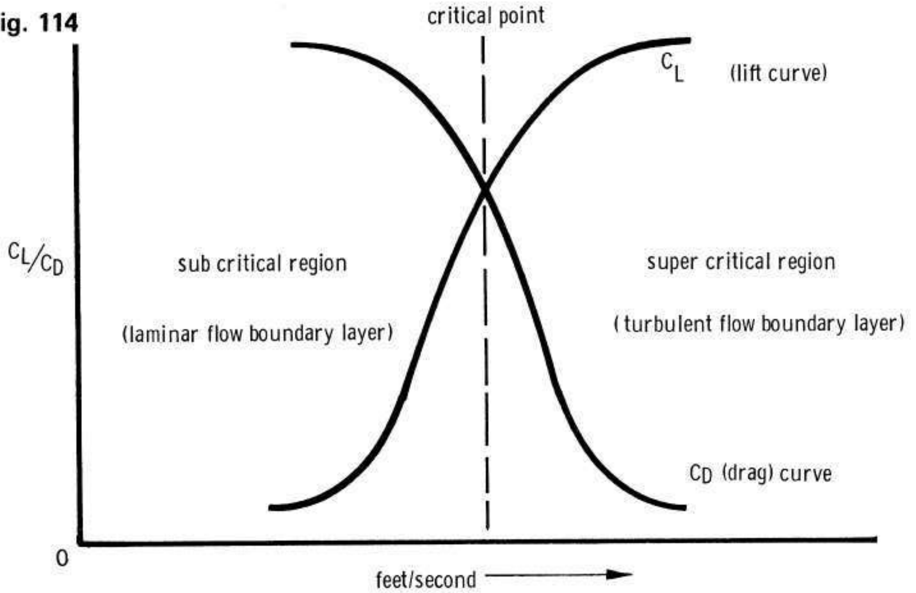
We are, perhaps, digressing somewhat from "structures" but it is worth mentioning at this point that, for best efficiency, the aerofoil needs to be operated in the "supercritical" region, as indicated in Fig. 114. It will be seen that the critical point occurs when the boundary layer (not the main airstream) changes from laminar to turbulent flow, this point being determined by the "Reynolds Number" at which the wing is operating. (Reynolds Number is a function of wing chord, density of air, and airspeed—in effect, being a measure of displacement volume. But now we really are digressing!).

Returning to the subject—correlation of the wing structure with wing profile—we can say that, having chosen the aerofoil section, one needs to consider the effect of the structure on the "ideal" profile. In more practical terms, a particular source of trouble can often be the trailing edge member. If this is insufficiently strong to resist the pull of the top surface covering, then it curls upwards resulting in a "reflex" section, which is detrimental to the lift-producing qualities of the wing (Fig. 115).

Resistance to incipient warping

We have already mentioned the effect of trailing edge warps on the aerofoil section, and this warping can also result in changes to wing incidence along the span of the wing. More simply—the wing twists! Whatever the particular cause of this trouble, it can be said that

Fig. 114



r/c thermal soarers are no different from others when it comes to warps; a model with a warped wing will fly like a . . . model with a warped wing!

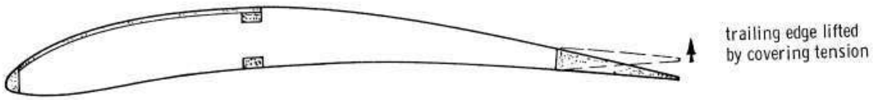
Worse than warps built-in, are those that come and go with changes in atmospheric conditions. Even a model with warps can be trimmed to fly reasonably well but, if the warps keep changing, it will not be possible to have the model correctly trimmed before a contest. Or, if you are not contest-minded, shall we say, to obtain any degree of consistency in its performance. If you find it necessary to make several flights to get the model trimmed right, on a particular day, suspect warps of this transient kind. However, we are concerned here with preventing rather than curing warps—by structural design. Geodetic or diagonal rib-spacing, or straight ribs with diagonal bracing struts, and trailing edge gussets are all commonly used methods of increasing the twist-resistance of wing structures.

Apart from wing warps, which are by far the major cause of troubles, changes in longitudinal dihedral, due to fuselage warps, represent the second most troublesome feature. On this score, fibreglass fuselages probably offer the most resistance to warping, and small cross-section balsa fuselages the least. In the case of sheet balsa fuselages, warp-resistance is best built-in by choosing evenly matched wood for the sides, or for longerons, and so forth. Beware, too, of leaning the fuselage against a wall since, over a long period, even this could cause a warp.

Inertia-destabilising effects

Impressive heading, isn't it? Perhaps it would be simpler if we said "pendulum effect." This is the tendency of weights at long moment-arms to oscillate about a pivot axis and disturb the model's flight path. The weights that cause us concern in a model are, effectively, the wing-tips and tail unit. See Figs. 116 and 117.

Fig. 115



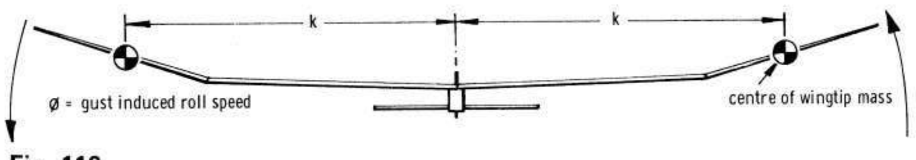


Fig. 116

Why should this pendulum effect be a problem in soarers? Those who fly four-function power models will probably never have experienced any trouble in this respect at all. Unfortunately, the laws of mechanics are working against us when we begin to increase the aspect-ratio of the wing, and the tailplane moment-arm, as is the case with thermal soarer design. As you will no doubt know from your schoolboy physics (if you can remember that far back!) the Moment of Inertia of a mass is proportional to the square of its distance from the axis of rotation. In layman's language this means that a wing-tip weighing, say, 1oz. on a 60in. span wing has a moment of 900oz.in.^2 whereas the same wing-tip on a 120in. wingspan model has a moment of 3600oz.in.^2—that is to say, four times as great! Now, so long as the model is moving along a straight flight-path all is well, since the two wing-tips balance each other out but, if the model's flight-path is disturbed by, say, a wind gust under one wing-tip, then the two tips are moving in the same direction (of rotation about an axis) and the model must correct an out-of-balance force of $7200.\emptyset\text{oz.in.}^2$ ($\emptyset$ equals the speed at which the wing-tip is being disturbed).

The dynamic balance of forces exerted on a model in three-dimensional flight are, of course, far more complex than we have suggested above, but at least this gives one an idea of the problem. What happens in real terms is that a model with heavy extremities, when disturbed, needs extra correction on the control-surfaces to bring it back into equilibrium. Since each deflection of the control surface causes additional drag to be produced, this results in a steeper glide angle, more rapid loss of height and, thus, a shorter flight time. The problem is further aggravated since we need the model to be sensitive to vertical air movements to enable us to detect thermals.

From all this you will see that, here again, we have the internal structure of the model directly affecting its performance, so attention must be paid to the distribution of weight in a soarer. There is an old aeromodelling expression—"To increase performance, add lightness." How to do this? Three areas are worth attention. Firstly, design for lightness; that is to say, use as little wood as is necessary to obtain the required shape without losing an excessive amount of strength. This can be achieved, for instance, by replacing block wing-tips by sheet or, perhaps, by covering the tailplane with tissue instead of sheet balsa. Fig. 118 shows structural details of a fairly typical thermal soarer.

Secondly, considerable weight can be saved by choosing the correct grade of wood. Some balsa is graded by colour, to help with just such selection of different grades, so we can select light wood for wing tips, tailplane and fin, while using the harder wood, or even spruce, for the spars and other more highly stressed parts of the model. Choosing the right grade of wood is not nearly as difficult as finding a model shop with an adequate selection!

Finally, avoid using excess amounts of colour paint and decoration, since these can add

Fig. 117

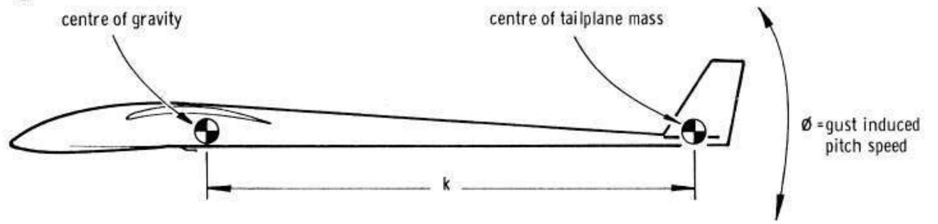
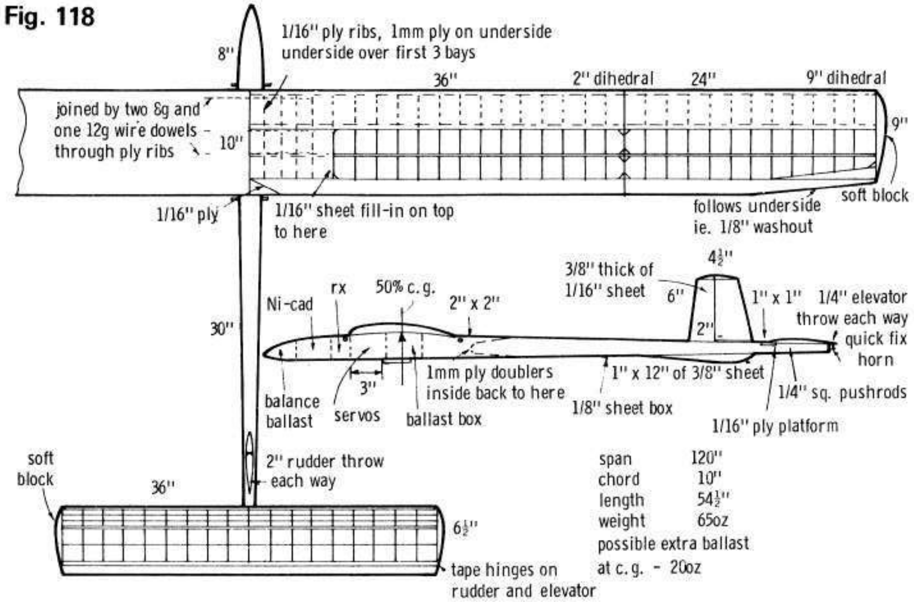


Fig. 118



quite appreciably to the weight of the model. Metal control-rods, clevises, hinges, horns and so on, whilst all small in themselves, do tend to accumulate and, unless care is taken, can result in a tail-heavy fuselage. A lighter alternative to the usual push-rod system is the use of spring-tensioned control surfaces operated by a taut link (thread, for instance) to the servo.

A last word, on building from kits. Generally most improvement will result from the things you leave out, rather than those you add on! If you think it must be "beefed up"—think again. Wait until it breaks; after all, it may never happen—and if it does, remember the repair can be stronger than the original!

CHAPTER 16

HI-START LAUNCHING

By GEORGE BUSHELL

MANY modellers seem to feel that there is an air of mystique surrounding the Hi-start, or "bungee" launch method for gliders. This is probably because it is particularly suited to the "lone hand" flier, who flies on his own, and has no one to tow up his model for him in the conventional way.

To clear up one great misconception first—"Hi-start" and "bungee" launching are one and the same thing. The former seems to be the American name for the system, whereas the latter actually applies to the type of cotton- or nylon-covered rubber cord which is used! Such is the persistence of the idea that there's something different in a Hi-start launch from a bungee launch, that it is hoped that this chapter will forestall a lot of unnecessary correspondence! Some users of electric winches, of late, are tending to call *that* method of launching "Hi-start"—which could lead to further misunderstandings. They would be better advised, I am sure, to call it simply "winch launching."

Having made it clear that the name is only the handle, so to speak, just what *is* a Hi-start or bungee launch? Very basically, it consists of using a length of rubber cord, attached to the "towing" end of a nylon (fishing line) tow-line, and anchored to the ground by some suitable means. The line has a towing ring on the "model end" and—usually—a form of drogue or parachute as well. This 'chute serves the threefold purpose of (i) pulling the line free of the model, for release (ii) deploying the line in a downwind direction, under some tension, ensuring that it is near at hand and tangle-free when next required, and (iii) acting as a marker, being brightly coloured, so that it is easily seen and retrieved.

In operation, the line is pulled back, away from the anchor point, until it has a good tension (this will be discussed later). The model is then hooked on and released, when it climbs at a good angle. Contrary to what many people expect, there is, in fact, very little "snatch" effect and the model behaves, on release, in a very similar manner to a model being towed by a runner. The difference is, of course, that the bungee does not run out of "puff," or trip over. On the other hand, *all* the controlling of the model, when it is on a Hi-start launch, has to be done by the pilot, whereas, with a towed model, the tow-man can slow down and "ease off" the tow, reducing the stresses on the model if required. Once the

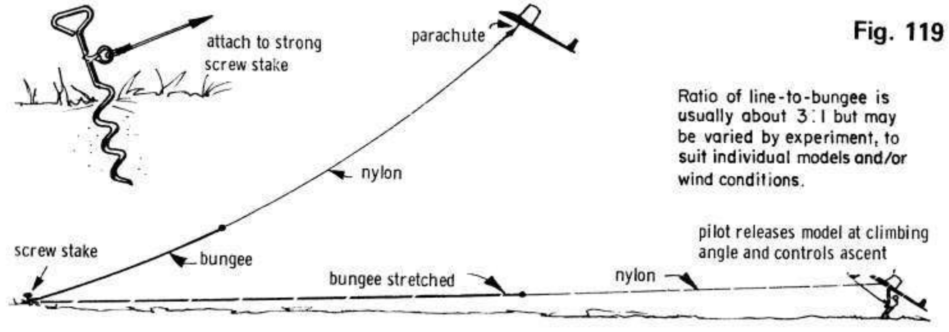


Fig. 119

Ratio of line-to-bungee is usually about 3:1 but may be varied by experiment, to suit individual models and/or wind conditions.

Hi-start has been released there is no stopping it until all its energy has been spent. Any reduction, or increase, in the model's angle of climb, therefore, must be effected by the pilot, using elevator control. Fig. 119 shows the overall set-up.

This brings us to another point, this time on the controlling of the model. Many people ask whether they should touch the elevator control at all during the launch. This rather depends upon the individual model, of course, but as a general rule, one should release the model holding in a little up-elevator, decreasing this if the model climbs *too* steeply (indicated by the wings beginning to flex too much for comfort). Then, as it nears the "top" of the launch, and begins to slow up, feed in more up-elevator to keep the line taut and maintain some climb. When the optimum point is reached, if the parachute does not pull off, the model will begin to sink (unless it is already in strong lift—lucky you!), so dip the nose *very briefly*, with a quick forward flick of the control stick, to release it. Try not to get caught unawares, pulling back on the stick, when the 'chute detaches or the model will stall and lose some of that valuable height, before you can flatten out its flight path.

We mentioned earlier, the running tow-man, towing a model and running out of breath. On dead calm days this can often happen, with the result that he slows down, the line sags and the model releases itself, actually flying at a greater speed than the person towing is able to run. (On days with some wind, of course, there is no problem, as there is no need to run so fast—in fact the tow-man will often have to stand still or even run back, towards the model.) It is on the calm, or near-calm, days that the bungee launch can come into its own, since the speed at which the model travels is, to quite a degree, governed by the amount of head-wind. It is, therefore, self-adjusting, to the conditions, and will always produce a launch.

So much for the basic operation of the system. Now let us look at the equipment required, the techniques used, and desirable model characteristics.

Equipment

The items required are (i) a secure anchorage for the bungee (elastic cord), (2) Bungee cord, (3) nylon monofilament line (fishing line), (4) drogue 'chute, (5) metal ring. Other accessories come under the heading of sophisticated refinements, and will be mentioned as the opportunity arises.

Dealing with the first item, then, a *secure anchorage* for the bungee cannot be over emphasised. A large old chisel or screwdriver *will not do!* These quickly work loose in the ground after a few consecutive launchings—and can be positively lethal when lifted out of the ground by a good "over the top" release. A short *screw stake* is far more safe and reliable, and I always use one. The steel tommy bar used to screw this into the ground doubles as a handle for my field box, so there is no fear of leaving it at home.

Screw stakes are available in several forms. At ships' chandlers, you can obtain a boat mooring stake, which is extremely substantial—if rather heavy—and usually has a galvanised finish. A lighter, more portable, and equally effective, screw stake is to be obtained at most pet stores, and is known as a tie-out stake—used for "round-the-pole" exercising of dogs, by lazy owners. It is a good idea to paint the above-ground portion of the stake—either bright red, or with black and yellow bands—to make it easily seen in the grass and help prevent anyone tripping over it.

To "lock" the bungee to the desired length, *never knot it*. This causes internal ruptures and localised over-stressing. Use either a fixed length of bungee with hooks at both ends, or a device known as a cam-cleat, as illustrated. This item, again, is obtainable at ships' chandlers—the sort of little marine suppliers one sees in most seaside or riverside towns. The action is to lock the rope—or, in our case, the bungee cord—without damaging it, so that it is firm in one direction but may be pulled in the other. A bracket can be easily made by the modeller, which allows the cam cleat to be clamped securely to the screw stake or, alternatively, if conditions permit, to the car bumper.

The bungee cord I use is the ¼in. diameter type, but many fliers seem to prefer the 3/16in. diameter size. This appears to be sufficient for all but the heaviest and most highly-loaded sailplanes and, as a general rule, I reckon that if a model is too highly loaded to be taken aloft by this bungee, then it isn't likely to perform at all well, even if you do get it up!

Why "bungee" as such, and not just any rubber strip or catapult elastic? The main reason is not so much one of efficiency, but of durability. Proper bungee will last many years, while bare rubber, used over rough terrain, or not properly stored, may not see a season out. Basically, the recommended bungee is composed of a number of very thin strands of rubber, covered by a woven cloth sheath. The cotton has each strand individually treated with PVC coating which imparts a fairly tough, abrasion-resistant, almost waterproof, covering.

The two alternatives are, first, the untreated cotton covered type, commonly used for luggage straps, and the PVC sheathed type. The main advantages of the former are that it gives a longer stretch and is marginally lighter—but it is less resistant to abrasion and not waterproof. The sheathed or shielded type is where the *completed* cotton sheathing is coated in PVC, producing a solid sheath. The main advantages of this are its extremely high abrasion-resistance and that it is completely waterproof. The disadvantages are considerably increased weight and insufficient stretch (with a positive deadstop!), together with the fact that it is more difficult to secure endhooks to it. The proper bungee described, therefore, is by far the best suited to our purpose.

We have seen that bungee should never be knotted, but that hooks should be fitted at each end. The bungee can then be hooked onto a clip on the monofilament line, and onto another hook or clip on the tie-out stake. Two or more lengths of bungee may be hooked together in this way, too, if required. What sort of hooks, then, should be used, and how are they secured to the bungee?

I used to use the "luggage hook" (à la car luggage rack cords) type of hook for the ends of the bungee, but have now abandoned this in favour of the "hook" type, which is an enlarged version of the "hook and eye" used to fasten ladies' bras! For the benefit of the unmarried or less adventurous, the sketch (Fig. 120) may be helpful, as the item is very easy to produce from 20 or 22 swg piano wire.

Fig. 120

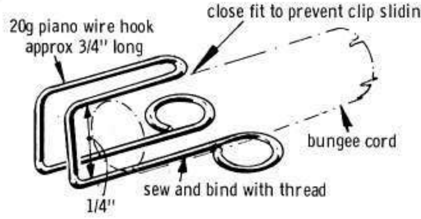
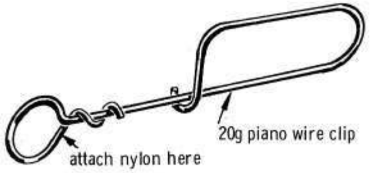


Fig. 121



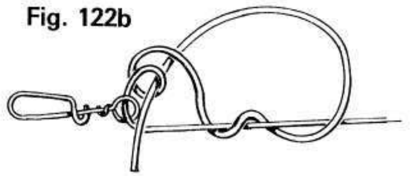
This hook, then, is simply sewn and bound to the end of the bungee, using two yards (approximately) of ordinary sewing thread as used in all kinds of binding, and passing the needle *through* the bungee a few times. The binding is then coated with contact adhesive and allowed to dry. If a neat job is made of this hook, it will pass easily through the staple of the cam-cleat. Although I have never known a hook fitted in this manner to fail, I always attach one to *each* end of the bungee, working on the assumption that, of one *were* to fail, it would be on the first flight of the day and far from home.

The breaking strain of the nylon monofilament line that I now use is 55lb. This is a heavier type than I have previously recommended (and, indeed, may seem ridiculously thick to those used to hand towing their models), but it is very helpful for crosswind launches, as it aids the directional stability of the model. For models with less than 600sq. in. or so of lifting surfaces, however, the 40lb. line is, in my opinion, the optimum, though many people use a 30lb. line and 3/16 in. dia. bungee with success.

As to the maximum size/weight of models capable of being launched efficiently, I can

Fig. 122a

Fig. 122b



say that models of up to 5lb. weight and some 12sq. ft. wing area have performed well (using $\frac{1}{4}$in. diameter bungee). In fact, the *smaller* models (say, under 5ft. span) tend to be the most inefficient, since the weight of line and bungee will tend to affect the height they can attain, more so than with models of greater wing area.

To join lengths of nylon monofilament line so as to provide the desired length of launch (I normally carry two 100yd., one 66yd., and one 33yd. length) I equip each end of my lines with a simple wire coupling, bent up from 20 swg wire, as shown in Fig. 121. Tying knots in nylon line is difficult, but there are some special knots which have been developed for the purpose. I invariably use the knot shown in Fig. 122a, this being well tried by fishermen for joining two pieces of nylon. The knot for fastening nylon line to metal fasteners and hooks is shown in Fig. 122b.

For the drogue parachute, you could try making your own but, quite frankly, I don't believe it is worth the effort. There are commercial ones on the market—the K.D.H. and the Graupner No. 55—but, of course, the availability varies, as these come from abroad, and you may have to shop around a little.

Now here is a point that far too many people fail to realise. *The drogue parachute is incorporated as part of the line.* Let me explain. When told that there is a parachute on the line, the uninitiated always ask "Won't it slow the model down too much as it goes up?" The answer is no, because the parachute does not just hang from the line—it becomes part of it, with its lines continuing a couple of inches beyond the top of the 'chute and terminating in the metal towing ring. Thus, when the bungee is in tension (prior to, and during, the launch) the parachute is pulled tightly closed and produces very little drag. When the bungee slacks off, however, so do the chute's lines, allowing it to open and help pull the line off the hook, to release the model. Fig. 123 shows what happens, with the line in tension, and then released.

Between the nylon line and the drogue, I fit a fishing swivel. By choice, I use a steel (grey-black finish) one in preference to the brass type as it is stronger and, like nylon line can be bought in various breaking strains. Needless to say, these are to be purchased at fishing tackle shops. The swivel must be securely tied to the nylon cord lines at the bottom of the parachute and the knots may be secured by a liberal application of balsa cement. Fitted at this position, the swivel reduces the chance of the parachute entering a "Roman candle" (failing to deploy correctly). I have only had four Roman candles on more than four hundred launches, using the swivel arrangement.

For the metal ring, I use a split ring (key ring). The top of the parachute is already well knotted, requiring only a smearing of balsa cement; the ring may then be slipped on, and the Hi-start outfit is ready for use.

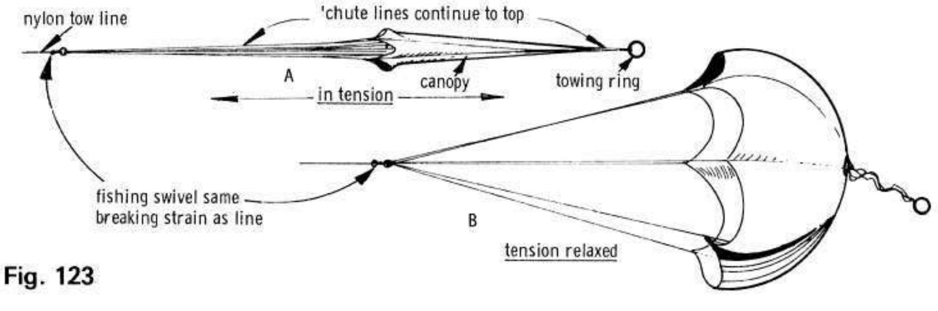
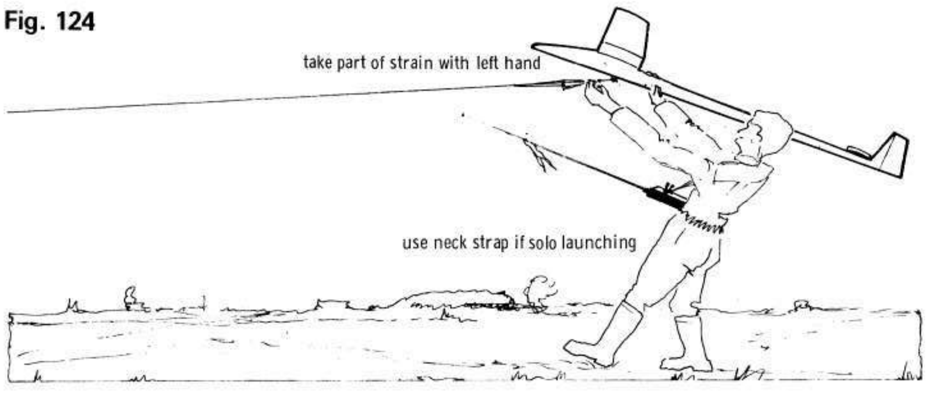


Fig. 123

Fig. 124



Launch techniques.

The basic operation has already been explained. It must be borne in mind that the whole object is to attain the maximum possible height before the model releases itself, or you release it. After the launch (*i.e.*, after the model leaves the launcher's hand), the angle of climb will control the rate of return of the bungee. This angle should not, of course, be excessive. As a rough guide, from the launch position, you should just be able to see the top surfaces of the wing. But only just. See Fig. 124.

Using elevator, as the model goes up, it is a simple matter to increase or reduce the model's angle of climb, as is felt to be necessary. The best use of elevator, to attain the best height at launch, with a particular model, will only come with practice, and one cannot lay down any rule-of-thumb laws. The modeller's renowned "feel" for what is right and what is not, has to come into play here, as well as in designing his models!

On a model of the rudder-only type—not equipped with elevator—a quick left-and-right of the rudder will effectively reduce the angle of climb. Try to avoid any jerky motions which may release the line prematurely. Mild weaving is not dangerous, provided the rudder is effective in all attitudes; towards the top of the launch, in fact, weaving has the beneficial effect of partially tensioning the bungee, thus allowing a higher release. Generally, however, weaving should be avoided as far as possible during the initial climb, as it places undue stress on the model, as does a jerky transition from the release through the initial climb.

With the foregoing points in mind, it will be seen that some attention to the position of the tow-hook will pay off in achieving a smooth, safe and optimum launch. Moving the tow-hook rearwards from its initial position will cause the model to climb faster, but lose some directional stability (though you can cope with this from the transmitter end) and is generally of more use as the wind speed decreases. Moving the tow-hook forwards of its initial position has the opposite effect, but a tow-hook positioned excessively far forward will again cause the model to lose directional stability.

You may not feel that your tow-hook was in the right position in the first instance, so it is best to check this before making any drastic alterations one way or another. To arrive at the basic tow-hook position—assuming the c.g. is in the correct place—balance the model under the wing root and, from the vertical, mark a line 30° forward from the balance point. This is shown in Fig. 125. As an example; with a depth of fuselage under the wing in the region of 3in., movement of the tow-hook by $\frac{1}{2}$in. would not be excessive, either side of the indicated optimum position.

Cross-wind launches, when the wind is in the region of 90° out of the launch direction,

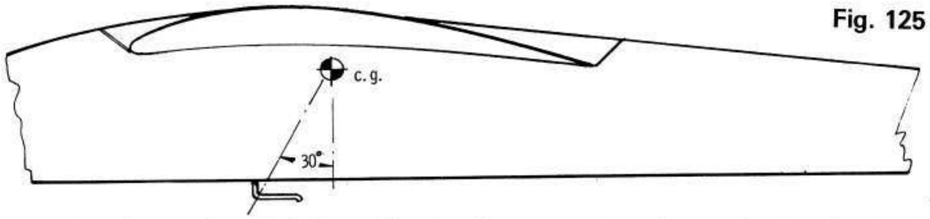


Fig. 125

are quite safe. Feed in a little bias, either by aileron or rudder trim, so that the wing that is into wind is kept low. On launch, take a couple of sharp paces forward to increase control effectiveness. It would be best, if conditions permit, to work your way gradually round to the full cross-wind launch, particularly if the wind is around 15 m.p.h. or gusty. This is a useful technique for narrow flying fields, but remember that the line will be blown down wind after the release.

Down-wind launches are handy for launching in front of low slopes which, because of their vegetation or inaccessibility, are impossible to use for ordinary slope soaring. Another example is sandhills, with a relatively short beach. The technique here is quite simply to move the tow-hook back to, perhaps, the optimum still-air position and launch the model, forgetting—if you can—that the wind is on your back. The release is best achieved actually cross-wind. I have used this technique to particularly good effect on various locations on the Dutch North Sea coast, where some excellent dune soaring is to be enjoyed.

The final item to be discussed, in the matter of technique, is the question of *line tension* and the *ratio of line-to-bungee*. Both these can vary to quite an extent, depending upon the models and the individuals flying them, and tend to be largely a matter of experience. This is, of course, no help whatever to the tyro, so let us again go back to basics.

Assuming that your first experience of Hi-start launching is in reasonably calm conditions (wind, say, up to a maximum of 10 m.p.h.), the bungee length should be about one-third of that of the nylon line. The tension applied by stretching would be in the region of 30lb. If you are nervous, or not sure of the model's suitability, this could be reduced to about 20lb., but, under these circumstances, I would recommend an absolute minimum of 100 yards of monofilament line, and 35 yards of bungee. This would allow a release at a reasonable altitude, affording you a better chance to observe the model's behaviour, both on and off the line. This tension may be progressively increased, on subsequent launches, to perhaps 45lb. or thereabouts.

True line tension is difficult to define exactly, as the type of terrain affects the tension/extension. Over a clean runway, little drag is felt and the *true* line tension is as much as you actually feel. Over a field, however, with the bungee and line going through long grass, thistle and nettles, the drag you feel is very high—probably the highest you are likely to encounter—but the true line tension is now actually much lower than it seems, so you can still happily step back a few more paces.

Don't be alarmed about line tension. I never carry a spring balance with me, as I think that this is being over-exacting. One quickly gets into the feel of it, particularly if one notes how far back one walks for a good launch with a particular model on a particular day and, if necessary, mark the spot, by dropping one's hat or handkerchief! My own golden rule is that it is better to have too much tension than too little, as it is easier to extricate a model from any trouble at a higher altitude, or with a little extra speed in hand—provided one has the correct reactions at the transmitter end.

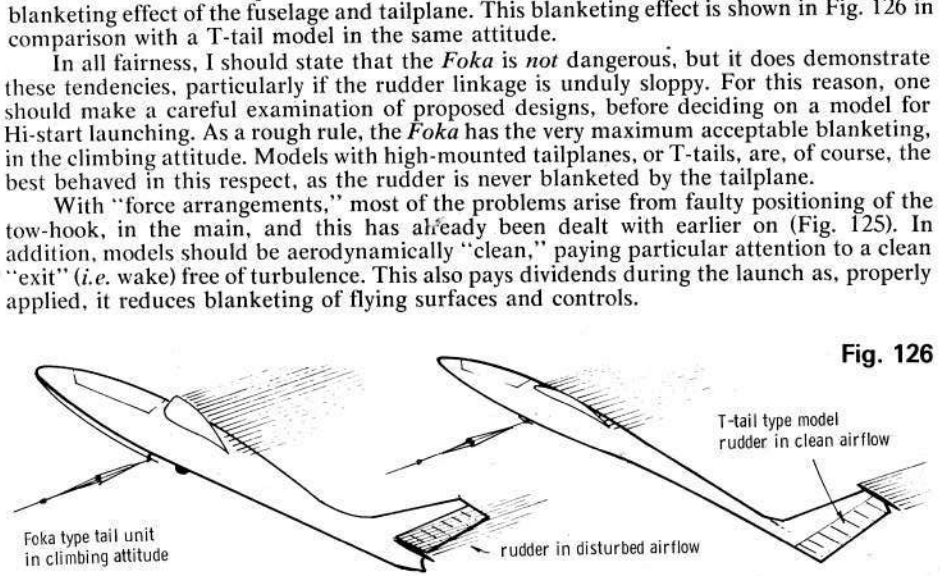
The model

From the design standpoint very little can be said. From my examination of various models performing, very few could be described as really "dodgy" on the Hi-start. Those that *are* difficult fall into two categories: those with unsuitable aerodynamic layout, and those with bad (for want of a better phrase) force arrangements. Aerodynamically, provided the model is reasonably stable in flight and capable of fairly rapid recovery from upsets, stalls, etc., the normal fault is that of the *blanketing* of flying and control surfaces while in a climbing attitude. A good example of this is the *Foka*—both full-size and model. The position of the fin and rudder makes them subject to the combined blanketing effect of the fuselage and tailplane. This blanketing effect is shown in Fig. 126 in comparison with a T-tail model in the same attitude.

In all fairness, I should state that the *Foka* is *not* dangerous, but it does demonstrate these tendencies, particularly if the rudder linkage is unduly sloppy. For this reason, one should make a careful examination of proposed designs, before deciding on a model for Hi-start launching. As a rough rule, the *Foka* has the very maximum acceptable blanketing, in the climbing attitude. Models with high-mounted tailplanes, or T-tails, are, of course, the best behaved in this respect, as the rudder is never blanketed by the tailplane.

With "force arrangements," most of the problems arise from faulty positioning of the tow-hook, in the main, and this has already been dealt with earlier on (Fig. 125). In addition, models should be aerodynamically "clean," paying particular attention to a clean "exit" (*i.e.* wake) free of turbulence. This also pays dividends during the launch as, properly applied, it reduces blanketing of flying surfaces and controls.

Fig. 126



For ultra-light types

The rudder-only model was mentioned early in this chapter, and the flier of this type of model may feel that, for him, with his usually very light model, the pukka bungee set-up is not required. Whilst what has already been said about the transient nature of unsheathed rubber strip still stands, there is here, perhaps, a case for its adoption, especially if it is felt that the initial outlay for bungee outweighs its long-term saving.

With a lightly loaded model, especially in near-calm conditions, success has been achieved by employing a very light Hi-start comprising about 50 yards of $\frac{1}{4}$in. flat rubber strip (the type used to power rubber driven models) and 100 yards of 6-7lb. b.s. nylon monofilament line. This gives a very slow pull up, with the rubber's energy expending itself at about half of the full stretch potential.

The trick now is to turn the model either left or right, on the line, causing the rubber to stretch before turning back into wind. This utilises the re-stored energy and enables more height to be gained. The process may be repeated a number of times, to good effect. To avoid pilot disorientation, with the model weaving all over the sky in this manner, it is advisable to have a very eye-catching marker at the anchorage position. The model should be very responsive to rudder for this technique to be fully effective.

Whichever method is used to get the models up, the prime aim is maximum height gain. Once off the line, then flying them is like flying any other models. With the Hi-start launch, it is the correct approach, and the technique on the line, that count.

CHAPTER 17

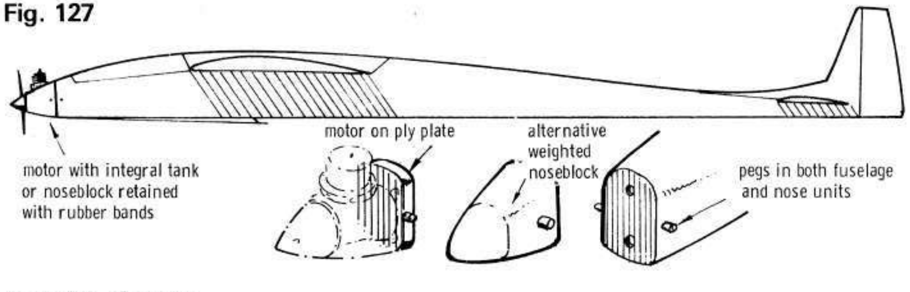
THE POWER-ASSISTED GLIDER

ALTHOUGH the sport of soaring—be it slope or thermal—is really one for the purist, there does exist an interest in the power-assisted glider. For obvious reasons, this interest is usually centred in areas with no hills. It is also favoured by the lone hand, with no one to tow up his model for him and who, for some reason, is not very happy about a bungee launch. (Perhaps he cannot be bothered with the "paraphernalia," such as it is, of reel, line, bungee and stake, described in the previous chapter.) For whatever reason, this group of modellers prefer the power-assist—despite getting oil on their models!

How much power?

First and foremost, it must be borne in mind that the power used should be just sufficient to take the model in a *very* gentle climb. We do not want our elegant, peaceful gliders to turn into "power duration" models, with screaming vertical climbs. An ·049 motor is ample for all small and medium sized models, up to about *Amigo* size,* with an ·09 or ·10 motor for anything larger. (The 8ft. span RM *Diphda* goes up nicely on ·09 power.) We would not recommend higher power for any glider—unless, of course, the wing loading is so ridiculously high as to make it necessary—but then it will, in effect, become just a "power model" and not a power-assisted glider at all!

Fig. 127



Location of engine

There are a number of different ways of mounting the engine on a power-assisted glider. Some designs feature a clip-on motor mount which goes on the nose, making the model look more like a conventional power model, as shown in Fig. 127, but this is not greatly favoured, as the motor can come in for some knocks, or easily get dirt in it, when landing in rough fields.

The most popular method, and one which keeps the motor well out of harm's way, is a power-pod, as shown in Fig. 128. This is mounted above the wing, on a pylon, in such a

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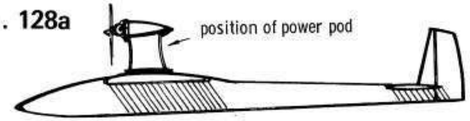
* The *Amigo* is an old-established kit model, of some 79in. span, which has become something of a yardstick among r/c gliders. It is a general purpose model, being suited either to tow-launched thermal soaring, or to slope soaring in light winds. In fact, it has come to be regarded as the ideal model for "marginal" lift conditions at the slope, when it remains aloft while most other models are grounded for lack of lift.

Fig. 128a



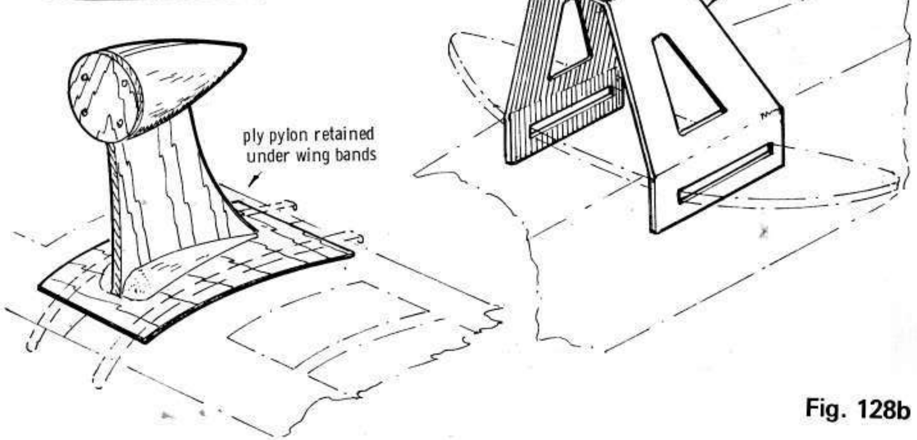


Fig. 128b

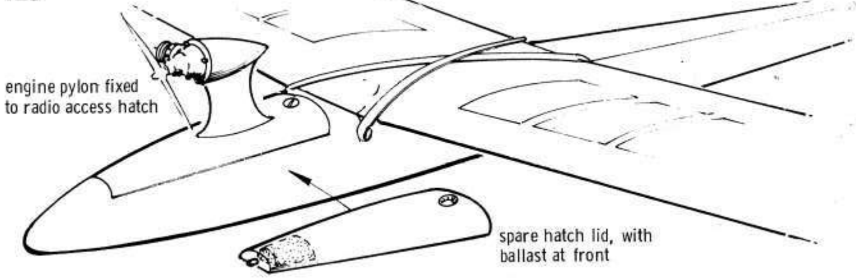
manner that it does not disturb the model's trim (that is, over the centre of gravity of the model). Very often the mount is devised so as to slip under the wing bands or between the wing-joining dowels or tongues, and locate between the wing roots and the fuselage (Fig. 128a and b). A variation on the "pylon" mount theme is that built onto the nose hatch of the model, as shown in Fig. 129. Thus, a plain hatch (plus an ounce or two of ballast) may be substituted for the pylon hatch whenever the model is to be used for pure gliding.

The question of thrust lines is one that is often raised in this connection but, in practice, there really do not seem to be any problems here. Theoretically, with the motor mounted some distance above the wing—and the centre of drag—its thrust should tend to produce a nose-down couple, as shown in Fig. 130. To counteract this effect, if it is noticed in practice, a degree or two of up-thrust is given to the engine.

In every day, out-in-the-field practice, however, most modellers find that with power-assisted gliders, using relatively low power, this downward-couple effect is not noticeable, and are quite happy with zero or neutral thrustlines. It is only when more powerful motors are used—*overpowering* the model, in fact—that the effect of offset thrustlines, or the need for them, is going to be felt to any degree.

"Extreme" locations of the engine, when designed into a model, can be interesting. That is to say, if the model is actually designed as a power-assisted glider, instead of merely being adapted to serve as such. For instance, on certain layouts—especially these featuring swept-back wings—it is possible to locate the motor at the tail end. (Apart from anything else, this means there will be no messy fuel on the rest of the model!) If the designer can come to terms with having weight still further aft, then even a pusher version is possible. Fig. 131 shows the configurations.

Fig. 129



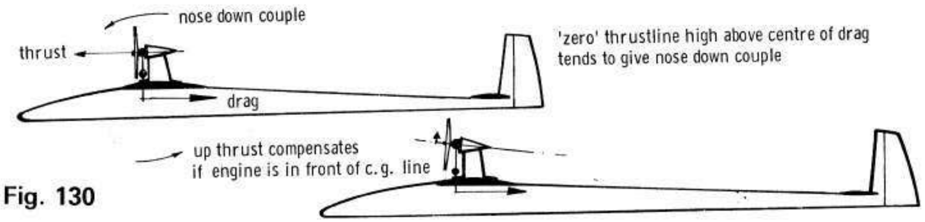
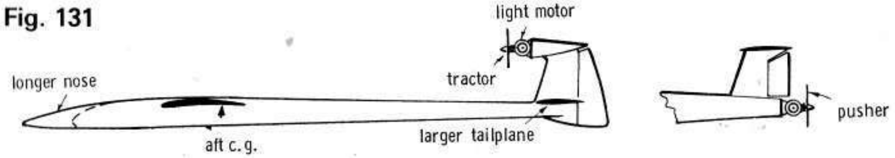


Fig. 130

Fig. 131



Gondolas—the drop-off engines!

A rather different concept is that of the motor-gondola. Here the pylon is, in fact, suspended *beneath* the model's c.g. instead of being mounted above it. The motor-pylon becomes a "gondola" when so positioned. The device is plugged into the fuselage in such a way that it is actually held in place only by its own thrust. When the motor stops, the whole assembly slides out and drops clear of the model, leaving it a "pure" glider in every sense. A parachute or streamer is used to slow the gondola's descent and to mark its position on the ground. Fig. 132 shows the set-up.

The idea is certainly an appealing one, from the point of view of dispensing with what, after it has served its purpose, is only a drag-producing appendage. In practice, however, there are sometimes problems connected with locating the fallen gondola (and also of its premature release—with motor still running!) which could tend to make one think that the carrying of the motor on the model might, after all, be the lesser of two evils!

As with most systems, there are innumerable variations on the theme, and some can be quite sophisticated, like the streamlined version shown in Fig. 133. This has a moulded glassfibre body, shaped to follow the lines of the fuselage. It is not self-jettisoning but is operated by radio, so that the pilot can choose his own "dropping zone," depending on the wind drift. There is, of course, a shift of the centre of gravity when this forward fitted type is used—but no doubt some ingenious r/c modeller has already found the answer to that one! There is certainly a lot of room for individual experiment with motor-gondolas and, once

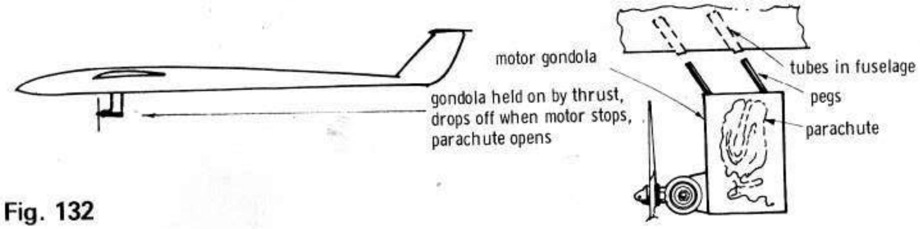
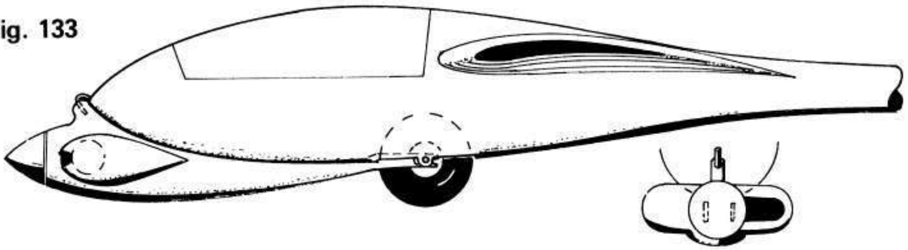


Fig. 132

Fig. 133



they have achieved a reasonable degree of reliability, in terms of the mechanics of actual fixing and release, they could quite possibly be the most satisfactory power-assist system of all.

All that height. . . .

Small engines run for several minutes on an ounce of fuel, so that slow, gradual climb is no disadvantage. The climb out, in calm weather, should be made in large circles, turning as flatly as possible. Do not start pointing the nose up, like an aerobatic model, or the glider will stall. Near the ground, this can be fatal. When a safe height has been reached, it will be in order to experiment, if desired, with some extremes of control, so as to determine just what are the safe limits of control which can be given. With practice, one becomes familiar with the model's handling characteristics, and the amount of fuel required for attaining a given height. Then the real thermal-hunting can begin.

If there is any amount of breeze, it is best to fly the powered glider in a manner rather similar to that in which slope soarers are flown in light winds. That is to say, after an initial into-wind launch and climb-out the model should not be flown directly into wind, but "tacked" to and fro in a crosswind direction. After a short trial period, it will soon be apparent which direction enables it to achieve the best height-gain. Once the motor has cut, it is probably best to fly in wide, flat circles, tightening them up if the model seems to be in lift. When it is lower once more, the pilot should be on the lookout for signs of thermal activity, as described in Chapter 14, so as to prolong the flight even further.

With a long motor run, of course, it is possible to fly the model much higher than with a tow-line or bungee launch and, at this sort of height, the problem, instead of being one of how to keep the model up, becomes one of how to get it down—or even how to keep it in sight! If you do not have spoilers fitted to your model, care must be taken how you go about bringing it down out of strong lift; too steep a dive could snap the wings. If the model will *spin*, then this is the safest way of bringing it down (not all the way, of course!) without over-stressing the flying surfaces. If it will not spin, then a series of stalls will often bring it down without too much strain. Simply ease the stick back gently until you are giving full "up." Let the model stall a few times and then, if it is becoming too violent, ease off until it levels out, then start over again, and so on. This method can be quite effective, where a dive (especially if the model is so high that you cannot see properly at what angle it is descending) could quickly result in debris raining from the blue.

It is necessary to know about such contingencies but, if you start with *small* amounts of fuel in the tank, and gradually increase them, you should be able to control the model all the time in such a manner that it does not get too high, in the first place.

On calm days or summer evenings, many happy and rewarding hours may be spent seeking lift and learning to recognise and use it, with a glider that has initially been helped aloft by that add-on motor, that "power-assist."

CHAPTER 18

AERO-TOWING

FULL-SIZE gliders are towed aloft by powered machines, so why not models? A few years ago it was thought this would be far too difficult, since the pilot of neither aircraft is *in* it, to fly "by the seat of the pants," as it were. However, modellers are a determined bunch, once they set themselves a goal, and quite a number of groups, in different parts of the country, have now brought methods of aero-towing with models to near-perfection. As a result, there are a number of different techniques—all of which work. Perhaps, as with model helicopters, once it is established that it *can* be done, then more and more people succeed.

Of course, aero-towing is an immensely elaborate way of getting a model glider into the air, and one would not normally think of it in this connection, in the way one does with full-size counterparts (which is why we have not included it under "Launching Techniques"!) It is, however, an interesting exercise and makes for useful co-operation between glider and power fliers. For demonstrations at shows and rallies, of course, it can be most impressive.

Early experiments

The experiences of one group, in the first stages of aero-towing, back in the 1960's gives an interesting insight into the sort of problems that arose and how these were overcome.

It was decided to attempt to tow a *Foka* glider with a *Taurus* as the tug. A release mechanism was devised, and strapped on top of the tug's fuselage. This had a special safety precaution built in, so that it would release the line if the glider were to "snatch" while on tow. If things went well, on the other hand, one could release both line and glider by giving "slow motor" command to the tug. The line, which was, in these early attempts, attached to the standard towing hook of the glider, would then drop away.

The launching procedure went like this: the glider and tug were attached by their line, and someone would hold the glider which, in turn, would hold back the tug. The engine on the tug would then be fully opened up and, at a given signal, the man who was holding the glider would gently run—just keeping the line taut—and launch it.

Although able to get the models airborne in this way, they found they were only able to make about half a circuit before having to release the glider, as it would, by then, be oscillating madly—and occasionally even barrel rolling!—behind the tug. Different hook positions and various lengths of line were then tried, but no real progress was made.

The breakthrough came when, almost in desperation, a very much greater line length was tried than previously—about 100ft. longer, in fact—making a total length of some 140ft. The line used was fishing line of 40lb. breaking strain. Everything went much more smoothly now and long, long, tows were achieved. They would release the *Foka* when tug and glider were mere specks in the sky, and glide durations of 20 minutes and more were regularly achieved. Once the tug had been landed, the two pilots would take it in turns to fly the glider.

The problem, at this stage, was that tow-lines were continually getting lost. As already mentioned, they were hooked onto the glider's normal tow-hook, and slipped off when the other end was released from the tug. So the attachment point was now moved up onto the top of the glider's nose, and a release mechanism devised so as to be able to release the line

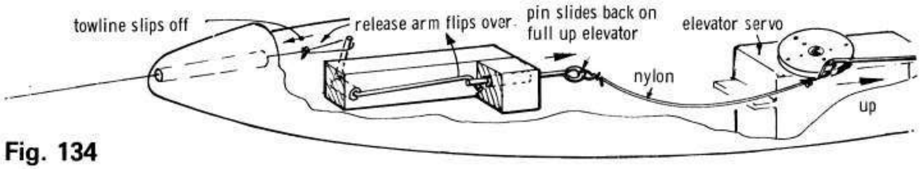


Fig. 134

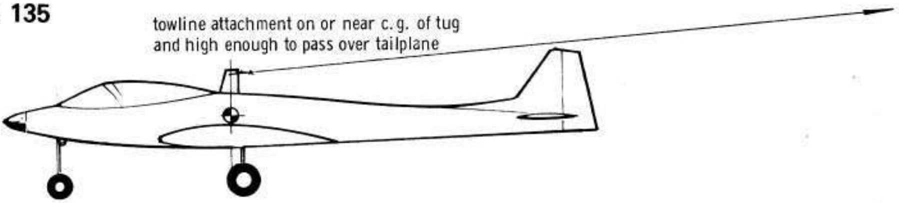
from the glider end, leaving it trailing behind the tug—as with full-size practice. The tug could then return with the line and, doing a low pass along the strip, drop it neatly in place for the next flight.

The release mechanism in the glider was quite simple and was actuated from the elevator servo. Ideally, of course, one would use an additional servo for this, and so avoid having to give up-elevator and "peel off" as it were. The release mechanism is shown in Fig. 134.

All the flights were made from a grass strip and, initially, the tug would make heavy going of attaining flying speed for take-off while towing the glider, which was already air-borne and above the still earthbound tug. This problem was eventually overcome by the glider pilot applying a fair amount of down-elevator soon after the glider was launched, effectively taking the load off the tug for take-off, though not allowing the line to become slack enough to cause the glider to wallow.

Once airborne, the tug pilot would make very wide, gentle turns—especially the turn down wind on a windy day. The glider pilot generally seemed to apply slight down-elevator throughout the towed part of the flight, and maintained station slightly higher than the tug. All towing was conducted at full throttle. At times, the models were so high that any *precise* control could not possibly have been applied, yet the models still performed satisfactorily and did not get into any sort of pitching trouble.

Fig. 135

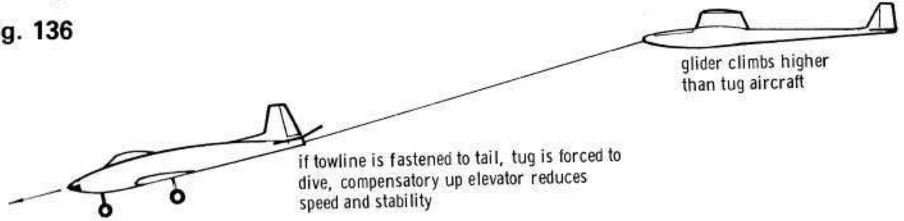


Recent pointers

Many groups of r/c fliers have since had success with their own variations of these methods and one, who have done a considerable amount of work on the subject, have come up with some fairly definitive pointers for those considering this rather off-beat branch of r/c gliding.

First, the attachment point on the tug is important, as it is critical in relation to the c.g. A line should be taken through the tug's c.g. and the attachment point (a small pylon or simply a hook) fitted to the point on the top deck of the fuselage where it emerges (Fig. 135). This way, the tug is virtually unaffected by any extra stresses and strains the glider attempts to put on it, by riding too high or too much to one side. A line attached to, or near, the tug's tail, however, will result in the tug becoming very difficult to handle. Fig. 136 shows how, with the glider riding in its normal position, slightly above the level of the tug, the tail attached line will pull the tail of the tug upwards. The pilot then applies a lot of up-elevator to the tug, to correct this, with the resultant loss of airspeed and general instability. The same sort of thing happens, as one can imagine, if the glider wanders too far either side. Too much to the left, and it pulls the tug's tail round and points it in the opposite direction, and so on. Keep the attachment fairly near the tug's c.g., therefore.

Fig. 136



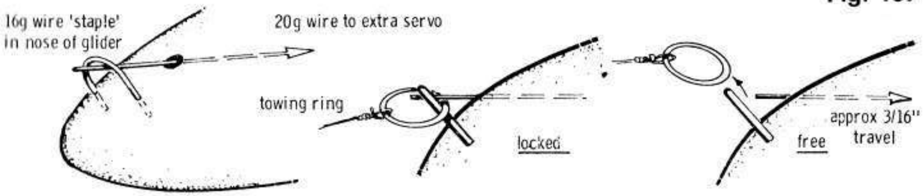
The attachment point on the glider is not, as we have seen, nearly so critical, but the optimum position is as high up on the nose as is possible. Various release mechanisms have been tried, the most satisfactory being a simple staple in the nose, with a rod from the servo going through a ring at the end of the line and holding it in place until withdrawn. This is shown in Fig. 137.

The towing line should *on no account* be of nylon monofilament, such as is used for ordinary tow-launches, as this has too much elasticity for aero-towing work and can cause snatch and oscillation in an otherwise satisfactory set-up. The recommended line is a shoe repairer's twine—linen thread, 7 cord, normal twist, WH&B. A "weak link" is used, to break in case of a bad "snatch," and is Keilkraft Terylene thread (as used for small control-line models). A length of rubber has been tried, to act as a kind of weak link, but only resulted in oscillation.

The length of the towing line should be 100-120ft. Longer lines are quite safe but do lead to weaving, and make it harder for the glider pilot to follow round turns.

The glider used should, for preference, have aileron control. The rudder steered model has to yaw before it can turn, and this can tend to build up into an oscillation, whereas the aileron controlled glider will follow quite smoothly. The rudder steered glider *can* be used, of course (as we have already seen) but more acquired technique is needed to ensure this yaw-swing remains at a minimum.

Fig. 137



Flying

With aileron controlled gliders, it is not necessary that they be hand launched, and it has proved surprisingly easy for them to be towed off the ground, without even the initial support at the wingtip that full-size gliders require, provided the grass of the strip is close cropped.

The glider is first taken to the extreme downwind end of the take-off strip, and the tow-line attached and laid out up wind. The tug then attaches to the up wind end, motor idling. At a given signal, the tug pilot opens up a little, and moves forward very slowly to take up the slack in the line then, at another signal from the glider pilot, he opens up the engine to full throttle—*not* looking at the glider any more—and starts the take-off. The climb-out should be very gentle, the tug pilot holding his model in as shallow a climb as possible, and straight into wind. The glider will take up a natural position some 20-30ft. higher than the tug.

Turns should be wide and flat, and the glider's nose should be kept pointing just slightly "out" of the turn, to maintain the line tension. If the line slackens due to the glider cutting across the inside of the turn, "snatching" will result, probably breaking the weak link.

Take-offs with rudder/elevator gliders are best done as described at the beginning of this chapter, with the glider being hand-launched, since, without aileron, it is not at all easy to keep the wings level, in the first few feet. As has been said, however, aileron control is infinitely preferable.

Weights and power

Gliders weighing between 2½ and 3½lb. can be towed quite adequately by ·40 powered models, it has been found. For towing gliders weighing between 3½ and 5lb. a ·61 powered tug is required, the figure of 5lb. having been found to be maximum weight for the glider, for reasonable and safe towing (the model in this particular case being a *Big Eagle).*

SECTION THREE

SOARING AERODYNAMICS

By FRED DEUDNEY

" Now that's what I call slope lift. "

CHAPTER 19

DOWNHILL ALL THE WAY

THE twenty years I spent in professional aerodynamic research have left me with the overriding impression that one uncovers new and harder questions at a greater rate than one finds answers to the old ones. I've got problems you've never even heard of. So, take my tip, acquaint yourself with some of the fundamental principles—if only to save chasing unattainable goals equivalent to perpetual motion. But don't try to dig too deeply, because you will never reduce it all to logic!

Who needs "Theory"?

Ours is a practical hobby. To be an expert needs no formal qualifications, and there are no lessons to be had. You learn piece-meal as you go, but the snag is that you pick things up in a random order, and the understanding of it is also hampered by encountering the innumerable handed-down half truths with which the folklore of our hobby is well supplied. Small wonder that so few persevere with trying to get their ideas on a sounder basis.

Take a look at a selection of the most advanced designs in all the fields of performance, gliding and powered, duration and aerobatics. You'll find always that the designer has quite a background of experience, and you'll often find that the model is the latest of a progressively developed series. But you'll seldom find that the designer will admit to knowing anything formally about aerodynamics (though intuitively he's done the right things), and you'll *never* find that the design was "theoretically calculated." The case for theory appears, to coin a phrase, underwhelming.

The most indisputable proven fact in the whole of modelling is that the design of (model) planes is so uncritical that no mathematical processes are needed. Also, from the sheer weight of evidence, it would seem unlikely that resorting to calculations would put your "solution" anywhere but in the middle of a broad tolerance band, at best. What is particularly discouraging to anybody who prefers not to leave it all to intuition, is that whilst there's no difficulty in using equations, the calculated result will be no more reliable than the aerodynamic data fed in, and this for models is likely to be very poor indeed. So, it isn't necessary, it isn't likely to offer advantages, and it's just as likely to be worse.

That concept of "theory" is not what I'm selling!

What, then?

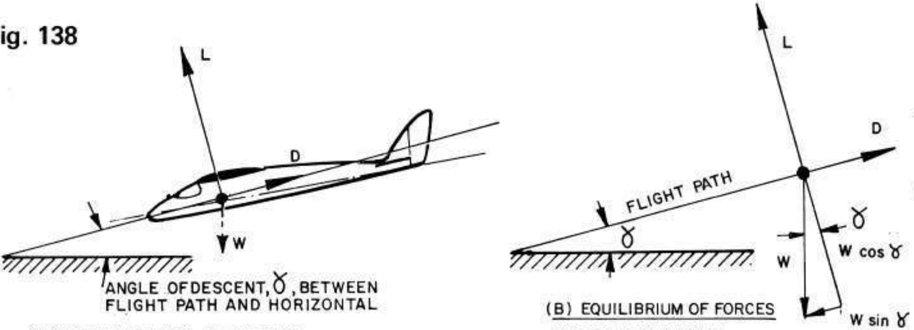
A professional engineer's approach to studying design requirements would be in three stages. First, to identify the main factors involved, secondly by theory and experiment to relate them in a mathematical sense, then finally to make an appraisal of the relative importance of each, in his particular application, by putting some figures in. Now, in our case, there's not much we can do in the latter respect, lacking good data. This is often taken as an excuse for ignoring the principles as well, and this is where the big mistake is made in the common dismissal of "theory."

The *principles* of flight, and of aerodynamics, are well established, without reference to the dimensions, which merely determine the quantities. You may be the pilot, but the laws of physics exercise an unseen control over what is possible in the way of performance. Better to have them working for you. What I offer is a very basic guide to the main principles, as something on which to build your own understanding. It's not a substitute for experience, talent and inspiration—you'll need those as well.

See me after school

If you found school algebra to be baffling, boring, and totally irrelevant to real life, then you're in the majority and I'm just an eccentric. But there's no other way to present a coherent account of a technical subject, so we have a problem of communication. At least we have a common interest—shedding a bit of light on model behaviour, something we see and experiment with for ourselves. As an incentive, tackling the "rules" is an economical alternative to building a hundred different models and trying to figure out why some are better than others, or why you can't get that elusive bit "more lift."

Fig. 138



(A) IDENTIFICATION OF FORCES

L = LIFT, PERPENDICULAR TO FLIGHT PATH
D = DRAG, ALONG FLIGHT PATH
W = WEIGHT, VERTICAL

(B) EQUILIBRIUM OF FORCES

FOR STEADY FLIGHT :—
$W\sin\gamma = D$
$W\cos\gamma = L$
HENCE $\frac{D}{L} = \frac{W\sin\gamma}{W\cos\gamma} = \tan\gamma$

Classical jazz

Back in school, they used to try to interest us in unrealistic problems involving inertialess masses connected by weightless string over frictionless pulleys. If you pursue book-learning, you do eventually find that you can progressively introduce all the tiresome realities and solve "real" problems: to have started this way would have been very off-putting. This "Classical" approach is the way to start thinking about gliding but because we don't need to simplify to the point of unrealism (a "frictionless" glider wouldn't come down), we don't need to go on to any difficult stuff. The only thing which we do, from convenience rather than necessity, is to start our considerations with a glider in still air over level ground.

(a) Glide angle. As a start we take a glider in steady flight at airspeed v, descending on a straight flight path at angle γ to the horizontal. The relation between the aerodynamic and gravitational forces can be deduced without knowing anything about the aeroplane. An overall aerodynamic force will be acting, which can be represented by two components; the major one is defined as the Lift, acting perpendicular to the flight path (not vertically), and the minor force acting along the flight path is defined as the Drag. See Fig. 138a. Similarly the weight can be represented as two components, as in Fig. 138b. The propulsive force is the component of weight acting forwards along the flight path, which is W sinγ. Now, because the plane is in steady flight, the propulsive force must be exactly balanced by the Drag; if it were not, the plane would be getting faster or slower, because any unbalanced force produces an acceleration. So we can write D = W sinγ. Similarly, the Lift must be equal and opposite to W cosγ or the plane will deviate from the flight path. Hence L = W cosγ. Dividing, we get: $\frac{D}{L}=\frac{W\sin\gamma}{W\cos}=\tan\gamma$

So the first thing to emerge is that the *Drag/Lift ratio is a direct measure of the angle of descent.* As an example, a Lift/Drag ratio of 15 gives a glide slope of 1 in 15, or just under 4 degrees.

Two points to mention before proceeding. The first is that the glide angle is *not* the incidence angle of wing to fuselage, nor the operating incidence of wing to airflow, nor the observed angle of the fuselage to the horizontal when in steady flight. It *could* be equal to any or all of these, by accident or design, but as anyone who has seen gliders descending in a nose-up attitude will confirm, it isn't necessarily so. The second point is that for straight steady flight, we can always say that the Lift is just about equal to the weight. For our example with a glide angle of 1 in 15, the exact figure is L = 0.998 W, a discrepancy of one part in five hundred. The glide angle would have to be as bad as 1 in 7 for the error to be as much as 1%. So, for all practical purposes, Lift equals weight, and the reason for your plane descending is not a shortage of lift! If you learn nothing else, learn that.

(b) Rate of Descent. This is apparent from the triangle of velocities. If the plane flies at v ft./sec. along its flight path, then it covers the ground at v cosγ and descends at v sinγ, Fig. 139a. As we've seen already, the glide angle is governed only by L/D, so for reasonably flat glide angles the rate of descent is v ÷ L/D. As an example, a model flying at 30ft./sec. with a L/D of 15 descends at 1/15th of 30, or 2ft./sec. Thus the D/L ratio represents the rate of descent as a fraction of the forward speed.

(c) Range. From a given height, the distance to touchdown in still air is the range. The same shape of triangle relates the starting height, horizontal range, and flight path, so that the ratio range/height is the same as the ratio Lift/Drag. As shown in Fig. 139b.

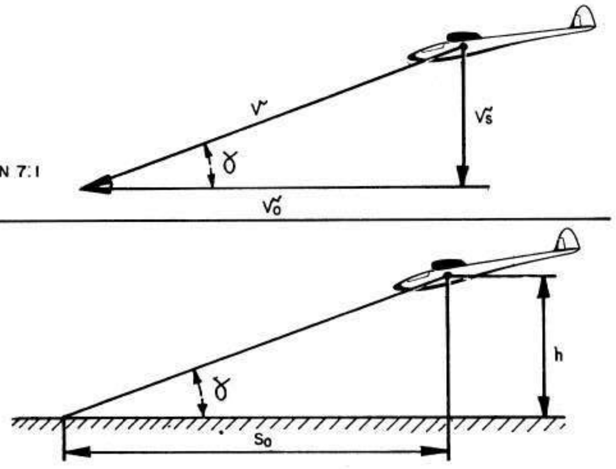
$$s_o = h \times L/D$$

The third result, then, is that the distance covered in still air is proportional to the L/D ratio, without reference to speed, weight, etc. As an example, from a height of 100ft., a model descending with a L/D ratio of 15 covers 1500ft. horizontally (1503ft. along its flight path).

(d) Duration. The time taken to descend will be the height divided by the rate of descent. Alternatively it may be derived from the slant range along the flight path, divided by the flying speed.

$$t=\frac{h}{v_s} \quad \text{and } v_s = v\,\frac{D}{L} \quad \text{hence } t=\frac{h}{v}\,\frac{L}{D}$$

As an example, from a height h = 100ft., at a flying speed v = 30ft./sec. and L/D = 15, the time of descent is $t=\frac{100}{30}\times 15 = 50$ secs.



(A) RATE OF DESCENT, V_s

$V_s = V_o \tan\gamma$
BUT $\tan\gamma = \frac{D}{L}$ (SEE FIG.138)
$V_s = V_o\frac{D}{L}$
APPROXIMATELY, $V_s = V \div L/D$
(WITHIN 1% FOR L/D BETTER THAN 7:1

(B) HORIZONTAL RANGE, S_o

$S_o = \frac{h}{\tan\gamma}$
$= \frac{h}{D/L}$
$= h.\,L/D$

Fig. 139

(e) Energy considerations. The whole business of gliding is bound up with energy. If you take a plane at rest on the ground and haul it up to a height h, you give it a potential energy W × h ft.lbs. This store of energy is used up on the descent by doing work against drag, and whether there is a high drag and short steep descent, or a low drag and a long shallow descent, the total work done is neither more nor less than the energy put in to the plane. This proves to be so, from the foregoing relationships. The distance covered along the flight path is $h/\sin\gamma$ and the drag force is $W \times \sin\gamma$; the work done is force × distance, which is W × h. It all ties up!

Pause to take stock

At this stage, what stands out is that the property of a plane known as its Lift/Drag ratio is of primary importance in every aspect of its performance.

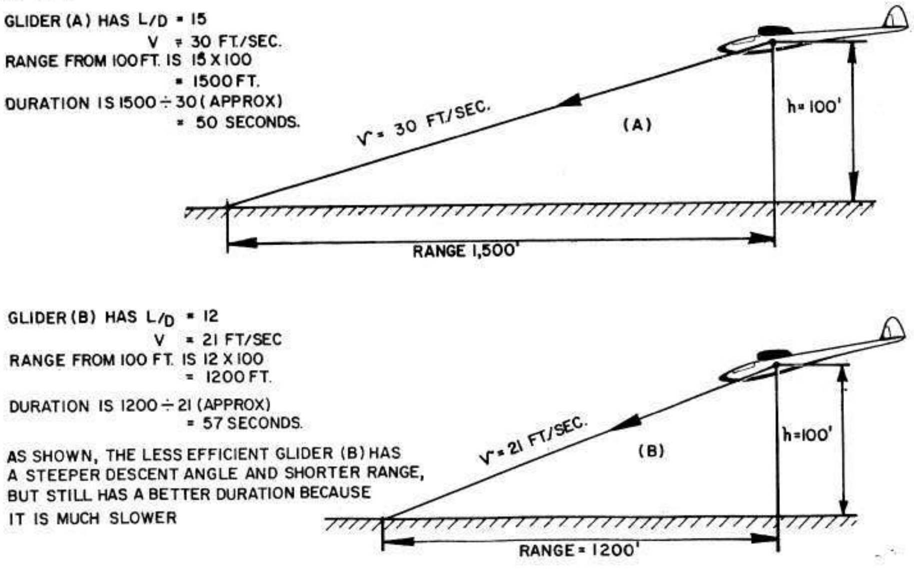
(a) Glide angle decreases with L/D.
(b) Rate of descent decreases with L/D; increases with speed.
(c) Range increases with L/D and height.
(d) Duration increases with L/D and height; decreases with speed.

Obviously L/D is a measure of what may be termed "efficiency," without needing to define what we mean, but it should be noted from *(d)* that where duration is the objective, both L/D and flight speed are equally important. It would seem that, in principle, we might trade L/D for reduced flight speed, to get a better duration if the rate of exchange is good.

As an example, our standard case in earlier illustrations has L/D = 15 and Speed 30ft./sec.; from a height of 100ft., it covers 1500ft. along the glide path, and the duration is thus 1500/30, or 50 secs. If we take another design where the L/D is less, having a value of 12, and where the flight speed is also less, at 21ft./sec., we get a glide distance of 1200ft. and a duration of 1200/21, or 57 secs. So the second example, though less "efficient," has a better duration, though its range is less, see Fig. 140.

So far, we've made some progress in isolating the main factors and relating them to performance; what we now have to do is to resort to some principles of *aerodynamics*, to see what governs the values of flight speed and the all-important Lift/Drag ratio.

Fig. 140



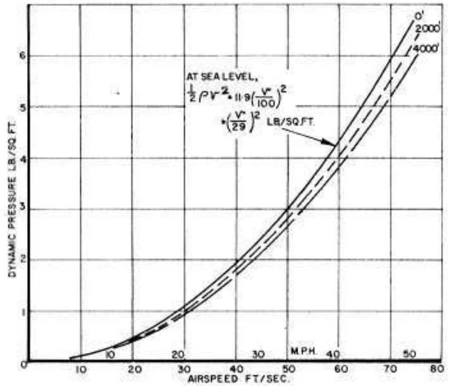


Fig. 141

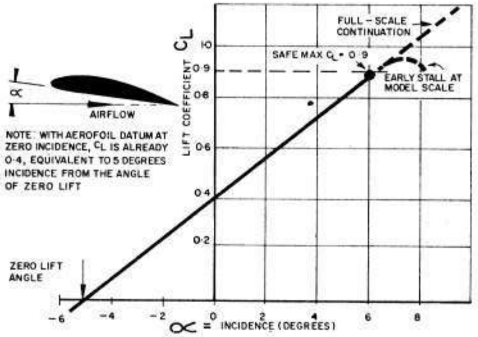


Fig. 142

Wings an' things

That "The lift is proportional to the square of the speed" is the first and often the only bit of aerodynamics that every modeller knows. It is possible to put it in terms which are more readily visualised, however, and as a start we have to accept that whenever air moves past an object, the motion generates what is called "Dynamic Pressure." Any solid object which slows or stops the air is then subjected to a force due to this pressure—this is the "wind in your face" effect. The dynamic pressure is the thing which varies with the square of the speed, and also depends on the air density, though the latter effect is only of concern to the really Alpine fliers. It is written $\frac{1}{2}\rho v^2$ and called "Half Rho Vee Squared," in spite of the printers' usual habit of putting a letter p where there should be a Greek symbol ρ, if you follow me. The value (in ft., lb. units, the only fit ones for an English-speaking gentleman) is $0.00119\ v^2$, or $\left(\frac{v}{29}\right)^2$, lbs. per sq.ft. at sea level, see Fig. 141. Air density is expressed in Slugs/cu.ft.—rather agricultural. It is self-evident that the lift produced by a wing will depend on its area, and the effectiveness of a wing (at incidence) in converting the available dynamic pressure into a Lift force, per sq.ft. of wing, is known as the Lift Coefficient C_L.

Thus Lift (lbs.) = Dynamic Pressure (lb./ft.²) × Area (ft.²) × C_L.

In the same way, Drag depends on a coefficient, C_D.

The equations are: $L = \frac{1}{2}\rho v^2\ S\ C_L$ and $D = \frac{1}{2}\rho v^2\ S\ C_D$.

The lift coefficient of a wing increases steadily with incidence angle, until the point is reached where the flow breaks down. This is the "stall," dependent on incidence, not speed, Fig. 142 and later chapters illustrate. For a complete aeroplane, it is a commonly accepted simplification to ignore tail and body contributions to the total lift, as they are normally only a few per cent. One can't do so for drag, however.

The foregoing shows what I mean by a useful principle; you may never want to use the equations to calculate quantities, but they do show what the parameters are, and as will be seen, enable us to get at what we want to know about the lift-drag-speed picture. First, however, we need an idea of what determines the incidence of a wing in flight, and what keeps it to a particular value. There's more to it than drawing the wing at a particular angle to the fuselage datum and hoping that's what it will fly at.

Stability and trim

The purpose of a wing is to provide lift; if it operated at zero incidence, the plane would follow a ballistic trajectory into the ground. The purpose of the tailplane is to provide a steady load to hold the wing at incidence, and to be capable of providing a change of load, as a result of any disturbance of the incidence, such as to restore the plane to its trimmed incidence. Digest that carefully, because the two functions of the tailplane are frequently confused. *The trimmed incidence* of the plane depends on the tail setting angle, or elevator angle, in relation to the wing setting angle; in other words, the *difference* between wing and tail incidence. The *stability* of the system does not depend on the rigging incidences, but on the tail size, moment arm, and c.g. position of the whole plane.

This latter state of affairs is invariably turned back-to-front by every modeller and every magazine article (and probably even by someone else in this book). The incidence difference does *not* govern longitudinal stability; it is governed *by* it! Anybody wanting to insist otherwise is taking on the world's entire missile/aircraft industry and denying the evidence of a prodigious number of measurements—including mine.

In Fig. 143a we show a symmetrical sectioned and symmetrically laid out design at zero incidence to the airflow. There is no lift from wing or tail, and no moment to change the incidence. In Fig. 143b, we've shown the same aeroplane at some incidence, say 3 deg. The *total* Lift (perhaps 90% wing and 10% tail) acts behind the c.g. and the result is a nose-down pitching moment tending to reduce the incidence. This is a *stable* aeroplane, but untrimmed; the incidence-reducing moment will not vanish until the lift and incidence are zero. The trimmed incidence is zero, and (like a weathercock on its side) any change of incidence, positive or negative, produces a stable moment restoring it to zero. In Fig. 143c, however, the same aeroplane is shown with the tail set negative to the datum at say − 2 deg. At 3 deg. body incidence, the tail lift is then less, and the total lift will have moved closer to the wing c.p. As shown, it acts through the c.g., so there is no moment acting to change the incidence; the plane is now *trimmed* to fly at 3 deg. incidence. To examine whether it is still stable, imagine another 3 deg. added to the body incidence. The *increment* of lift added to wing and tail will be the same as case *(b)* experienced in going from 0 deg. to 3 deg., and the position of this added lift will be the same, so the restoring moment will be the same. This time, the restoring moment will vanish on returning to the trim at 3 deg. incidence. Thus, the plane is not only stable, but has the *same* stability as the zero-rigged one, *i.e.* it experiences the same restoring moment for any given displacement *from its steady trim.*

It needs a chapter rather than a paragraph, but that's the essence of it. How it applies in practice is as follows: if the c.g. were moved aft in Fig. 143b, the restoring moment about it would be less. This is a reduction in stability. At the same time, the tail setting would have to be reduced if you want to retain the trim at 3 deg. as in Fig. 143c. The two factors are inseparable; the lower the stability (aft c.g.), the less the negative tail angle required to trim the plane to any given incidence or lift, *i.e.* the more responsive the plane becomes. But it isn't the reduction of tail setting that reduces the stability; the point is that if you *rig* a plane in this way, you will *then* have to move the c.g. aft in order to avoid an excessively nose-heavy (low incidence) trim.

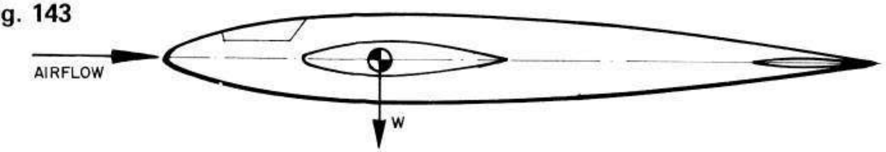
The first requirement of a model is *some* measure of stability, without which it becomes unflyable whatever the tail setting. This means in practical terms that the tail and its moment arm must be large enough and that the c.g. must be far enough forward; these three variables may be juggled to get the desired characteristic, and it's all done by trial and error! Having ensured stability, the question of trimming the model is obviously then a matter of how much tail incidence is built in, and how much is left to be set up in flight by shifting the elevator angle.

In practice, a high wing position, and the presence of the fin, may contribute a built-in nose-up moment, so that even with zero incidence wing and tail settings, it is not necessary to apply "up" elevator to trim at positive lift. All that we can say is that, provided the plane is stable, it can be flown continuously at any incidence within its range by adjustment of its tail setting or elevator. We can't predict how much incidence for how much elevator, and don't really need to. It could be done with reliable data, of course, but we don't believe in mathematical design, do we?

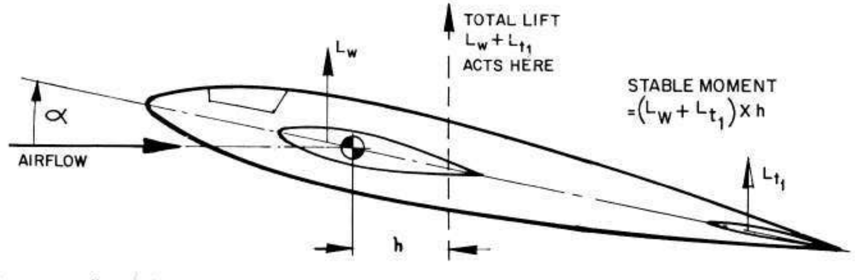
Back to the equations, men

After that digression, we now know that incidence, and hence the Lift coefficient C_L, is something that can be varied or held, in flight, by altering the tail setting. We know also that whether it takes a lot of up-elevator or only a little is governed by whether we've balanced the plane to have a well forward c.g. or a more aft one, and whether we've used generous tail

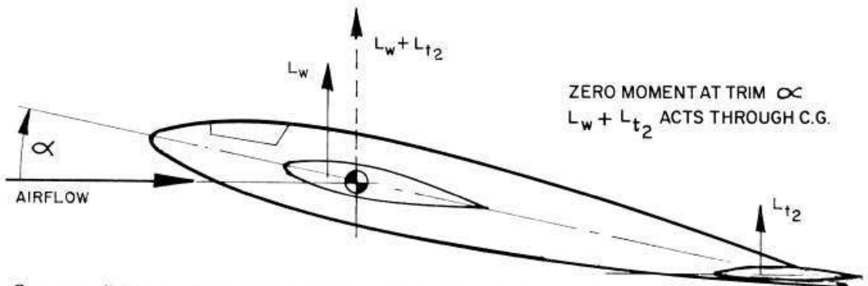
Fig. 143



(a) Symmetrical wing and tail aerofoils set at 0 deg. on fuselage axis. At zero incidence, no force or moment acts to change incidence α ∴ This is *trimmed* to zero lift. We cannot say whether it is stable till we examine the effect of body incidence.



(b) Same configuration, incidence α *Combined* lift of Wing + Tail acts aft of wing C.P. If, as shown, this is aft of c.g., then a nose-down moment results, tending to reduce incidence. Thus, config. (a) is *stable,* but trimmed to zero lift. It won't fly in this state!



(c) Same as (b) but with tail set negative to fuselage datum. At the same α, the tail lift is less, and total lift $L_w + L_{t_2}$ acts closer to the wing C.P. If, as shown, it acts through c.g., then there is no moment, and model is *trimmed* at α.

BUT: adding further incidence produces *extra* lift on both wing and tail, acting at h behind c.g. as in (b). Model is therefore *stable* about its trimmed α.

(d) This one was *unstable.* We moved the c.g. in case (b) to behind where $L_w + L_t$ acts. Model went both ways simultaneously and disappeared up its own antenna.

Moral: move the c.g. back in steps. The safe aft limit is then the step before the one at which it crashed.

surfaces or not. We can't tell from the drawings what C_L the plane will settle to, but by rigging and trimming, we can get what we want in flight.

Reverting to the equation relating lift, speed, and wing area, we have $L = C_L \, \frac{1}{2}\rho v^2 \, S$, and now know two of the three things which we need, namely C_L and S. Also, we can say that after time to settle to a steady glide, the Lift L is equal to the Weight W.

$$\text{Hence } W = C_L \, \tfrac{1}{2}\rho v^2 \, S$$

This is the flight speed equation, in which the only unknown is $\frac{1}{2}\rho v^2$. Rearranged, it becomes: $v = \sqrt{\dfrac{W}{\frac{1}{2}\rho S C_L}} = 29\sqrt{\dfrac{W}{S\,C_L}}$ ft./sec.

Thus, in flight, the only thing governing the speed of any given glider is the Lift coefficient C_L, provided that we allow time to settle. A glider is a self-regulating device as regards speed, and if we change the trim in flight to a different incidence and C_L, then the speed will adjust itself in accordance with the above relationship. It's as easy as that. It follows that the elevator is the speed regulator; if you ease in "up" elevator trim gently, the plane will get slower, and vice-versa. A high C_L dictates a low speed, low C_L demands high speed. Unless your plane flies around shedding radio gear or wings, the weight and area are fixed, and all that the pilot can do is to trade speed for incidence, where steady flight is concerned, because the outcome of each elevator change is the same result, Lift equals Weight, after the appropriate settling time. The limits of this are the "too much elevator" case where the plane stalls, and the opposite where it comes straight down—no lift at all!

Weight, drag, and speed

So far, we've concentrated on sorting out the relationship between Lift, Weight, and Speed, and with the use of one more parameter, the Wing Area, we've got the whole story. We can now dispose of a widely held belief concerning the part played by the Drag.

The equation: $v = 29\sqrt{\dfrac{W}{S\,C_L}}$ may be simplified, if we note that $\dfrac{W}{S}$ is Total Weight divided by Wing Area, i.e. the Wing Loading in lb./sq.ft. Writing "w" for wing loading, we then have:—

$$v = 29\sqrt{\frac{w}{C_L}}$$

Thus it is not necessary to know separately the Weight and Area, and the wing loading is a useful criterion for judging a model's potential speed. The point to note, however, is that the speed depends only on the *two* parameters, wing loading and lift coefficient. It may seem intuitively "obvious" that cleaning up a design to reduce the Drag will make it go faster. Not so! Drag governs the *Angle of Descent*, and any reduction of drag will result in a shallower glide path at the *same* forward speed. The only speed change that results is in the rate of descent, which gets *less*.

The background to this common misinterpretation of evidence may become clearer (or possibly foggier) if you read my other bit. If you use a particularly thin aerofoil to reduce Drag, it will stall at a lower incidence, or C_L, so it will not then be possible to fly the plane as slowly as the *minimum* speed of its thick-winged counterpart. But if the thin-winged model is retrimmed, by under-elevating, to *make* it descend as steeply as the other, *then* it will fly faster. The drag reduction *permits* faster flight, if you throw away the primary effect of a reduction of glide angle.

There is one exception—straight down at zero lift. The plane will accelerate under gravity until the Drag equals the Weight, at some fearful Terminal Velocity. If you persist in this sort of thing, it would be more appropriate to study excavation than Aerodynamics.

Up, up and away

That tempting carrot before the donkey, the notion of getting "more lift," should by now be losing its allure.

The equation was: $L = C_L \times \frac{1}{2}\rho v^2 \times S$.

Can't we fiddle one of those three things on the right hand side, just to squeeze a bit more lift out of our plane? The answer, to your regret and mine, is an unqualified No. Return to the beginning of all this rigmarole and you'll see that the vital "Lift = Weight" principle was established purely as a consequence of the steady flight condition, without needing to know the value of either, and without needing to know anything about aerodynamic behaviour. Old Isaac Newton himself would have told you that. If your plane seems to come down too fast, it's not a bit of good treating it as a case of shortage of lift, and resorting to "high lift" sections" and grafted-on wing extensions. What you need is less drag.

Of course, if you increase wing area, or change to an aerofoil which can achieve a higher C_L, the self-adjusting property of the stable aeroplane will ensure that the final outcome is $L = W$, as always, and this implies a reduction in speed. So although your plane may descend just as steeply, it will do so more slowly. If you could "get more lift," the logical outcome would be the plane that just got up and flew away. And don't ring us, we'll ring you.

The price of flight

The Lift/Drag ratio is a direct factor in every aspect of measurable performance. A scale model would have exactly the same L/D as the prototype, if it were not for the deterioration in aerodynamic characteristics, called "Scale Effect," which occurs somewhere between "their" conditions and ours. The point I'm making is that, if we stick to models, then the L/D ratio of a given design is a property of the layout, its proportions and sections, and not dependent on the scale to which it is built, or the weight at which it is flown. Remember that L/D is the same as C_L/C_D, so forget the *forces* and think of coefficients which depend on the geometry.

Just as C_L is a measure of the lifting effectiveness, so the C_D value is a measure of the bluffness of the aeroplane; a well streamlined plane has a low C_D. For a plane with elevator control, the incidence and C_L can be varied in flight, so that a whole range of values of C_L/C_D must be possible. At $C_L = 0$, the value of C_L/C_D must be zero, and one may infer that increases of C_L to normal flying values, say 0.2 to 0.9, will lead to respectable values of C_L/C_D. Without knowing anything about the behaviour of the Drag Coefficient with incidence, we may still safely infer that L/D will tend to deteriorate whenever the incidence and C_L are reduced to build up speed.

An aeroplane needs lift, however, and associated with the generation of this lift is a penalty known as "Induced Drag." Even if a designer were clever enough to make a perfectly streamlined plane having zero profile drag, it would still have this lift-dependent drag. This is what I call the "Price of Flight," because it's still there for the perfect plane, but wouldn't be there for a buoyant thing such as an airship. The importance of induced drag to model gliders is illustrated in a later numerical example, but at present we should mention that the Induced Drag Coefficient increases with the square of C_L, and decreases with aspect ratio. If we write C_{Di} for it, and say that the rest of the drag is independent of incidence and is called C_{Dp} (Profile drag), then:—

Total $C_D = C_{Dp} + C_{Di} = C_{Dp} + (C_L^2 / 3{\cdot}14A)$, where A = Aspect Ratio.*

Thus the least value of total drag coefficient occurs at zero C_L, where L/D must also be zero, and the rapid rise of C_{Di} with C_L^2 suggests that the total drag may reach an excessive value at particularly large values of C_L, prohibiting the attainment of a high value of L/D. An optimum should exist somewhere, at an intermediate C_L, before the induced drag has risen to an excessive amount. This is the case, and in fact it follows mathematically that the *maximum* value of L/D will occur at a C_L where C_{Di} is equal to C_{Dp}. In practical terms, this is invariably at quite a high value of C_L.

Under model conditions, of small chords and low speeds compared with full scale, there is always a premature breakdown of lift at a lower incidence and C_L than that attainable full-size, and in practice this may occur before reaching the incidence at which the theoretical L/D max. occurs. Under these circumstances, the best L/D obtainable is found at the

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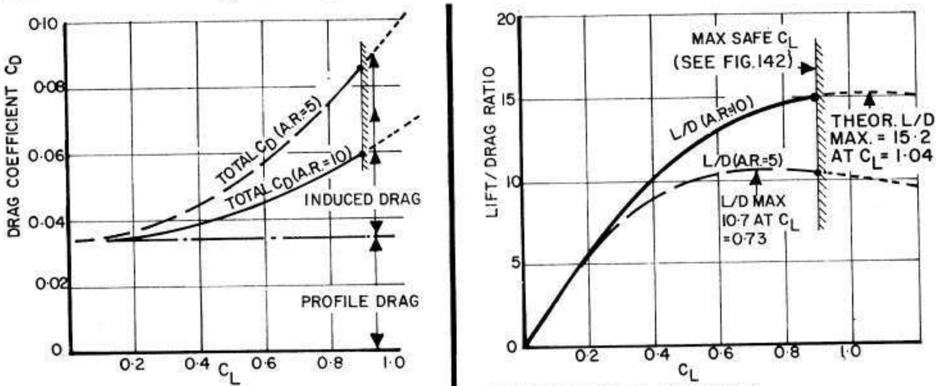
* The Aspect Ratio of a wing is the ratio of Gross Span to Average Chord. There is no need to calculate the Av. Chord for an awkward planform, provided that the Gross Area (including the part of the wing 'covered' by the fuselage) is known. The universal definition for all planforms is:—

A.R. = $\text{Span}^2 \div \text{Gross Area}$

highest C_L to which the model can be trimmed, and the standard duration-flying practice of trimming the plane to fly right on the brink of stalling is then the right one to get the best L/D, or flattest glide angle. It isn't always so for all models, especially where the aspect ratio is particularly low, when the best L/Dmay occur at an intermediate C_L which is well below the stall. Likewise, a model having low profile drag, *i.e.* good streamlining and slender cross-sections, may have its best L/D at a middling C_L.

Without measured evidence from a range of models, it is not possible to make forecasts, but one's eyes may be kept open for evidence of a visual nature, in the light of the above account of the workings of things. By way of an example, Fig. 144 illustrates the sort of characteristics which our earlier specimen would have, given the additional information that the quoted L/D = 15 occurred at C_L=0·9, and the wing aspect ratio was 10. It may be seen that the theoretical max. L/D is 15·15, occurring at C_L = 1·04, beyond the safe incidence of the aerofoil. Also indicated is the result of changing the planform to an aspect ratio of 5; the L/D is inevitably worse, and its maximum occurs well below the stall region. The peak L/D region is pretty flat, however, so the penalties are not large if you don't hit the ideal trim.



(a.) VARIATION OF C_D WITH C_L (b) VARIATION OF L/D WITH C_L

Fig. 144

Sinking speed is a somewhat different matter, as it results from the simultaneous combination of L/D (which ensures a shallow descent angle), and forward speed. For models, it always pays to trim to the slowest possible forward speed (high C_L), as the saving in speed outweighs any changes in L/D near the peak.

To sum up, Drag is your enemy; you can't eliminate it but you can minimise it by commonsense clean design. Induced Drag may be 50% or more of the total, so high aspect ratio benefits "floaters."

Crazy, man

There's no denying the joy of silent aerobatics, but the design of models for it is a fine example of the art of compromise. Aerodynamic efficiency in terms of L/D demands high aspect ratios and thin, cambered wings. Rapid responses, especially in roll, demand short wing spans; strength demands thick wings, and matched looping ability upright and inverted demands a symmetrical uncambered section. I'll leave the recommendations to the experts.

The unseen penalty of every turn and every loop is that they all require *extra lift* to accelerate the model away from its steady-state straight path, and so there is a rise in induced drag, which is in any case a high proportion of the total at high C_L. So the combination of low aspect ratio with high-g turns and loops is unfavourable to the aim of keeping the thing moving. Doesn't stop people making very effective aerobatic gliders though.

Never do it into wind

The "ideal" environment used in our analysis was adopted to avoid the added complication which would arise when considering range, glide angle, etc., in the presence of a wind. The speed referred to throughout is that of the model in relation to the air; if you want to know what progress is being made in relation to the pilot on the ground, you must add or subtract wind speed. Our example flying at 30 ft./sec. airspeed would literally hover if it was heading into a steady wind of 30ft./sec., and its glide angle would be 90 degrees in relation to the ground. Down-wind flying would result in a disappearance rate of 60ft./sec. Nothing more needs saying; if the trim is unchanged, the airspeed is independent of whether it flies downwind or upwind, once it has settled down. What is *visually* confusing, however, is the *transient* effect of any quick change of direction. A fast-flying model going downwind at say 60ft./sec., turned *rapidly* into wind without any change of trim, has an excessive airspeed momentarily, which will cause it to "balloon" upwards; eventually all the excess energy will be used up and the steady state, in our example, will be a descent at the normal sinking speed, and at zero rate of progress relative to the ground. Similarly, real-life winds aren't steady, and a sudden gust will subject the model to a gratuitous bonus of "$\frac{1}{2}\rho v^2$": because of its momentum, the model can't lose speed instantaneously, and the result is that bit more lift than you wanted. On the other hand, when a sudden lack of blow appears, the model acts as if somebody pulled the air from under it. These effects are reversed for a model flying downwind, of course, and what appears to be a downwind stall may often be due to a gust "catching up" with the plane and reducing the lift to a value well below the weight.

Slope soaring must have wind, to prevent the model straying from the flying site, and that wind must be an uphill one to compensate for the rate of descent of the model relative to the air. These are essential conditions, and the arts of designing and flying the special breed of model to suit this particular environment will be found elsewhere. I do have something to say later about ballasting, however.

At last he's finishing

What I've written is no more than a distillation—a simplified exposition of the mechanics of gliding flight, restricted to the aspects of most relevance to modelling. If you're a newcomer, it won't have meant much to you. It never will until you've sampled the realities, got in some flying hours, seen it all happening, and made a few mistakes, because you don't need the answers before you've found the questions! When you come down to earth after the exhilarating landmarks of progress from the first "surviving" flight to the first "Own-design" success, then is the stage where my contribution may help you to interpret the confusion of visual evidence which you have acquired *en route*. Don't reject it as beyond your understanding; it's only what's in your head already, but re-arranged and disentangled from the fluff.

CHAPTER 20

SPEED AND EFFICIENCY

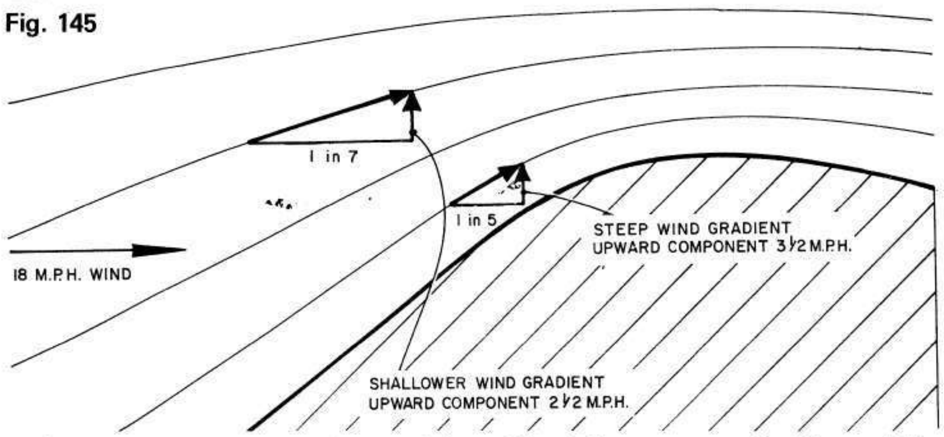
IF, at an early stage in the curriculum, you and mathematics cheerfully agreed to go your separate ways, then you'll certainly have developed compensatory talents, and modellers are especially good at getting the feel of what they want to know. So, don't be put off by the appearance of my presentation. In the interests of getting at the facts concerning weight, speed, glide angle, etc., I've resorted to some technical stuff. What I've done is to take a handful of separate factors, all of which you know vaguely to be of some consequence, and end up with numerical answers which speak for themselves. The bit in the middle, where these things are mathematically expressed and manipulated, is only the means, not the end, so the subject matter should still be comprehensible without dwelling on the detail of how it was done.

What's the problem?

The problem is the real-life one of "wind," and the remedy is not as easy as "Keep taking the tablets." In the two main categories of gliding, namely slope soaring and thermal soaring, the *effectiveness* with which a model can be operated is very dependent on the wind strength, though for different reasons. It is true to say that each change of environment defines its own "ideal" small range of flying speeds, to which the model should be matched for best performance, or for which a model should be selected. As explained elsewhere, a wind blowing up the slope is essential for hill soaring; without it, and in the absence of thermal lift, the model can only descend to the valley. The wind close to the hill goes upwards at the same angle as the surface slope, but further away from the hill its inclination is less, so the useful region of upward-inclined wind lies upwind of the crest. For a 1 in 5 hill, the upward component of the wind close to the surface must be one-fifth of the speed, say 3½ m.p.h. for a wind of 18 m.p.h. A model flying safely upwind of the ridge would experience less than this, say one-seventh or 2½ m.p.h. (Fig. 145). If the still-air sinking speed of the model is no worse than 2½ m.p.h., then it can maintain or gain height, *provided* that its flying speed is neither so fast that it moves out into less helpfully inclined air, nor so slow that it blows back downwind of the ridge. Excess speed is no problem, as a margin is desirable for manoeuvres, and the model can hold station by tacking. An increase of wind speed to twice as much, 36 m.p.h., will give twice the upward component, which sounds fine, but the model then has to be capable of a much higher flying speed in order to make headway. It is found in practice that retrimming a lightly loaded model, to cope with stronger winds, generally results in a performance no better or even distinctly worse than it would normally manage, in spite of the greater upward component of the wind. So the first problem is that of looking for reasons and remedies for unhappy matching of model speed to wind speed, for slope soarers.

The case for the thermal soarer is different, because wind is neither necessary nor desirable. The object is to achieve the maximum duration from a given starting height, and to this end the model will be flown as slowly as possible, and will in any case be lightly loaded to minimise its slowest speed, as explained in my "Downhill . . ." Chapter. The less the wind blows, the longer the model stays in sight, and the easier it is to bring it back to the landing spot. A stiff wind necessitates a fair turn of speed from the model, if only for that part of the

Fig. 145



flight spent in getting back to base, and the problem is how to arrange for this capability without undue sacrifice of the ability to glide at a shallow descent angle.

For any given model, the only way of controlling the airspeed *in flight* is by use of the lift-trimming system, *i.e.* the elevator, and flaps if fitted. Drag-producing devices may be used on occasion to spill off excess speed, so that a slower trimmed state can be resumed without undue zooming after a burst of high speed, but otherwise such devices function to steepen the glide, not to reduce the speed. As a premeditated step *before* flight, there is, in addition to trim changes, the alternative of adding ballast, to raise the wing loading. This *may* be done by the addition of weight ahead of the centre of gravity, in which case it serves the two purposes of increasing the total weight and also balancing the model more nose-heavy, but for the purpose of comparing separate effects, any reference in this article to ballast means weight installed *exactly* on the c.g. Thus, there are two alternative ways of adjusting the airspeed, and the relative merits are a point of controversy. The interdependence of speed, weight, glide angle, and state of trim, etc., is often only too obvious, especially when one wants to penetrate a headwind without the model sinking like a lift, but the answers are not to be found from casual, and often misleading observations. It's a case for "paper-work," not everyone's cup of tea, and for that reason the area in which I can usefully contribute something.

Sorting it out

Using nothing more complicated than the basic aerodynamics dealt with in the previous article, it is possible to derive a relationship between the state of trim, speed, and Lift/Drag ratio of a given model, the last item being a measure of the glide angle. The relation between speed and total weight, at a fixed trim, is a simple one. By taking a well-known model as a specimen, I've produced some comparative figures for the effect of the two alternatives, ballasting or retrimming, on the glide angle and sinking speed, over a wide range of forward speeds. From these particular results, I've drawn some general conclusions, applicable to the two modes of flying.

Also, because the same analysis can readily be extended to cover it, I've looked separately at the effect of modifying the design to a higher aspect ratio. This shows not only that the percentage benefit can be calculated, but that the value of such an "improvement" is very dependent on the type of flying undertaken.

Victimisation?

The chosen specimen model is Dave Hughes's *Soarcerer*, and it may appear from some of my deductions that a criticism of its versatility is implied. This is in fact a compliment, because the *Soarcerer* is specifically intended to be an aerobatic slope soarer and, as will become apparent, the nature of this activity emphasises different qualities in a model. In its intended rôle, its universal popularity is a measure of the designer's success in achieving a good balance of many conflicting requirements. Its performance as a *thermal soarer* may be shown to be inferior to that of a model designed specifically for that purpose, but of course it was never intended for that type of flying. By examining it in this rôle, however, the reasons for, and merits of the different design approaches used for the two classes of model become more clear. The *Soarcerer* has a moderate wing loading, so it makes a good starting point for examining the effect of added ballast; also, the aspect ratio is quite low, so the effect of a change to a more sailplane-like A.R. should be significant.

The *Soarcerer* statistics are: Span 52in., Chord 7·5in., Wing area 386sq.in. (2·68sq.ft.), and Aspect ratio 7·0. At a typical weight of 26·8oz., or 1·675lb., the wing loading is 10oz./sq.ft.

At this stage, we can now launch into the incomprehensible.

The Lift/Drag characteristics

The notation, and the relation between Lift, Drag, Weight, etc., in steady flight, has already been set out in the earlier "Downhill" chapter. To attempt to predict the performance of any model "from scratch" would be totally unrealistic, because the conventional approach needs reliable, wind-tunnel measured data, on the lift and drag characteristics of the various components of the aeroplane, which we do not have. Full-scale data is just not relevant, because at the lower speeds and chords of our models there is a serious deterioration of lifting ability and an unavoidable rise in drag coefficient. However, part of the total drag is due to the generation of lift, and this "Induced Drag" is calculable quite accurately *without* reference to measured data. So, if we know the *real* Lift/Drag ratio of our model at just one speed (as distinct from the grossly optimistic value which an estimate from full-scale data would give), then we can calculate the *changes* of Induced Drag which would occur if the model were retrimmed to fly at other speeds, and thus derive the L/D ratio versus speed relationship.

As explained earlier, the trimmed state of a model is regulated by the incidence difference between wing and tailplane, and is thus susceptible to elevator movements. This defines the incidence at which it settles in steady flight, and the lift coefficient at which the wing operates. Since the Lift equals the Weight, the speed adjusts itself to suit the trimmed Lift Coefficient in accordance with the relation:- Lift $= C_L \times \frac{1}{2}\rho v^2 \times S =$ Weight.

Thus, a low C_L implies low incidence and high speed, and vice versa. The method of getting at what we want, then, is to relate the Drag Coefficient to the Lift Coefficient, and translate the latter into the corresponding airspeed.

Ideally, we should start from a measured value of the Lift/Drag ratio of the *Soarcerer* at a typical flying speed; as I don't have this information, all I can do is to make a fair guess at it. This is not too important for the main purpose of this article, which is to make comparisons rather than accurate predictions. A reasonable guess at the L/D value would be about 12, occurring at an incidence near, but not at, the stall, where the C_L value is 0·75. The corresponding speed comes from the equation relating C_L and wing loading "w," the latter being 0·625lb./sq.ft. in this case.

$$v = 29\sqrt{\frac{w}{C_L}} = 29\sqrt{\frac{0{\cdot}625}{0{\cdot}75}} = 26.4\text{ft./sec. (18 m.p.h.)}$$

Since $C_L = 0{\cdot}75$ and $L/D = C_L/C_D = 12$, then Total $C_D = \frac{0{\cdot}75}{12} = 0.0625$

But Total $C_D = C_{DP} + (C_L^2/3{\cdot}14A) =$ Profile Drag + Induced Drag, where A is the wing Aspect Ratio.

The Induced Drag coefficient for *Soarcerer*, at $A = 7$, is thus 0·0256. Hence $C_{D_P} = 0{\cdot}0625 - 0.0256 = 0{\cdot}0369$.

We now have the means of calculating the total drag for any chosen value of C_L, using the above derived value of the Profile Drag coefficient of 0·0369, and adding to it an Induced

Drag coefficient of $C_L^2/3.14A$. Then, at each chosen C_L, the value of C_L/C_D follows, and the final step is to calculate speed from $v = \frac{22.9}{\sqrt{C_L}}$

The sinking speed $v_s = v \div C_L/C_D$

A set of calculations is tabulated below:—

C_L	C_{Di}	C_{D_P}	C_D	C_L/C_D	$\sqrt{C_L}$	v	v_s
0.90	0.0369	0.0369	0.0738	12.22	0.949	24.1	1.97
0.75	0.0256	0.0369	0.0625	12.00	0.866	26.4	2.20
0.50	0.0114	0.0369	0.0483	10.35	0.707	32.4	3.13
0.375	0.0064	0.0369	0.0433	8.66	0.612	37.4	4.32
0.1875	0.0016	0.0369	0.0385	4.87	0.433	52.9	10.85

These are illustrated as L/D v. C_L in Fig. 146, v against C_L in Fig. 147 and v_s against C_L in Fig. 148. At this stage, the most obvious thing to emerge is the rapid deterioration of L/D as C_L is reduced, this implying a steepening of the glide angle as speed is increased. The other feature is that the best obtainable glide angle, at maximum L/D, would occur at a C_L of 0·9, *if* it were possible to reach this incidence without flow breakdown. It is unlikely that the *Soarcerer* section could achieve much above $C_L = 0{\cdot}75$, however, so the 2% improvement indicated is not realisable in practice. Discussion of the relation between L/D, v_s, and speed, as obtained by these trim changes, will be made later, after examining the effect of ballast.

The weight-speed relation

This is a very simple matter, requiring no assumptions or guesses. If the only change made to the model is the weight, with no change of c.g. position, or wing and tail settings, then the trimmed C_L remains the same, and the speed increase will be proportional to the square root of the weight increase, in accordance with the equation $v = 29\sqrt{\frac{W}{S\ C_L}}$

Thus $\frac{v_2}{v_1} = \sqrt{\frac{W_2}{W_1}}$

This is illustrated in Fig. 149, as a general curve applying to any model. The particular version of this, applying only to our *Soarcerer*, is shown as Fig. 150, based on a speed of 18 m.p.h. at a weight of 26·8oz. The striking thing about it is the large amount of ballast needed to produce a worthwhile increase in speed; in simple terms, doubling the weight (of any model) only increases its speed by 41%. What is not revealed by these results, however, is that these speed increases have been obtained *without* any deterioration of the glide angle; the C_L was not altered, so the C_L/C_D ratio still remains at the value of 12. The sinking speed is always one-twelfth of the forward speed, for the "fixed trim, ballast at the c.g." case.

Fig. 146

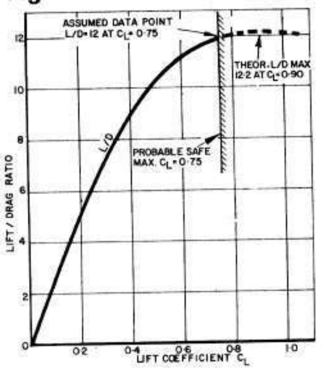


Fig. 147

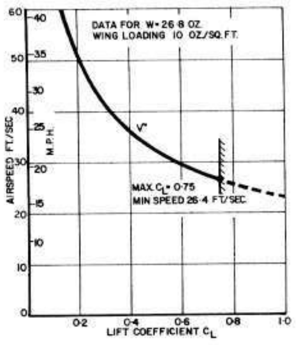
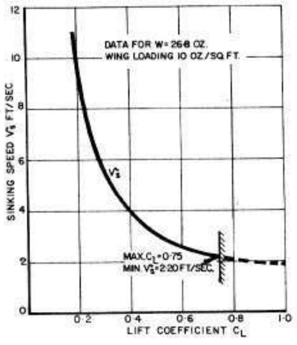


Fig. 148



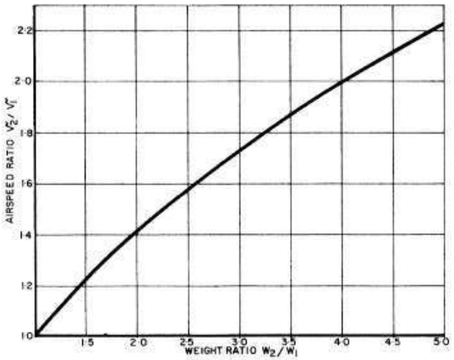


Fig. 149

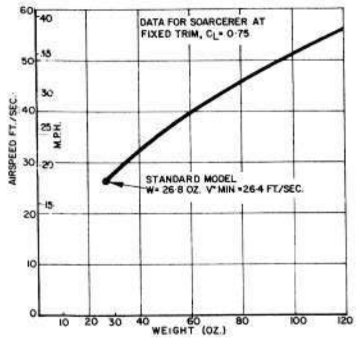


Fig. 150

Ballast or trim?

We can now compare the performance of *Soarcerer* over a range of speeds obtained by the alternative methods of retrimming and ballasting. In Fig. 151, the L/D ratio which results from retrimming with down-elevator is shown plotted against the corresponding forward speed; for comparison, the constant L/D of 12, which would be retained if the speed were raised by ballasting only, is also shown. Likewise, the sinking speeds for the two cases are shown in Fig. 152. The most strikingly obvious feature is that for the speed range shown, the advantage of using ballast, as compared with the effect of trimming for high speed, rises

Fig. 151

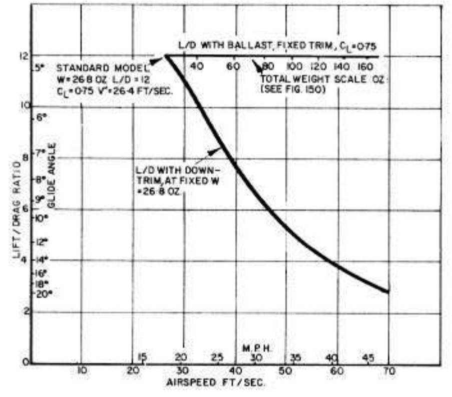
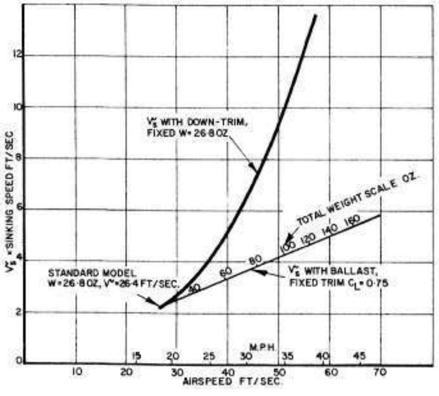


Fig. 152



so rapidly that there is a factor of *three* between either the glide angles or the sinking speeds obtained by the two methods, at 40 m.p.h.

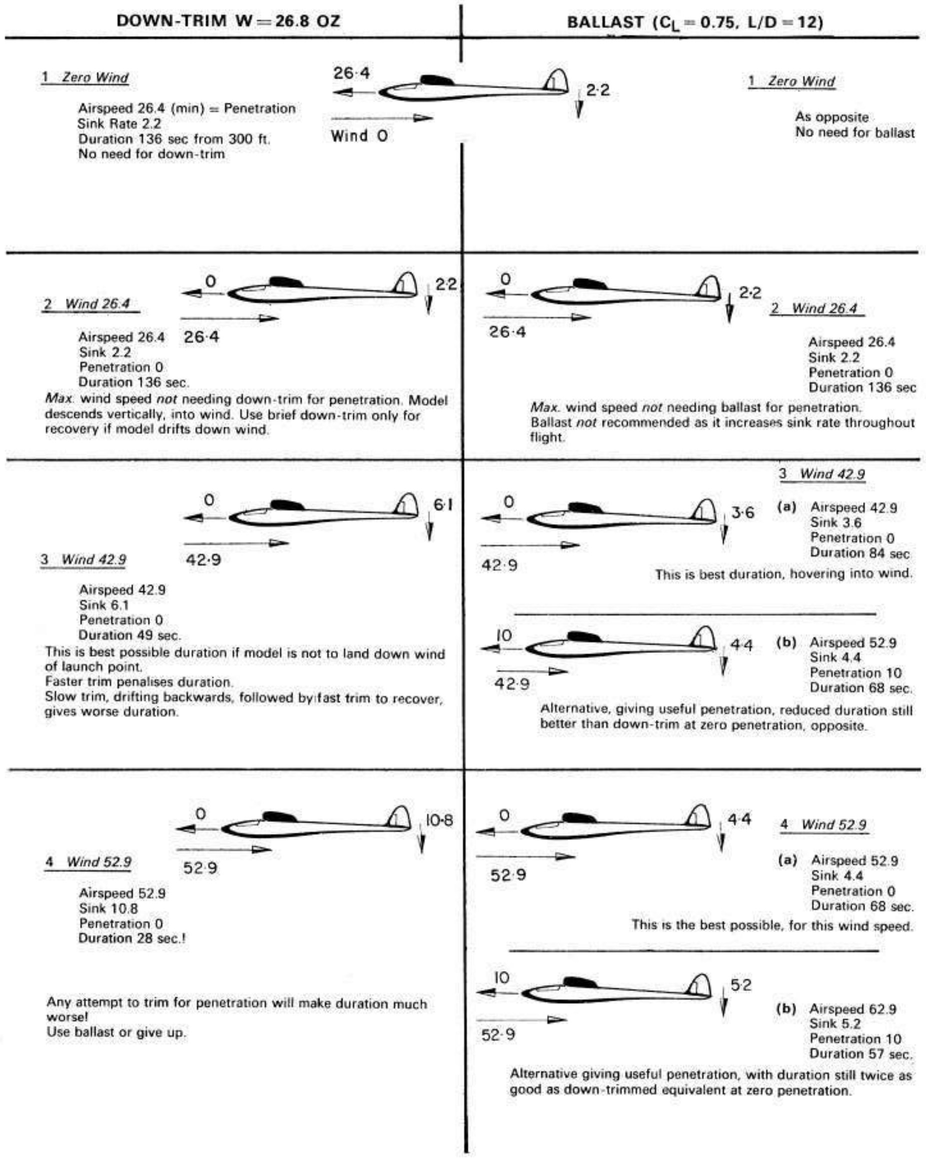
(a) *Slope Soaring.* There are too many variables to permit a concise but adequate appraisal of the situation; for each hill slope there is a different envelope of wind speed—model speed—model trim combinations within which successful operation is possible. All increases of airspeed are accompanied by an increase in sinking speed, an effect which is unavoidably worse when down trim is used rather than ballast. "Penetration" may be defined as the ability to make headway upwind, *i.e.* airspeed exceeds wind speed, and we note also that climb occurs when the model sinking speed (relative to the air) is less than the upward component of the wind speed. Then the ideal situation is when the model penetrates and climbs; it is also OK when it climbs at zero penetration, because temporary down trim may then be used to build up speed when you can afford to lose height. But if zero climb occurs when the model is trimmed to L/D max., this is a threshold condition, whether there is penetration or not, because the model sink rate cannot be reduced further to get a climb.

As an example, I've considered a 1 in 7 wind gradient and various wind speeds, and compared the extreme cases where the model speed is obtained *wholly* by trim or ballast; in practice, a bit of both would be better for various reasons. In Fig. 153, both versions start equal at a threshold wind speed which just permits height to be held. As the wind speed rises, we find that the ballasted model can rise faster for the same penetration, or penetrate faster at zero climb. The limit comes for the trimmed model at 42.9ft./sec., where the glide angle has deteriorated to 1 in 7, it cannot penetrate without losing height, and to climb it must retreat. The ballasted version can climb at 2·6ft./sec. at zero penetration, or penetrate at 30·3ft./sec. at zero climb, so it's quite happy. From this point on, the trimmed model cannot cope, as to penetrate faster winds or even "hold its own" it can only sink: no such upper limit applies to the ballasted model, which has an even bigger range of climb or penetration and can take full advantage of the higher wind component.

The figures used are solely for this model, on this particular slope. The implications are quite general, however, in the sense that the model which is speeded up by trimming alone must inevitably glide more steeply, and cannot be flown into winds which exceed the flying speed at which the glide angle becomes as steep as the wind inclination. For a steep hill, the problems are few; for a shallow hill, the operational band of the retrimmed model gets narrower, but the ballasted version flourishes on high winds.

(b) *Thermal soaring.* The best wind is none at all, as the model may then be flown in the trim for least sinking speed, at the least weight. There's always *some* wind, and if this is as great as the airspeed, then straying downwind poses a need for penetration, to get the model back to the launch point. Unless there is a good chance of thermals elsewhere, it may be best to hover the model into wind, when you can still get the still-air duration. Brief periods at a faster airspeed carry some penalty in sinking speed, so the allowable distance downwind is not much. Ballasting the model to ensure penetration imposes a penalty in sinking speed which acts throughout the flight, so it seems better to leave it to trimming (and judgement!). For windspeed well *in excess of* the normal airspeed, the result is different. Retaining the normal trim, the model will retreat rapidly, and will very soon have to be trimmed to a much higher speed to get back; this introduces a very high rate of descent. It is still best to hover the model, though the efficiency soon drops as the excess of wind speed over normal airspeed rises. Examples shown in Fig. 154. Ballasting the model now becomes increasingly effective, because if it is necessary to *double* the airspeed in order not to drift backwards, the rate of descent is only twice that of the normal model, whereas it would be almost *five* times as bad if the airspeed had been doubled by retrimming. As before, the actual figures are for this model, but the nature of the result is of universal application, as the deterioration of L/D with increase of speed is inevitable for all models, whatever the aerofoil.

To sum up, there is an advantage in ballasting for wind speeds above a certain level in relation to the normal flying speed of the model considered. For particularly strong winds, in the case of slope soarers over hills lacking steepness, it becomes essential to ballast in order



1 *Zero Wind*

Airspeed 26.4 (min) = Penetration
Sink Rate 2.2
Duration 136 sec from 300 ft.
No need for down-trim

1 *Zero Wind*

As opposite
No need for ballast

2 *Wind 26.4*

Airspeed 26.4
Sink 2.2
Penetration 0
Duration 136 sec.

Max. wind speed *not* needing down-trim for penetration. Model descends vertically, into wind. Use brief down-trim only for recovery if model drifts down wind.

2 *Wind 26.4*

Airspeed 26.4
Sink 2.2
Penetration 0
Duration 136 sec

Max. wind speed *not* needing ballast for penetration. Ballast *not* recommended as it increases sink rate throughout flight.

3 *Wind 42.9*

Airspeed 42.9
Sink 6.1
Penetration 0
Duration 49 sec.

This is best possible duration if model is not to land down wind of launch point.
Faster trim penalises duration.
Slow trim, drifting backwards, followed by fast trim to recover, gives worse duration.

3 *Wind 42.9*

(a) Airspeed 42.9
Sink 3.6
Penetration 0
Duration 84 sec

This is best duration, hovering into wind.

(b) Airspeed 52.9
Sink 4.4
Penetration 10
Duration 68 sec.

Alternative, giving useful penetration, reduced duration still better than down-trim at zero penetration, opposite.

4 *Wind 52.9*

Airspeed 52.9
Sink 10.8
Penetration 0
Duration 28 sec.!

Any attempt to trim for penetration will make duration much worse!
Use ballast or give up.

4 *Wind 52.9*

(a) Airspeed 52.9
Sink 4.4
Penetration 0
Duration 68 sec.

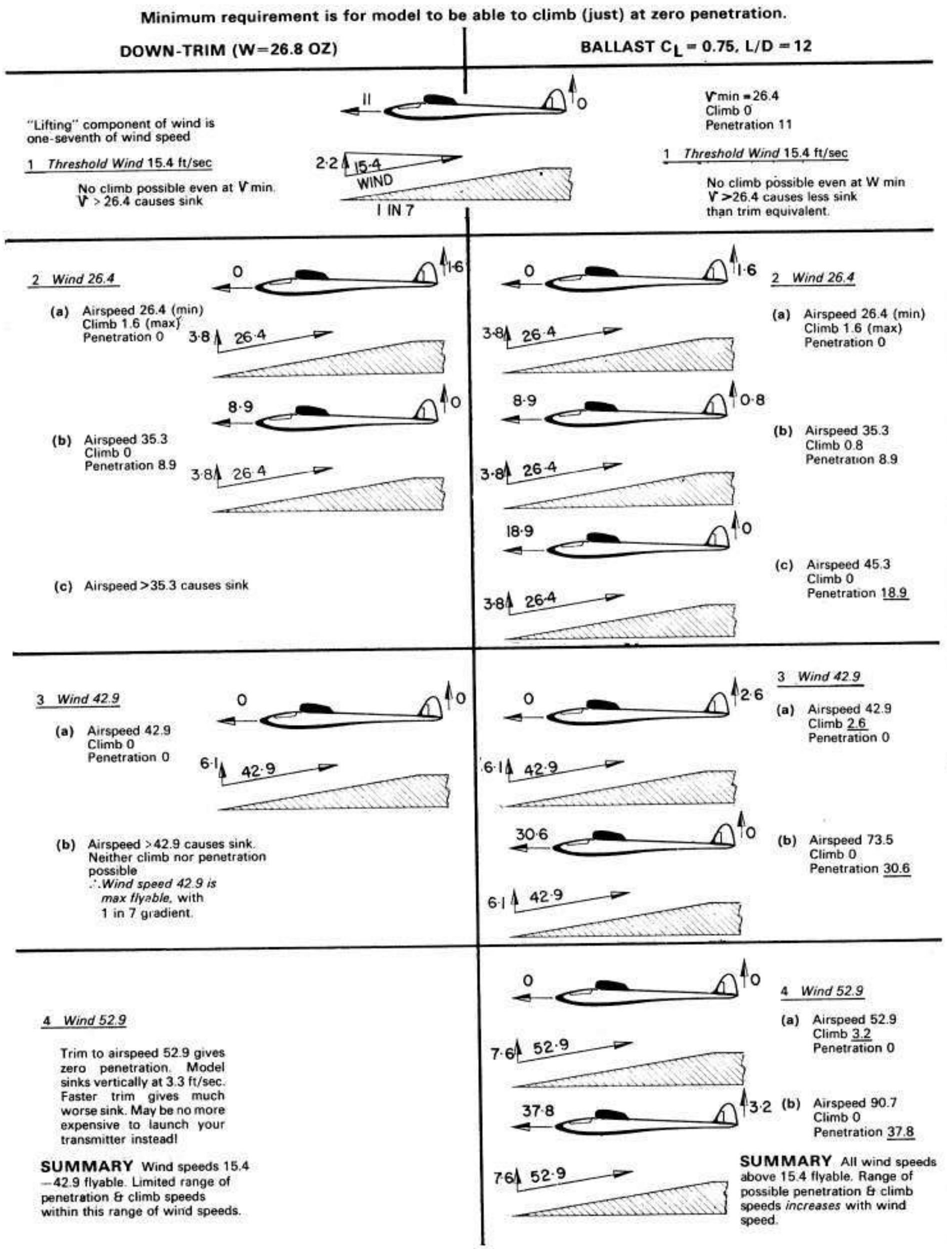
This is the best possible, for this wind speed.

(b) Airspeed 62.9
Sink 5.2
Penetration 10
Duration 57 sec.

Alternative giving useful penetration, with duration still twice as good as down-trimmed equivalent at zero penetration.

SUMMARY Trim for min. speed, max. L/D. For wind speeds *up to* flying speed, use no ballast, only brief trim when required. For *higher* wind speeds, *ballast is better than down-trim*, but never fly in a down-wind direction.

Fig. 153 SOARCERER AS A TOWLINE GLIDER. BALLAST v TRIM AT VARIOUS WIND SPEEDS.



SUMMARISED SUMMARIES:— BALLAST IS BEST

Fig. 154 SOARCERER PERFORMANCE ON 1 IN 7 SLOPE. BALLAST v TRIM AT VARIOUS WIND SPEEDS

to fly. For thermal soarers, in winds exceeding normal flying speed, ballasting greatly aids duration and recovery.

More efficiency?

A more efficient model is one with less drag, or to be more exact, a better Lift/Drag ratio. The above considerations have been of the *effectiveness* with which it is flown, with regard to external considerations such as wind gradient, etc. The inherent qualities of the model clearly influenced the numerical answers we got, and it's reasonable to look into the pros and cons of using that conspicuous feature of the "classical" sailplane, the high aspect ratio wing.

Taking the sample, *Soarcerer*, and revising the wing to 65in. span and 6in. chord, gives the same area of 386sq.in., but an aspect ratio of 10·94, say 11. The same calculation process follows, substituting A = 11 where it was previously A = 7 when calculating the Induced Drag: no other changes are necessary, and it is assumed that such a modification can be made without adding weight. Some results are tabulated below:—

C_L	C_{Di}	C_{D_P}	C_D	C_L/C_D	C_L	v	v_s
1.00	0.0291	0.0369	0.0660	15.15	1.00	22.9	1.51
0.75	0.0164	0.0369	0.0533	14.07	0.866	26.4	1.88
0.375	0.0041	0.0369	0.0410	9.14	0.612	37.4	4.09
0.1875	0.0010	0.0369	0.0379	4.95	0.433	52.9	10.66

The effect of the higher A.R. on the aerodynamic qualities is shown in Figs. 155 and 156, and the new relation between L/D and speed, and between sinking speed and airspeed, appear in Figs. 157 and 158. The increased efficiency of the aeroplane occurs not as a result of any change in lifting ability, but as a result of drag reduction at a given lift. In Fig. 155 it is clear that at the same "max. usable" $C_L = 0.75$ as the original wing, the version of A.R. = 11 has a net model L/D of 14·1, which represents a 17% improvement. At half this C_L, the improvement is only 5·5%, and at quarter C_L it is only 1·6%. The second feature is that the L/D curve is still rising at $C_L = 0{\cdot}75$, and *if* it were possible to persuade the wing to keep working to a higher incidence, giving $C_L = 1{\cdot}13$ then we could realise a L/D of 15·3, which is then a 27% improvement over the original wing best L/D of 12. The same percentage improvements apply to sinking speed at the same C_L's, but *if* we could attain $C_L = 1{\cdot}13$, then

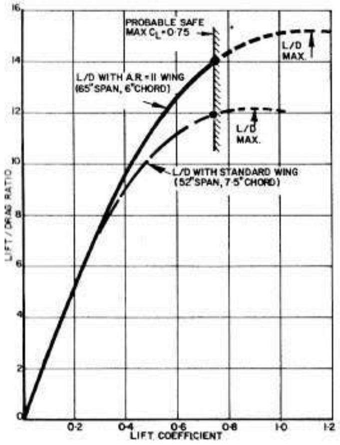
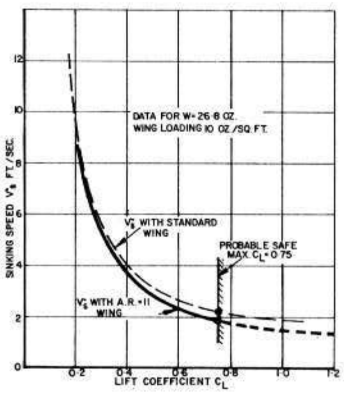


Fig. 155

Fig. 156



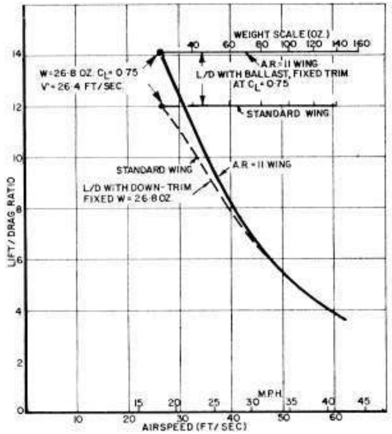


Fig. 157

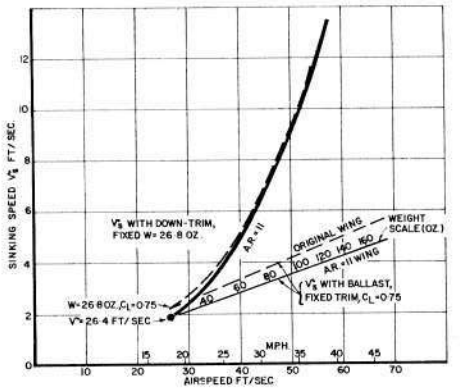


Fig. 158

the additional benefit of reduced forward speed would augment the effect of increased L/D to give a sinking speed of 1·42ft./sec., which represents a 55% improvement in still-air duration! This is out of reach with the existing aerofoil, but it gives an idea of the *potential* benefit.

From the graphs relating L/D and sinking speed to the model flying speed, it is apparent that the benefits are worth having at low speed, but the percentage benefit of high aspect ratio becomes negligible when the model is trimmed to higher speeds.

Soarcerer on the slope

In its intended rôle of aerobatic intermediate slope soarer, the *Soarcerer* has many virtues; the modest a.r. ensures a low roll inertia and thus enhances the speed and accuracy of response. At the chosen A.R. the sums show that there would be no advantage in L/D from using an aerofoil capable of a higher C_L, and in fact such an aerofoil would be inferior to the one used, in its ability to operate inverted. An increase in A.R. would barely improve the ability to penetrate strong winds by use of down trim, and would be detrimental to the handling qualities, so it seems that when there's a good "blow" to permit aerobatics, there's no merit in increasing the A.R. When there's not much slope or wind, and the problem is one of staying airborne, then a higher A.R. might make the vital difference. The advantage of using ballast rather than down trim for penetration increases rapidly with the wind speed for the standard model. The L/D when *trimmed* for high speed is hardly improved by use of a high A.R. wing, but the L/D ballasted may be 17% better than the standard model, so the advantage of ballast over trim is even greater. For fast flying aerobatic models, it is generally better to concentrate on the top end of the speed range, and reduction of *profile* drag is profitable. For example, a "slenderised" *Soarcerer* would have only 13% better L/D at low speed if the profile drag were reduced by 20%, but at high speed, where the retrimming causes a severe drop in L/D, there is a 24% improvement of this inherently poor L/D, which helps to reduce the "sink like a brick" effect.

The quantities of ballast needed in our examples are alarming; in practice it would be better to use both ballast and down trim, if only for the fact that speed obtained by ballast alone cannot be "turned off," and a model weighted to fly into a gale would move downwind like a rocket. The other problems are in finding room for ballast around the c.g., and ensuring that the model is strong enough to carry the dead weight. All this is not to imply that the standard *Soarcerer needs* a lot of alterations in normal circumstances; on the contrary, it is a versatile performer in a wide range of conditions, and using it as a "guinea pig" in this study serves to indicate the relative merits of different ways of extending the ability of

this, or any model, to cope with wind and slope conditions ranging from "too much" to "not enough."

Soarcerer as a thermal flier

Add a tow-hook, and your *Soarcerer* will serve you well enough as an introduction to the launching and flying techniques of tow-line gliding. You'll have fun, but if you match it in calm conditions against a specialised design, you'll wonder what's wrong. Nothing's wrong; you're asking it to do something for which it wasn't designed, and the features which make it so good at its intended purpose are not conducive to a high, still-air duration. This is a universal rule, not just a criticism of a particular design. I'll set out the lines of thought in an imaginary "let's make it better" exercise, and you'll see that most of the modifications which would make it a better thermal soarer would detract from its capabilities as an aerobatic slope soarer.

The first change to think of is an increase of aspect ratio, because in this class of flying, a model is flown at the highest C_L possible, *i.e.* at minimum speed, on the verge of stalling; the improvement to L/D is greatest under this condition. A change to A = 11 would then give about 17% improvement to L/D and thus to duration, say about half a minute added to a three-minute flight. This assumes a 65in. span, 6in. chord wing of the same section, flying at the same C_L. The next change could be to a more highly cambered aerofoil section, capable of reaching a higher C_L before stalling. For the standard *Soarcerer*, there is no significant improvement of L/D at C_L values above the normal 0·75, so the only advantage in getting a higher C would be in the reduced forward speed at the same angle of descent. However, the full benefits of *increased A.R.* may be realised if one can persuade the wing to "hang on" to a higher C_L; from Fig. 155 it appears that if C_L= 1.13 can be reached, then the increase of A.R. to 11 which gave 17% improvement of L/D with the standard aerofoil C_L of 0·75, will give 27% better L/D if the more cambered section is used. The forward speed *and* glide angle have been reduced by this joint change of section and A.R., with a net benefit to duration of 55%, adding over 1½ mins to what would have been a three-minute flight. While you're changing the aerofoil, you could go for something thinner, reducing the profile drag, a technique long favoured by the free-flight exponents. Incidentally, an A.R. of 11 would be considered low by A/2 standards* where 13 to 16 is normal practice, and some leading exponents have used even higher figures, though strength and weight problems then become disproportionately high for the small benefits to duration.

Thus, an alternative wing for thermal flying would bring marked benefits, using the same area but a higher aspect ratio, and a more cambered and possibly thinner aerofoil. The final stage in this line of reasoning is:— why not make the above changes but increase the area? This will reduce the wing loading and lower the flying speed still further, and because the parasitic drag of fuselage and tail is "spread" over a larger wing area, the resultant L/D of the whole aeroplane will be better. If the original chord of 7·5ins were retained, and the span extended to about 82ins., the A.R. would be 11, but the area would be more than 50% greater. After allowing for the extra wing weight, the benefit in terms of reduced wing loading would still be large. A performance at least twice as good as the standard *Soarcerer* should be obtainable. This last suggestion is not practical as it stands; you've gone too far, and the result is a lot too much wing for a properly proportioned model. So you stretch the fuselage by a foot or so, then the light dawns. You've arrived at Dave Hughes's *other* design, the *Ascender*! That's the one that *was* designed for thermal flying, and it's just as good at that, as the *Soarcerer* is at gyrating over the windy slopes. If you'd *started* with an *Ascender* and subsequently wanted to go chucking models off hills, then you'd probably end up reversing the process described, sawing off lengths of wing and so on. The *Ascender* would make a good reserve model for the near-windless conditions which ground the normal breed; its aerobatic abilities would be poor, but at least you could enjoy some relaxing flying.

A point to bear in mind, concerning a specially designed thermal flier, is that in stiff

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* The A/2 is an international specification for free-flight gliders, first introduced over 20 years ago. Models in this class are now highly refined and developed.

breezes the advantage of slow flying speed can easily be thrown away if one has to use excessive downtrim to penetrate, because the glide angle then goes to pot. Use ballast for most of the extra speed that the conditions demand.

In conclusion. No need to go through all that again! The conditions under which various features of a design become important have been discussed, and the essential difference between the two methods of influencing flying speed has been illustrated. When all's said and done, there comes a time when you chuck the slide rule away, and go flying. The figures are only to show what to expect and why, and what to do about it. The remaining 90%, *i.e.* how to be a good designer/flier, is *your* problem.

CHAPTER 21

AEROFOIL SECTIONS

WHETHER or not you chose to follow the arguments of my previous chapters, we can agree on one thing: wings are indispensable. Those of us who have made the "not more than once per model" practical test of this proposition are generally keen *not* to seek further proof. As we've observed earlier, the Lift = Weight relationship is what distinguishes flight from a ballistic trajectory, and wings are by far the most *effective* way of providing lift. Also, whilst anything that looks remotely like a wing will work, even an unshaped plank, it makes sense to give some thought to the *efficiency* with which this lift is generated.

The voice of experience

Ask any seasoned modeller what an aerofoil section is for, and he'll tell you "To fill the gap between the leading and trailing edges," or alternatively "To keep the top and bottom of the wing from touching." Concise and true. The only embellishment I would add is that the wing needs thickness in order to have strength, and it is customary to streamline the cross-section, if only to reduce the drag. All that remains to be said is that it is known that variations of the thickness and shape of the streamlined section, between something resembling a pear drop and something more like a banana, influence both lift and drag. If you suspect that this is oversimplifying things, I'll give you a reference to a 700-page book* which will make you sorry you asked.

How it works.

It is not enough to provide wings; they must be persuaded to operate at an incidence to the airflow in order to generate lift. The symmetrical, zero-rigged example of Figs. 144 (a) and (b) in Chapter 19 cannot generate lift, and the wings serve no useful purpose until the tail setting is changed to hold them at incidence. All wings, regardless of the aerofoil section used, generate lift by deflection of the airflow. In steady flight, the lift force is an upward reaction on the wing due to imparting a downward momentum to the air molecules. You can't have lift without some inclination of the zero-lift datum to the airflow, and the generation of lift always produces a "downwash" in the airstream as it leaves the trailing edge. There's more to it than the simple momentum analogy, however, otherwise we might all be using flat plates. The total lift from a typical streamlined section may be evaluated from a measurement of its pressure distribution, when it is found that most of its lift comes from suction on the upper surface, and of this, most is concentrated over the forward part of the chord, say from the L.E. back to about one-third. The term "suction" means only a small reduction in pressure from the surrounding atmosphere, not a vacuum. For a wing carrying one pound per square foot loading, the *average* pressure drop must be of this order, whereas normal atmospheric pressure is 2116lb./sq.ft. So it is only an insignificant change in the static pressure of the airstream, but a vital one.

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* *Theory of Wing Sections* by Abbott and von Doenhoff; 700 pages, of which 400 are aerofoil ordinates and characteristics, and there are 160 references to further reading. It's a paperback by Dover Publications, great value for money if only one could understand it.

breezes the advantage of slow flying speed can easily be thrown away if one has to use excessive downtrim to penetrate, because the glide angle then goes to pot. Use ballast for most of the extra speed that the conditions demand.

In conclusion. No need to go through all that again! The conditions under which various features of a design become important have been discussed, and the essential difference between the two methods of influencing flying speed has been illustrated. When all's said and done, there comes a time when you chuck the slide rule away, and go flying. The figures are only to show what to expect and why, and what to do about it. The remaining 90%, *i.e.* how to be a good designer/flier, is *your* problem.

CHAPTER 21

AEROFOIL SECTIONS

WHETHER or not you chose to follow the arguments of my previous chapters, we can agree on one thing: wings are indispensable. Those of us who have made the "not more than once per model" practical test of this proposition are generally keen *not* to seek further proof. As we've observed earlier, the Lift = Weight relationship is what distinguishes flight from a ballistic trajectory, and wings are by far the most *effective* way of providing lift. Also, whilst anything that looks remotely like a wing will work, even an unshaped plank, it makes sense to give some thought to the *efficiency* with which this lift is generated.

The voice of experience

Ask any seasoned modeller what an aerofoil section is for, and he'll tell you "To fill the gap between the leading and trailing edges," or alternatively "To keep the top and bottom of the wing from touching." Concise and true. The only embellishment I would add is that the wing needs thickness in order to have strength, and it is customary to streamline the cross-section, if only to reduce the drag. All that remains to be said is that it is known that variations of the thickness and shape of the streamlined section, between something resembling a pear drop and something more like a banana, influence both lift and drag. If you suspect that this is oversimplifying things, I'll give you a reference to a 700-page book * which will make you sorry you asked.

How it works.

It is not enough to provide wings; they must be persuaded to operate at an incidence to the airflow in order to generate lift. The symmetrical, zero-rigged example of Figs. 144 (a) and (b) in Chapter 19 cannot generate lift, and the wings serve no useful purpose until the tail setting is changed to hold them at incidence. All wings, regardless of the aerofoil section used, generate lift by deflection of the airflow. In steady flight, the lift force is an upward reaction on the wing due to imparting a downward momentum to the air molecules. You can't have lift without some inclination of the zero-lift datum to the airflow, and the generation of lift always produces a "downwash" in the airstream as it leaves the trailing edge. There's more to it than the simple momentum analogy, however, otherwise we might all be using flat plates. The total lift from a typical streamlined section may be evaluated from a measurement of its pressure distribution, when it is found that most of its lift comes from suction on the upper surface, and of this, most is concentrated over the forward part of the chord, say from the L.E. back to about one-third. The term "suction" means only a small reduction in pressure from the surrounding atmosphere, not a vacuum. For a wing carrying one pound per square foot loading, the *average* pressure drop must be of this order, whereas normal atmospheric pressure is 2116lb./sq.ft. So it is only an insignificant change in the static pressure of the airstream, but a vital one.

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* *Theory of Wing Sections* by Abbott and von Doenhoff; 700 pages, of which 400 are aerofoil ordinates and characteristics, and there are 160 references to further reading. It's a paperback by Dover Publications, great value for money if only one could understand it.

Fred's frustrated

The most important aspects of performance may be studied in terms of the characteristics C_L and C_D for the whole aeroplane. It should be possible at the design stage to define the required aerofoil characteristics, and by studying the C_L and C_D figures of a range of sections, make our choice "scientifically." It should be, but it's not possible, because the data don't exist. I would be happy to launch off into reams of technical stuff, explaining how to interpret and apply aerofoil characteristics, but without reliable measured data this would be no more use than swimming lessons in the Sahara. So you're spared the clever stuff, as we're all in the same boat, except that I regret it more because I've got a headful of equations, with no prospect of ever using them.

Scale effect

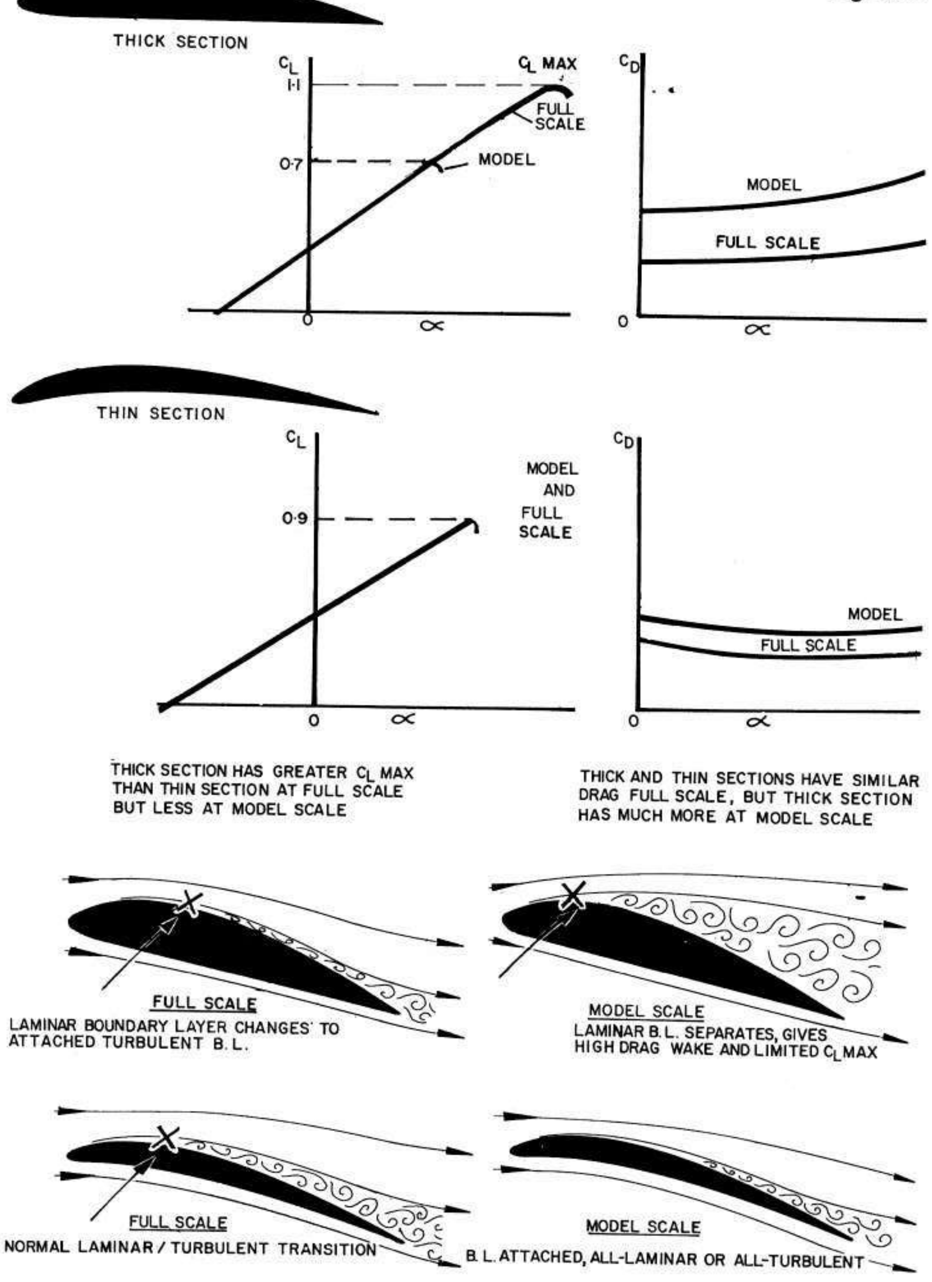
The equations such as $L = C_L \frac{1}{2}\rho v^2 S$ are convenient approximations. In full scale practice, they are valid for the range of flight speeds of which a plane is capable. If we make a model of that plane, however, it may be one-eighth scale, operating at half the speed, and this will cause a change in the coefficient values. The *equation* may still be valid for the range of speeds of which the *model* is capable, but we may well be operating in a region of low energy flow which gives markedly different values to C_L and C_D. A factor of *two or three* on drag coefficient is quite possible, for example, and the maximum lift coefficient may be seriously reduced. Model glider performance calculations based on full scale data are misleading rubbish. The criterion which determines where a wing is operating on the "aerodynamic scale" is Reynolds Number. This is essentially the product of airspeed and chord, VL, together with an allowance for viscosity and density which need not concern us. The sea level value is 6400 VL, where V is in ft./sec. and L is in ft. For R above about 0.2 million, the characteristics are "supercritical," and only change *very* slowly with further increases of R. Below this figure is where we operate, and there is a broad band of totally unpredictable behaviour between about 80,000 and 160,000 (VL between 12 and 25) where the behaviour may remain supercritical, may be subcritical, or may alternate between the two according to incidence and speed for a given model. There is very little evidence on the subject, and there are very few test facilities in the world capable of providing it.

The air adjacent to the aerofoil surface is stationary, a litle further out it has some velocity, and so on, till at some small distance from the surface it has the free stream speed. This envelope of slower-moving air is the Boundary Layer. Over the front portion of an aerofoil, it is normally "Laminar," a smoothly sliding layer with a minimum of associated drag. Somewhere along the top surface, it normally undergoes a transition to "Turbulent" flow on a full scale wing, a self explanatory term which implies a higher local drag from these regions. The energy level is too low on many model wings for this to occur; the boundary layer air can't make headway against the rising pressure (less suction) as it goes aft, and the result is *separation* of the airflow. This is the essential feature of subcritical flow—separation instead of transition (Fig. 159).

You can't possibly use Reynolds Number to factor full-scale data; the change from supercritical to subcritical may occur anywhere in the range mentioned, and it is discontinuous, not progressive. It is possible for one aerofoil which is inferior to another, full-scale, to retain its characteristics down to a low speed × small chord value at which the "better" section has undergone separation and become much inferior for model use. The many years of free-flight model development have demonstrated that the thin, slender-nosed sections work well down to low R, and the thick, bluff-nosed sections, especially the biconvex ones, are very poor. With our faster and larger R/C models, we seem to be in an intermediate region where the distinctions are less obvious, and in any case the emphasis is not always on maximum efficiency and minimum flying speed.

It's clearly not worth reproducing full-scale data for a range of sections, because the comparisons will be affected by the low R of our applications. Experience shows that many of the *qualitative* characteristics are similar under model conditions, however, and it is possible to indicate the *type* of lift-drag-incidence relationship to be expected from the principal types of aerofoil, without giving numerical values. If you want order-of-merit data

Fig. 159



on sections of a given type, you'll have to conduct careful flight tests in which the *only* variable is the aerofoil. The results will only be valid for the chord and speed at which you test, so unless the job is done comprehensively, it won't resolve the conflict of opinions and experiences which prevails at present. Plenty of scope for a collective effort, or on a smaller scale for the individual to develop a particular model by experiment.

Think about it

We're all looking for that aerofoil with unlimited lifting ability and no drag. Meanwhile, back at the drawing board, we may as well make the best of our lot—sub-critical or otherwise—and decide first *which* particular aspects of performance are of most importance to us for our proposed new design. It is possible to make a *good* all-rounder, but *excellence* has to be paid for by sacrificing one quality to gain another. The choice of the right *type* of aerofoil is important, but the full benefit will not be achieved unless the geometry, loading, and trim of the plane are also right for the type of flying we are attempting. The mechanics of gliding flight have been covered already, but to reiterate briefly:

airspeed is $v = 29\sqrt{\frac{\text{Wing loading}}{\text{Lift Coefft}}}$, Glide angle is $\tan\delta = \frac{\text{Drag Coefft}}{\text{Lift Coefft}}$, and sinking speed is $V_s = v \sin\delta \div v\, C_D/C_L$.

For the thermal flying class of model, we need minimum sinking speed. This suggests minimum forward speed in conjunction with maximum Lift/Drag ratio, so a light wing loading is called for. The aerofoil should be one capable of achieving a high lift coefficient without stalling, and its profile drag should be low *at high C_L*. The wing aspect ratio should be high to reduce the induced drag associated with operation at high C_L; a "high lift" aerofoil on a low aspect ratio wing may only reduce forward speed at the expense of a steeper glide angle.

For a fast-flying slope soarer, as we've seen, the most efficient way of achieving speed is by using a high wing loading, and operating the wing at a reasonable C_L, where the model L/D ratio is satisfactory. Operating a lightly loaded model at a low C_L *inevitably* results in a poor glide angle. However, one must have the ability to penetrate when required, and this puts the emphasis on aerofoils having low profile drag. At low C_L, the induced drag is a much lower fraction of the total, so the wing aspect ratio is less important, and reduction of profile drag has thus a relatively greater effect on the overall L/D ratio.

Aerobatics impose special considerations. Loops and banked turns require lift in excess of the weight; this is achieved by trimming to a lower C_L than the maximum (shoving on down elevator), till the speed builds up, when restoring the incidence gives the required extra lift to pull the plane round in a curved path. The ability to perform outside loops as well as inside ones dictates an aerofoil with adequate, or even equal, lifting ability in the negative direction. Profile drag should not be too large at low C_L, when diving for speed, nor should it be excessive at high C_L when performing manoeuvres. Response to control about all axes is enhanced by compactness, so modest aspect ratios are generally preferred.

Thus, admitting that the ideal aerofoil section doesn't exist, we've taken the step of putting an order of priorities on the qualities to be sought, in accordance with the type of plane and the performance required of it.

Geometric properties of aerofoils

There are various terms used in describing aerofoil sections, and it is important to know and use them correctly, and to have an idea of how the characteristics may be expected to depend on them. In particular, thickness and camber are separate parameters which are sometimes confused.

The simplest aerofoil is a flat plate, which is inefficient and has no strength. Adding a symmetrical fairing round it makes it a practical proposition (Fig. 160). This is the "Thickness Form," "Profile," or "Fairing shape." The maximum top-to-bottom depth is the section "*Thickness,*" normally expressed as a percentage of chord. The thickness, its location chordwise, the general profile of the fairing, and the nose radius all affect lift and drag characteristics.

The above is a special case. In general, the fairing may be added to a *curved* datum,

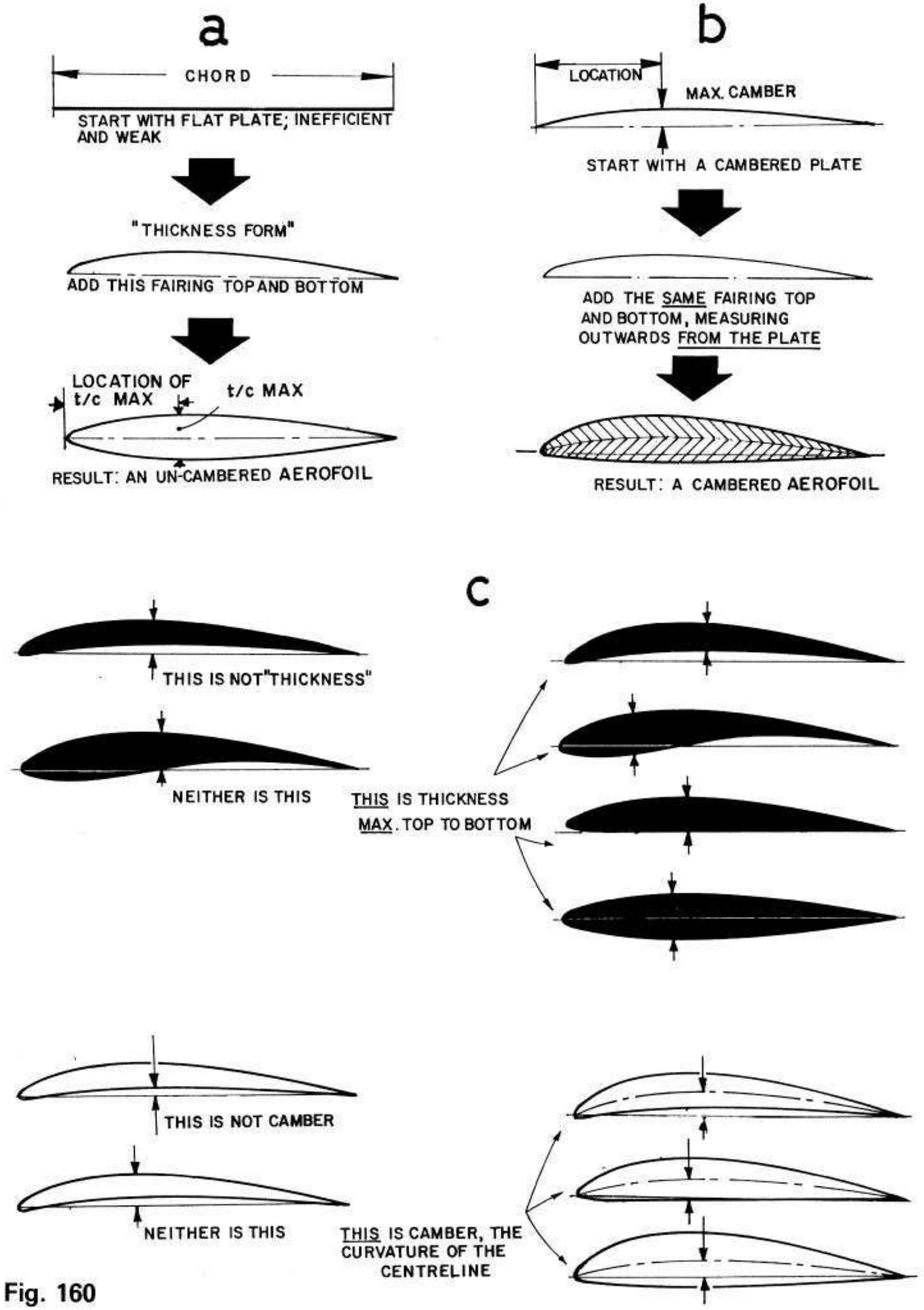


Fig. 160

and the maximum deviation of the bent *datum* from a straight line joining leading edge and trailing edge is known as the *camber,* also expressed as a percentage of chord. The amount of camber, location of the maximum (chordwise), and shape of the camber line all affect lift and drag.

The distinctions between camber and thickness are illustrated in Fig. 160. Reversing the process, the test for camber is to plot the *centreline* of the profile, because an aerofoil section consists of a *symmetrical* fairing plotted about a datum line. If the aerofoil centreline is bent, you have a cambered aerofoil.

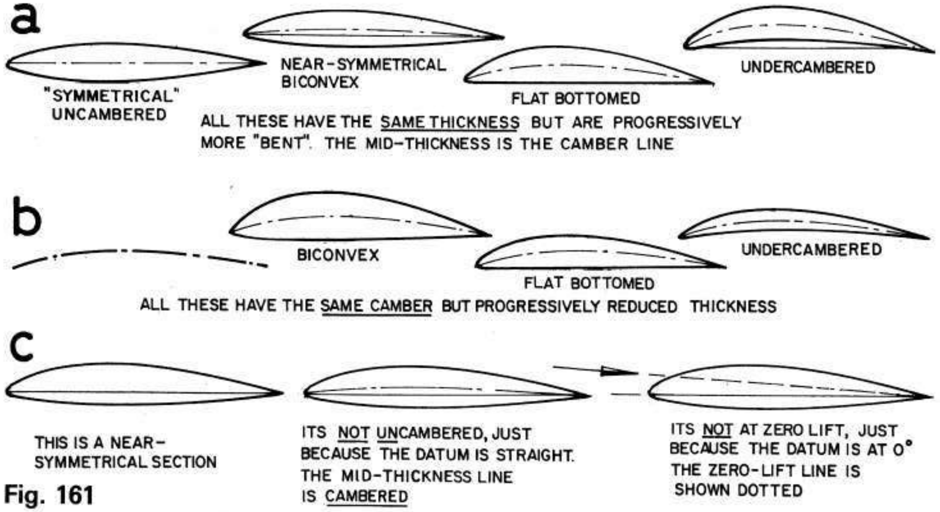


Fig. 161

It follows, allowing that all practical sections have thickness, that there are only *two* sorts of section—those with camber and those without! For convenience in visualising the actual section appearance, four groupings are used, namely symmetrical, "semi-symmetrical," flat-bottomed, and undercambered. The second term is totally meaningless and used only in the model world; such a section is *asymmetric* about the datum used for plotting, *symmetric* about its camber line, and not semi anything. A better term would be "near-symmetrical," or "(low) cambered biconvex." Starting with a given thickness form, it is possible to "bend" it to any of these aerofoil sections by plotting it about suitable camber lines. Likewise, one may take a given cambered line and plot various thickness distributions about it, to give undercambered, flat-bottomed, or biconvex sections. The *real* parameters, which govern aerodynamic behaviour, are not the visual appearance of the whole section, but the separate values of its components, namely camber and thickness.

The reference line used for plotting the section is generally used as a datum for incidence. This gives rise to some confusion, because undercambered and flat-bottomed sections are often plotted from the tangent to the lowest extremities, whereas biconvex sections use a line from the T.E. to the centre of the nose radius. The *only* case where the datum is of aerodynamic significance is the *uncambered* symmetrical section, where obviously zero incidence will give zero lift. The slightly cambered (near-symmetrical) section is effectively at positive incidence, giving positive lift, when the trailing edge-to-nose datum is at zero incidence to the airflow. The geometric datum is purely a matter of convenience and bears no relation to the aerodynamic "zero lift line," see Fig. 161.

Aerodynamic properties of aerofoils

An idealised example of an *aerofoil* characteristic is shown in Fig. 162. The lift is zero at a negative incidence of the datum line, it continues in a straight line till, at just above $C_L = 0.75$, it falls off at the stall. The drag has been assumed to remain constant with incidence α, and the L/D curve reproduces the shape of the C_L v α curve. This is the *section* characteristic of our *Soarcerer* example. When applied to the *actual wing,* the slope of the C_L curve is reduced due to the effect of aspect ratio. Lowering A.R. necessitates more incidence for the same C_L, but does not affect the achievable C_L value. Also, induced drag appears, and must be added to the profile drag, introducing a variation of *total* drag with incidence and C_L. Finally we add something for fuselage and tail profile drag, to end up with a L/D ratio of 12 at $C_L = 0.75$, having started with a *section* L/D of 27 at infinite A.R. At full-scale Reynolds No. the L/D could have been as high as 100 for the section.

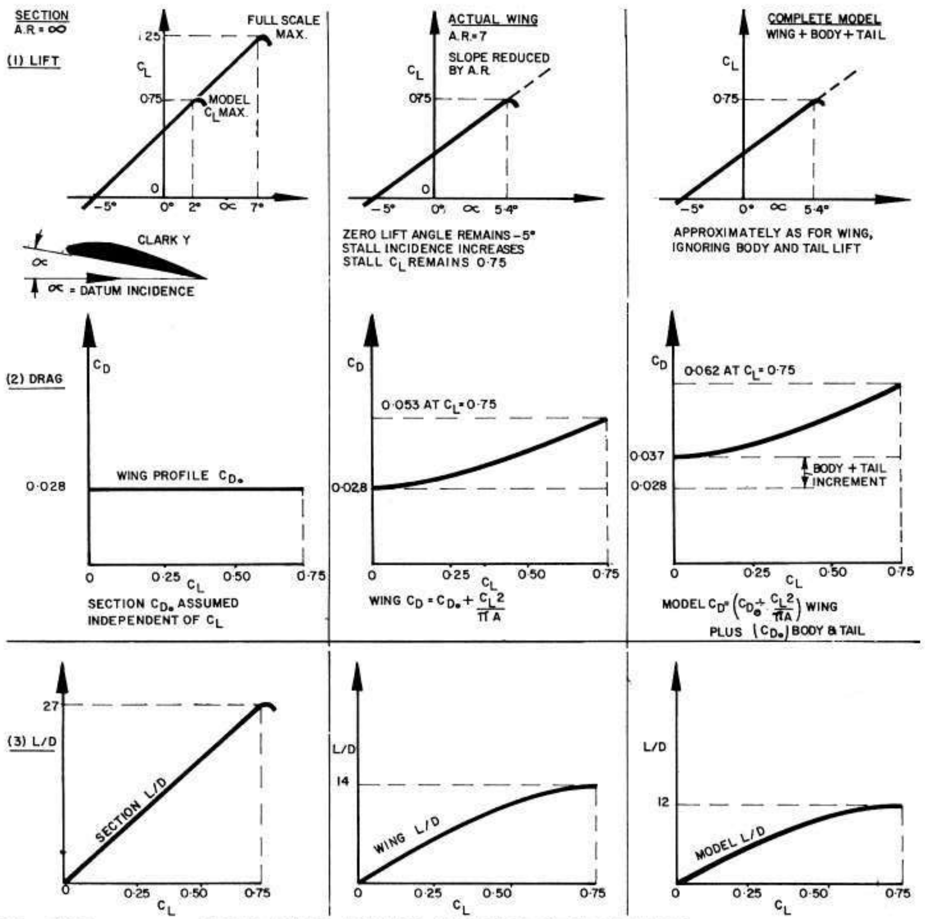
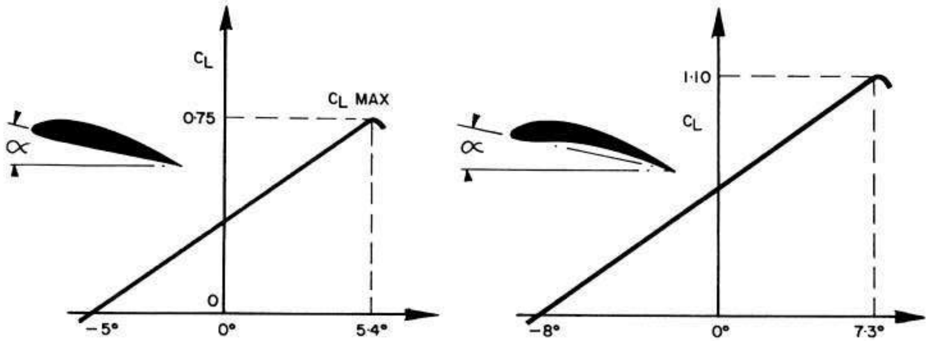


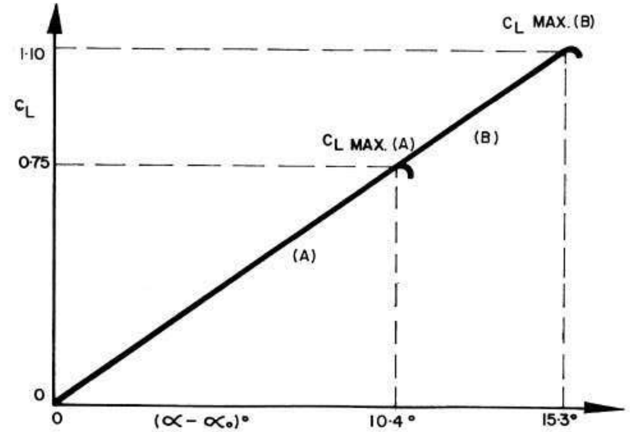
Fig. 162 LIFT AND DRAG CHARACTERISTICS

These characteristics are for the "Soarcerer" calculations in earlier chapter.

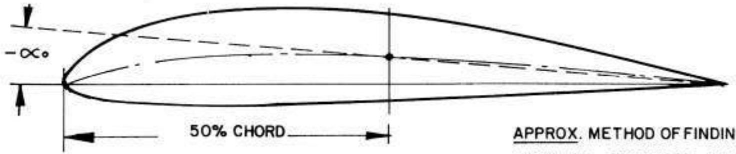
The zero lift angle for the Clark Y section is −5 degrees, using the lower surface of the section as a datum, or −3 degrees if the line from L.E. to T.E. is used. If a highly cambered section were substituted, its zero lift angle might have been −8 degrees, and its C_L v curve as shown in Fig. 163, reaching a higher C_L value at the stall. But if the curves are replotted



(A) MEDIUM CAMBER, $\alpha_0 = -5°$ (B) HIGH CAMBER, $\alpha_0 = -8°$

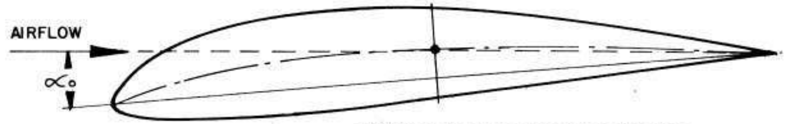


PLOTTING C_L V^r INCIDENCE MEASURED FROM THE ZERO LIFT ANGLE SHOWS THAT BOTH AEROFOILS (A) & (B) HAVE THE SAME SLOPE, OR LIFT PER DEGREE, UP TO THEIR RESPECTIVE C_L MAX VALUES



APPROX. METHOD OF FINDING ANGLE OF ZERO LIFT, α_0

MARK MID-THICKNESS AT MID-CHORD AND JOIN TO TRAILING EDGE



SAME AEROFOIL SET TO GIVE ZERO LIFT

Fig. 163

by measuring incidence in each case from that at which $C_L = 0$, then they are superimposed, because (within plus or minus about 10 per cent) *all* sections produce lift at the same rate with incidence measured from their starting point, or zero lift angle. The fact that the high-cambered section gives more C_L at 5 degrees incidence of its datum line than does Clark Y doesn't make the former more "efficient," because the datum could have been drawn anywhere. The zero lift line has to be found by experiment, but as a *very rough guide,* if you join the T.E. to a point at mid-chord on the mid-thickness (camber) line, then the slope of this line gives a fair visual indication of the airflow direction which will give zero lift.

From correlated full-scale test data, reasonably well-defined trends have been established for the separate influences of camber, thickness, etc., on the lift and drag properties of aerofoils. Experience with models bears out the validity of most of these, as long as they are accepted as generalisations.

Firstly, it must be admitted that the assumption of a *fixed* profile drag, independent of C_L, is only a convenient approximation (used in my *Soarcerer* sums). In general, there is a minimum value of C_{D_P} occurring at a modest C_L, and at incidences above or below this the profile drag will be higher. This increase may only be a *very* small fraction of the *total* drag of a real wing-body-tail combination, but it can be important for off-design operation, such as flying a model at very low C_L for penetration, when a rise in profile drag can lead to undesirably steep descent.

The *thickness* of an aerofoil, and its shape and distribution, mainly affect the profile drag. As some of this drag is skin friction, which remains unaffected by increases of thickness, the profile drag does not increase in direct proportion to thickness. Full-scale, one may double the t/c from 12% to 24% and experience only about 25% increase in profile drag.

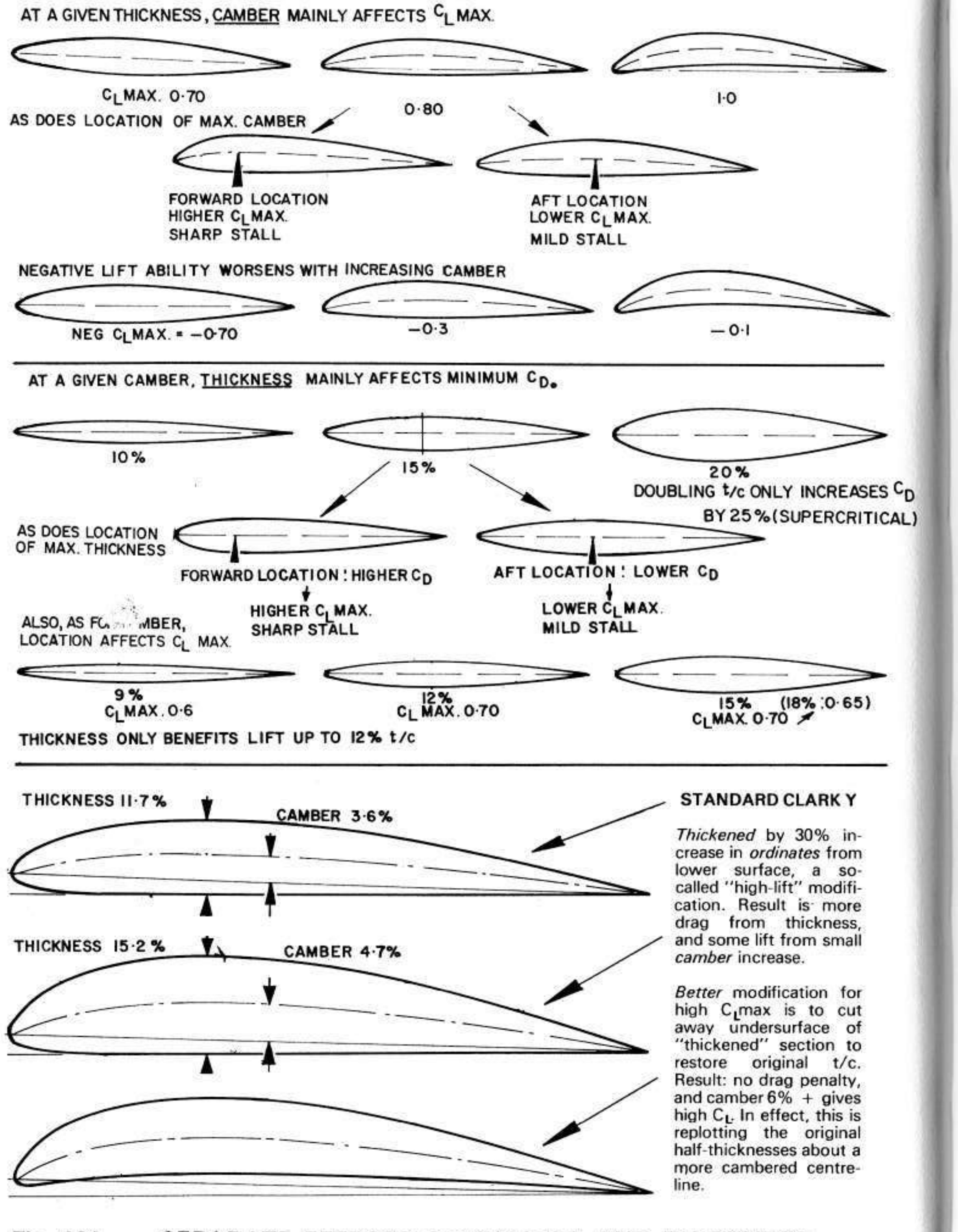
The *camber* mainly affects the maximum achievable lift coefficient. The rate of increase of C_L with incidence is unaffected, but the curve goes a bit higher with each increase of camber, *i.e.* the stall is delayed. The other effect of increasing camber is to shift the minimum drag point to a higher C_L, without necessarily altering the amount of minimum drag, so high camber suits slow flight.

The nose radius mainly affects drag, but also has some influence on the incidence at which the section stalls, and the severity with which it does so. One may expect less drag from a sharper L.E., but stall behaviour is less predictable; the blunt L.E.s inherited from power fliers have no merit from any point of view, as they are capable of violent stalling and have excessive drag, but at the same time it *may* be a mistake to use an almost sharp entry. It is possible for a sharp L.E. to act as a turbulator on a small-chord, slow-flying section, giving a more stable and efficient flow than the separated laminar flow which might otherwise prevail. It is also possible for a sharp L.E. to induce premature stalling, a trick which may be employed to get a design to spin more readily.

There is a common belief that thick sections "give more lift." This is not supported by the masses of full-scale evidence, though it is true if one considers the range of low thicknesses from 6% to 12%. Going to 15% offers no consistent advantage, and above this thickness the stall occurs at a *lower* C_L. If you scale up the ordinates of a flat-bottomed section, such as Clark Y, measuring from the lower surface and increasing the ordinates by say 30%, the result will be a section of 15% thickness compared with the original 11.7%. It may well function as a "higher lift" section, but this will be because this method of increasing its thickness has *also* increased the *camber* from 3.6% to 4.7%. If the original thickness form had been retained, but "bent" to an undercambered shape, at least the same increase in C_L max. would have resulted, but *without* an accompanying drag rise.

Regarding the location of the maximum thickness and camber in the chordwise sense, it may be said of both that a forward location may give a higher C_L max., but the stall when it comes is more violent. Also, forward location of the max. thickness (at 20%-30% of chord) tends to give more drag. A more aft location of these maxima, at say 35%-55% chord, tends to give a milder stall at the expense of a small reduction in the C_L max. at which it occurs, and an aft position for max. thickness naturally gives a more slender entry and less profile drag.

In the light of the above, one may get a pretty good idea of what to expect from a section, or how one section compares with another, purely from appearances. It must be stressed that even on the basis of available full-scale data, these are sweeping generalisations to which there are numerous detailed exceptions. For models, the position is much worse, because different sections are affected differently by Reynolds Number, and there is in any



Thickened by 30% increase in *ordinates* from lower surface, a so-called "high-lift" modification. Result is more drag from thickness, and some lift from small *camber* increase.

Better modification for high $C_L$max is to cut away undersurface of "thickened" section to restore original t/c. Result: no drag penalty, and camber 6% + gives high C_L. In effect, this is replotting the original half-thicknesses about a more cambered centre-line.

Fig. 164 SEPARATE EFFECTS OF CAMBER AND THICKNESS

case an almost total lack of measured data. However, on the basis of experience and observation, the foregoing is a very good foundation, on which may be built your own understanding of how model sections behave.

Particular classes of aerofoil

(1) Symmetrical (Uncambered)

If you must have equal performance upright and inverted, use this. It gives the highest possible *negative* C_L for outside loops and slow inverted flight, but the *positive* C_L obtainable (equal in magnitude) is less than for any other type of section. There is no other advantage, and for every other application than slope soaring aerobatics, there is no worse aerofoil. The minimum drag is at zero lift, and rises with the application of lift in either direction. For a thick section, the "face" presented to the airflow ensures high drag at high incidence. The stall comes quite early, especially with thin sections. Good for fast models flown at low C_L, where symmetry of manoeuvring is important and slow flight and shallow descent angle are not!

(2) Near-symmetrical

Generally a good bet for all-round performance in the aerobatic field. A better positive C_L max., with some slight deterioration in the negative lifting ability, according to how much camber is used. The optimum performance is biased towards cruising flight at some *moderate* value of C_L, where the minimum drag will occur, so that penetration and the building up of speed for manoeuvres do not entail too much height loss. The drag rise at high C_L will also be less than for the symmetrical section.

(3) Flat-bottomed

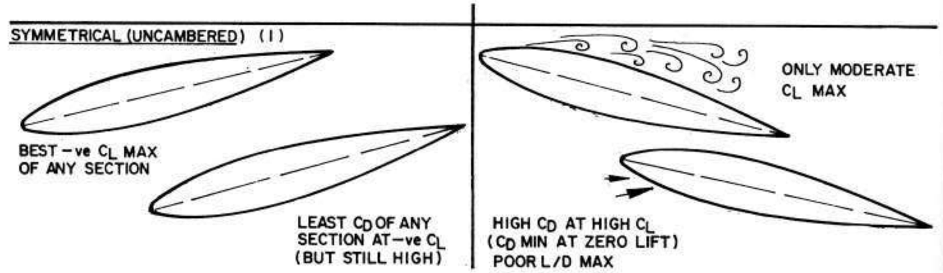
As above, only more so. This is the great "All-rounder" category. In fact, they're not particularly good at anything and in various *single* respects can easily be outclassed by other sections, but they do combine a very fair measure of all the qualities and are much favoured for multi-purpose models. The practical virtues of easy rib cutting, flat assembly without jigs and packing pieces, and ease of covering and aligning ensure that the 57 varieties of Clark Y will be the most popular section till long after old Virginius E. Clark, who designed it in 1922, is forgotten. By now, the effect of camber begins to become obvious on the inverted performance as the inverted stall occurs at quite a small negative C_L. The drag in inverted flight will have risen well above the minimum, which now occurs at a higher C_L than for the near-symmetrical sections. Penetration abilities are less, in the sense that the accompanying drag is higher. Slow flying with a flat glide path is improved, not only by the higher C_L max. but by the lower drag at high C_L than the near-symmetrical section. This type of section may be used on any category of model, though it has no place at contest level as a rule. Depends on the contest and the opposition!

(4) Undercambered

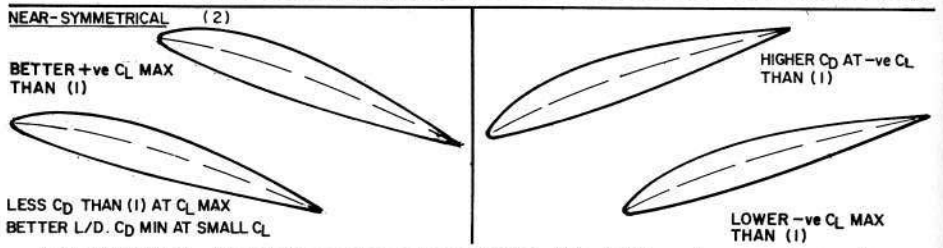
These are the truly high performance sections, for models where high efficiency is the requirement. The presence of a high *camber* is of multiple benefit to models where minimum sinking speed is the primary goal; it provides a high C_L max. which alone ensures slow flight, it enables the full potential of a high aspect ratio design to be realised because it enables the wing to attain the extra high C_L at which the L/D ratio has a maximum value, and it also ensures that the minimum profile drag occurs at a high C_L. Provided that the thickness is kept moderate, the amount of profile drag need be no more than for a less "bent" section, and it will occur closer to the minimum flying speed than for any other class of aerofoil. Let it be clear that the *camber* of the centreline is responsible for the high lift capability, and that there is no early limit to the amount which gives benefits, as with thickness. Camber may be raised to an absurd amount in the interest of obtaining high C_L and low stalling speed, but the drag may begin to suffer, and the effectiveness of camber increases in raising C_L max. is less if the thickness is raised above about 10%-12%.

The thin, high-cambered section is the "end of the line" where specialisaton is concerned. Its deficiencies in other respects are very marked. The lower the C_L, the higher the profile drag, so penetration is at the expense of a steep descent. The inverted

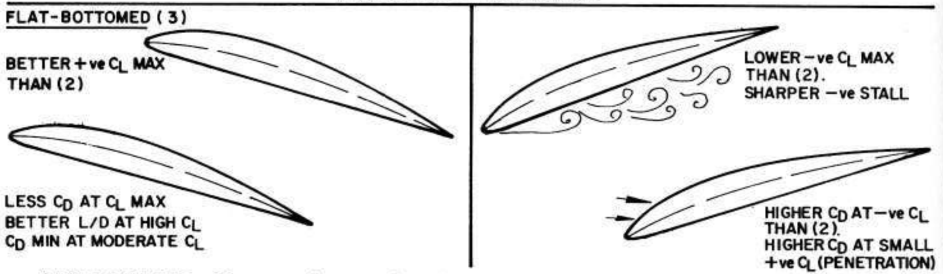
GOOD POINTS Fig. 165 BAD POINTS



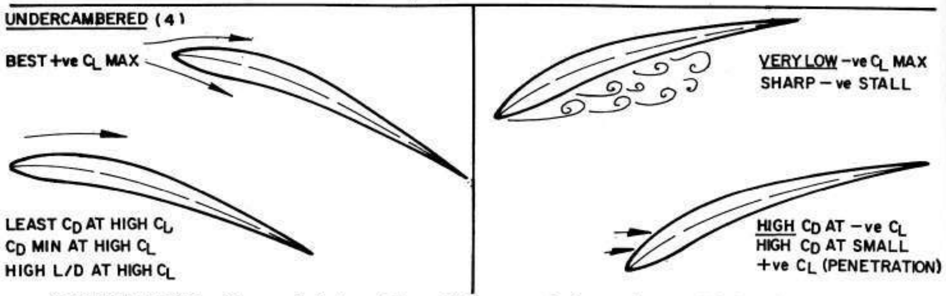
APPLICATION: Fast aerobatics, upright and inverted. Fair penetration. Slope soarers only



APPLICATION: Aerobatics and good penetration. "Upright" performance better than (1), at cost of inverted perf.



APPLICATION: Compromise section for slope/thermal flying. Fair C_L, L/D, and penetration



APPLICATION: Thermal flying. Slow flying on shallow slopes. High L/D at high C_L gives min. sinking speed. Good "load carrier." No inverted perf.!

N.B. The foregoing are generalisations; there are overlaps and exceptions, depending on shapes, thicknesses and Reynolds No.

These 2 graphs summarise the trend to better C_L and lower C_D as camber is increased.

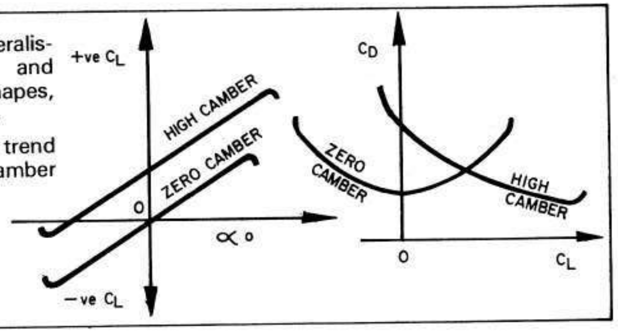


Fig. 165a

performance is very limited indeed, as the inverted stall occurs violently at a very low negative C_L, and drag is excessive in these regions.

For a load carrier, as with aerial photography, where a light wing loading is hard to achieve, but slow flight is required, lots of camber is what you need. Thickness will be a matter of structural strength, the less the better for performance. For all duration flying activities, including slope soaring in marginal winds or from shallower slopes than usual, there are benefits to be had from employing well-cambered sections which are not too thick, and the need for penetration may often be met better by using ballast. For small, light models, the combination of fairly high camber and low thickness gives an improvement which is exaggerated by the fact that the flat-bottomed moderately thick sections deteriorate to sub-critical behaviour at a much higher Reynolds Number, whereas the thin cambered ones work well down to very low R.

Specimen aerofoils

Ordinates are given for a number of "proprietary" aerofoils in each category. No attempt is made to present the sections in any order of merit, nor is there any implication that this selection is the best of the many hundreds available. The Hungarian sections by Dr. George Benedek, and the Swedish ones by Sigurd Isaacson were specifically designed for use on free-flight gliders, *i.e.* at low Reynolds Numbers, and the sharp L.E. is intended to promote turbulent flow. The German sections by Dr. Richard Eppler were also designed for model use, but intended to have attached laminar flow. The flattering published characteristics of these appear to have been computed, not measured, which impresses me not at all, after spending 15 years measuring the differences between theories and practice, in wind-tunnels. However, these sections are now quite widely used and have acquired a good reputation; their thinness and slender shape *look* efficient especially when compared with some of the "old faithfuls" used for years by conservative model glider exponents! Some of the latter sections are a hangover from the 1920's, when the structural problems of cantilever monoplane wings made thick sections desirable. The remaining examples given are all "full-scale" sections which have the right sort of camber and thickness to suit our purposes. The method of plotting from tabulated ordinates is given in Fig. 166.

If you don't want to be bothered about duplicating a particular section, try a spot of do-it-yourself with a french curve. From the outline given of the effects of thickness, camber, etc., you can forecast the sort of characteristics to be expected from any existing section, so you can apply the same concepts to creating your own section, and can in fact create a systematic series more easily than you can find a ready-made range of the type you are seeking. You may find success by combining various features; for instance, a near-symmetrical fore-portion helps inverted performance, and may be combined with a mor cambered aft portion which has a flat, or even undercambered lower surface, whic improves upright performance in comparison to that obtained with a conventiona uncambered or low cambered biconvex section (Fig. 167). This sort of "tailoring" has bee

(1) Start with a Table of Ordinates:—

x	0	5	10	15	20	30	40		100
y_u	0	5·36	7·58	9·18	10·34	11·65	11·80		0
y_L	0	–1·99	–1·99	–1·67	–1·25	–0·38	+0·20		0

This is location of ordinate, % chord from L.E.
This is *upper* surface height, % chord, above datum line
This is *lower* surface height, % chord, above datum line.
(negative values lie below datum line)

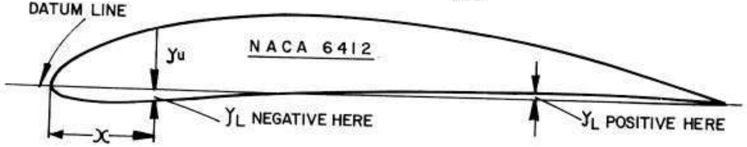
(2) Draw a blank table of three lines, with columns as for the table of ordinates. This is to be filled with ordinates and their locations *in inches,* for the particular chord chosen.

EXAMPLE: Chord = 7.5 inches. Take fourth column.

Ordinates are at $x = \frac{15}{100} \times 7.5'' = 1.125''$

Upper surface ordinate $y_U = \frac{9.18}{100} \times 7.5 = 0.689''$

Lower surface ordinate $y_L = \frac{-1.67}{100} \times 7.5 = -0.125''$



(3) Get a slide rule! Arithmetic is only done right by kids. Now go forth and multiply.

(4) Completed table looks like this:—

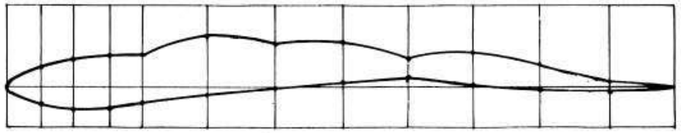
x"	0	0·375	0·75	1·125	1·50	2·25	3·00		7·50
y_u"	0	0·402	0·568	0·689	0·775	0·874	0·885		0
y_L"	0	–·149	–·149	–·125	–·094	–·028	+·015		0

(5) Get some graph paper with 1/10 inch squares (available in 14" × 9½" pads). Mark ordinate stations on a chord line.

0 0·75" 1·5" 2·25" 3·0" → 7·5"
0 10% 20% 30% 40% → 100%

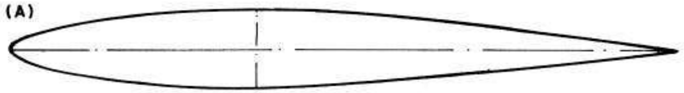
(6) Now plot! Use correct end of a hard, sharp pencil, not an old fibre-tip pen.

(7) Join plotted points with smooth curve.

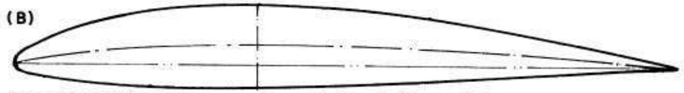


If it looks like this, it's your rotten arithmetic. See step (3).
Aerofoils never have 'umps.

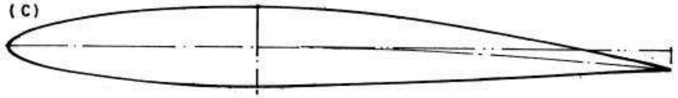
Fig. 166 PLOTTING AN AEROFOIL



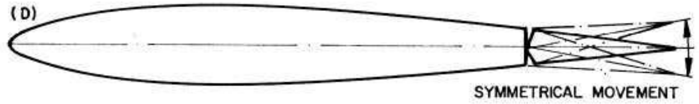
Standard uncambered section. Limited L/D and $C_L$max.
Good inverted performance.

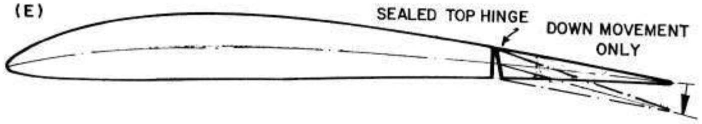


Standard 3% camber section. Better L/D and $C_L$max.
Higher C_D and lower $C_L$max inverted.



Home-made hybrid. Front part of (A) ensures good negative lifting ability, delaying stall & drag rise. Rear part of (B) enhances normal flight, improving L/D both for cruise and penetration, compared with the uncambered section (A).
Note: no discontinuity of slope where the camber lines of the respective portions join.





Variable camber sections. For type (D), the movable "flap" endows the fully aerobatic model with an improved cruise L/D and higher manoeuvering C_L, without sacrificing symmetry of upright and inverted perf.
For type (E), a slender, low-camber section may be used on a thermal soarer to enhance penetration, and lowering the T.E. increases camber to provide high C_L and L/D for "lift-sniffing."
Avoid excessive movement, like a true "flap": high drag!

Fig. 167 WHY NOT EXPERIMENT WITH AEROFOILS?

done, and in my opinion, it's well worth pursuing. The design principles employed for the older sections were no more scientific, the understanding of camber and thickness effects was less than clear, and in any case they weren't designed for model conditions or requirements!

There is one further point worth mentioning; the simple explanation of longitudinal stability given earlier took the lift force as acting at quarter chord, but in practice the centre of pressure of a wing tends to move aft of this point at low incidence, by an amount which increases with the camber. The stability tends to diminish at high C_L for a model with a highly cambered wing, and the best way to reduce this tendency is to make the tail area a larger fraction of the wing area, so that the position of the *total* lift doesn't move too much.

These C.P. movements were a nightmare to the pioneer designers, leading to wing failures in a dive because of lack of torsional stiffness with the thin, undercambered aerofoils of those days, but for models it is the effect on stability that matters, and to deal with it is no problem.

Talking of tails . . .

There is an interchange between c.g. position and tail "volume" (*i.e.* Tail Area × Moment Arm), for a given amount of stability, and a shortage of arm or area can be compensated for by a forward movement of the c.g. The tail also provides *damping*, however, which is essential, and this does depend on tail area and moment arm. For this reason, and for the stability non-uniformity mentioned above, it is highly desirable that the high-cambered thermal flying model be provided with a good size tail a long way aft, so that it can ride steadily, finely trimmed to near the stall. Never be stinting with the tail volume; the stall will be less sudden, less violent, there will be less height loss, and it will damp out more rapidly. All these vices will appear with too small a tail, more than offsetting any small potential performance increase due to the drag saving.

Tail sections are not critical. A flat plate suffices for smallish models, but for extra strength and stiffness at little or no drag increase, a slender biconvex section is better, if you think it's worth the trouble. For thermal soarers, it is best in practice to trim with an aft c.g. so that the tail is contributing lift; thus it may as well have a "lifting section." By this we mean simply a cambered section, such as a thinned Clark Y, for convenience of rigging. There seems to be no need to employ a section capable of high C_L comparable with that of the wing, though I have heard tales of stability improvements resulting from such things. The main aim is to *avoid undue drag*, which is detrimental to performance and has no effect at all on the stabilising and damping properties of the tail, which are a function of its ability to provide *lift* forces.

Future Developments

I am convinced that (next to proportional R/C), the most significant recent innovation with the greatest potential for development, for all classes of glider, and for powered applications, is the *variable camber wing*. I've wanted to try it for years and am only now getting something "on the board," but I'm pleased to see that the aerobatic exponents who are pioneering the use of a "trimmable trailing edge" are finding that it's *the* way to *combine* the merits of a symmetrical section, for manoeuvres up or down, and a cambered section for cruising, gaining height, or landing slowly. Applying the same concept of a full-span "flap" of say 15% chord, or perhaps more, to a thermal soarer wing with a thin, flat-bottomed section, one should be able to deflect it to give high effective camber for the necessary high C_L to give minimum sink rate, and restore the flap to revert to the normal section for penetration without the high drag which the cambered section would have given at low C_L. Plenty of scope for experiment with proportions, movement range and preset, perhaps coupling to elevator, and flying techniques (Fig. 167).

On wing design in general, it seems to me that for fixed camber wings, the best way of producing a multi-role model (slope and flat field) is to provide alternative wings, as concluded in the previous chapter. For wide ranges of conditions in either mode, detachable panels would help in arriving at the right sort of wing loading, without using ballast in great quantities. The main thing is to recognise that whilst the section is important, *no* section will work miracles in curing shortcomings of design, trimming, and ballasting.

UNCAMBERED (SYMMETRICAL) SECTIONS

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Ordinate ± y	0	1.50	2.50	3.12	3.60	4.35	4.80	4.92	5.00	4.90	4.60	4.10	3.50	2.65	1.50	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Ordinate ± y	0	1.74	2.37	2.80	3.12	3.56	3.83	3.96	4.00	3.87	3.53	3.04	2.44	1.75	0.97	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Ordinate ± y	0	1.74	2.41	2.92	3.32	3.95	4.40	4.71	4.91	4.97	4.61	3.94	3.04	2.04	1.03	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Ordinate ± y	0	2.02	2.79	3.36	3.84	4.58	5.13	5.53	5.81	5.99	5.61	4.80	3.72	2.50	1.26	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Ordinate ± y	0	2.41	3.26	3.96	4.55	5.49	6.20	6.73	7.12	7.50	7.27	6.39	5.06	3.45	1.74	0

This selection of profiles is given in order of increasingly aft location of max. thickness, from 28% chord to 42%. All may be scaled to greater or lesser thickness, as required. No need to retabulate the percentage ordinates, simply calculate thicknesses as if for a larger chord. The thickness ratio of the section as presented is given by the last two digits.

LOW-CAMBERED BICONVEX SECTIONS

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.41	3.42	4.17	4.77	5.67	6.28	6.67	6.88	6.84	6.36	5.58	4.55	3.30	1.82	+0.10
Lower y	0	−1.93	−2.48	−2.81	−3.02	−3.23	−3.28	−3.23	−3.13	−2.84	−2.47	−2.02	−1.55	−1.07	−0.59	−0.10

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.99	4.13	4.96	5.63	6.61	7.26	7.67	7.88	7.80	7.24	6.36	5.18	3.75	2.08	0.13
Lower y	0	−2.27	−3.01	−3.46	−3.75	−4.10	−4.23	−4.22	−4.12	−3.80	−3.34	−2.76	−2.14	−1.50	−0.82	−0.13

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	1.90	2.69	3.29	3.79	4.59	5.20	5.66	5.98	6.27	6.01	5.32	4.31	3.04	1.55	0.02
Lower y	0	−1.47	−1.96	−2.32	−2.60	−3.03	−3.34	−3.55	−3.69	−3.72	−3.35	−2.72	−1.94	−1.17	−0.57	−0.02

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	3.61	4.91	5.80	6.43	7.19	7.50	7.60	7.55	7.14	6.41	5.47	4.36	3.08	1.68	0.13
Lower y	0	−1.71	−2.26	−2.61	−2.92	−3.50	−3.97	−4.28	−4.46	−4.48	−4.17	−3.67	−3.00	−2.16	−1.23	−0.13

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.20	3.40	4.20	4.90	5.90	6.60	7.20	7.50	7.65	7.10	6.00	4.60	3.15	1.60	0
Lower y	0	−1.20	−2.00	−2.40	−2.70	−3.00	−3.10	−3.20	−3.25	−3.20	−2.95	−2.60	−2.15	−1.50	−0.80	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.23	3.15	3.85	4.43	5.36	6.06	6.58	6.96	7.27	6.94	6.10	4.90	3.43	1.75	0.03
Lower y	0	−1.80	−2.42	−2.87	−3.24	−3.80	−4.20	−4.48	−4.66	−4.71	−4.28	−3.50	−2.54	−1.56	−0.77	−0.03

The above are low/medium thickness sections of moderate camber. The "64" series, and Eppler, offer less drag than their conservative equivalents 23012 and the "24" series, at slight cost in C_L max. Scaling any set of ordinates to give different max. thickness may be done, but it will also result in a change of camber.

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	3.71	5.07	6.06	6.83	7.97	8.70	9.17	9.38	9.25	8.57	7.50	6.10	4.41	2.45	0.16
Lower y	0	−2.86	−3.84	−4.47	−4.90	−5.42	−5.66	−5.70	−5.62	−5.25	−4.67	−3.90	−3.05	−2.15	−1.17	−0.16

Ex power fliers may feel more at home with the appearance of 2415, and the glide angle!

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.71	3.83	4.68	5.39	6.51	7.35	7.98	8.42	8.77	8.31	7.26	5.78	4.02	2.05	0
Lower y	0	−2.29	−3.11	−3.71	−4.20	−4.95	−5.49	−5.87	−6.12	−6.21	−5.65	−4.65	−3.42	−2.15	−1.07	0

If you *must* use thick sections, you must accept more drag, unless you embody a slim entry as on 64_2A215. Any lift advantage is unlikely, compared with a 12% section.

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	7.18	9.70	10.70	11.35	11.84	12.52	13.00	13.10	13.14	12.48	11.42	9.80	7.74	5.40	2.92	0.12
Lower y	7.18	4.72	3.74	3.10	2.58	1.72	1.14	0.70	0.44	0.12	0.02	0.10	0.22	0.32	0.24	0.12

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.46	3.54	4.38	5.06	6.14	6.93	7.50	7.87	8.06	7.58	6.56	5.15	3.49	1.74	0
Lower y	0	−1.72	−2.28	−2.69	−3.00	−3.45	−3.75	−3.92	−3.98	−3.78	−3.16	−2.28	−1.27	−0.31	+0.33	0

These are sections "biased" towards upright performance without undue sacrifice of inverted performance. The RAF 31 is like our suggested "home-made hybrid," and the $63_1$412 shows the characteristic lower surface concavity which results from bending a section which has a slender, cusped tail.

FLAT BOTTOMED SECTIONS

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.4	4.5	5.5	6.2	6.6	7.3	7.7	7.9	8.0	7.8	7.1	6.2	5.0	3.6	2.0	0.2
Lower y	2.4	1.1	0.6	0.4	0.25	0.15	0.05	0	0	0	0	0	0	0	0	0

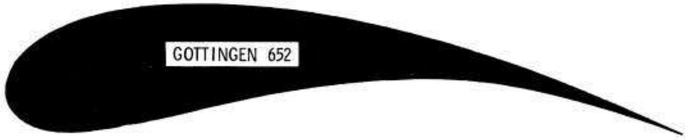
Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.0	4.5	5.6	6.5	7.2	8.3	9.2	9.7	10.1	10.2	9.5	8.3	6.8	5.2	3.6	2.0
Lower y	2.0	0.8	0.6	0.5	0.5	0.5	0.7	0.8	1.0	1.4	1.7	2.0	2.2	2.3	2.3	2.0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	3.74	7.40	9.17	10.37	11.25	12.53	13.34	13.60	13.80	13.34	12.27	10.63	8.53	6.12	3.40	0.25
Lower y	3.74	1.28	0.69	0.35	0.18	0.03	0	0	0.05	0.17	0.27	0.33	0.35	0.27	0.13	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	3.50	6.50	7.90	8.85	9.60	10.68	11.36	11.60	11.70	11.40	10.52	9.15	7.35	5.22	2.80	0.12
Lower y	3.50	1.47	0.93	0.63	0.42	0.15	0.03	0	0	0	0	0	0	0	0	0

Some of the "easy-build" sections for undistinguished performance, mainly inherited from obsolete full-scale practices of 50 years ago. Not worth detailed consideration, as by scaling Clark Y up or down one arrives at all the others, near enough. The exception is Eppler 387; this is not a flat-bottomed section, and the common practice of ignoring the concavity may well take the edge off its high-lift performance, but its reputation is undoubtedly due to the modern slim profile and moderate thickness, which give it a marked drag advantage over those fat old Göttingen relics.

UNDERCAMBERED SECTIONS



Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	5.80	11.60	13.60	15.10	16.20	17.70	18.60	19.00	19.20	18.60	17.15	14.80	11.90	8.46	4.50	0
Lower y	5.80	1.70	0.50	0.10	0	0.60	1.40	2.45	3.60	5.90	7.45	8.00	7.80	5.90	3.25	0

We're not serious! This archaic notion of a glider section, used in the 1920's, gave an amazing C_L and a deplorable L/D, even at full-scale. For slow flight with a heavy model, lots of camber is what you need, but don't wrap a shape like this round it.

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.45	7.05	8.55	9.65	10.50	11.60	12.25	12.60	12.75	12.05	10.70	9.00	7.10	4.90	2.60	0.10
Lower y	2.45	0.80	0.50	0.30	0.15	0	0	0.10	0.25	0.65	1.05	1.35	1.50	1.35	0.45	0.10

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	3.80	5.36	6.57	7.58	9.18	10.34	11.10	11.65	11.80	11.16	9.95	8.23	6.03	3.33	0
Lower y	0	−1.64	−1.99	−2.05	−1.99	−1.67	−1.25	−0.82	−0.38	+0.20	0.55	0.78	0.85	0.73	0.39	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.96	4.30	5.42	6.31	7.78	8.88	9.58	10.13	10.35	9.81	8.78	7.28	5.34	2.95	0
Lower y	0	−1.11	−1.18	−1.08	−0.88	−0.36	+0.17	0.70	1.12	1.65	1.86	1.92	1.76	1.36	0.74	0

Three long-time favourites from free-flight days. 532 is one of the less dramatic looking Göttingen sections, used on the R.M. *Ascender.* NACA 6412 appears on many published designs, including R.M. *Slinky,* and the 6409 has a long history of contest wins for duration performance.

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.0	4.6	6.0	7.1	8.0	9.2	10.2	10.9	11.4	11.8	11.2	10.1	8.5	6.6	4.6	2.0
Lower y	2.0	1.2	1.2	1.3	1.4	1.8	2.3	2.8	3.1	3.6	4.1	4.4	4.4	4.1	3.5	2.0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.0	4.1	5.2	5.8	6.6	7.6	8.3	8.8	9.2	9.7	9.6	9.3	8.5	7.2	5.2	2.0
Lower y	2.0	1.5	1.5	1.6	1.8	2.5	2.8	3.2	3.6	4.3	4.8	5.1	5.0	4.7	3.9	2.0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	2.32	5.00	6.42	7.55	8.42	9.75	10.70	11.10	11.40	11.00	10.00	8.67	6.95	4.93	2.79	0.25
Lower y	2.32	0.72	0.28	0.12	0	0.28	0.73	1.10	1.50	1.75	1.72	1.53	1.22	0.92	0.50	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	1.00	3.90	5.40	6.50	7.45	8.60	9.35	9.75	9.95	9.70	8.95	7.90	6.45	4.65	2.90	0.70
Lower y	1.00	0.10	0.35	0.55	0.75	1.10	1.40	1.80	2.10	2.55	2.90	2.80	2.40	1.85	1.00	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0.90	3.95	5.60	6.60	7.40	8.55	9.20	9.55	9.65	9.30	8.60	7.70	6.65	5.40	3.95	0.50
Lower y	0.90	0.10	0.45	0.80	1.00	1.50	1.95	2.40	2.80	3.40	3.80	3.75	3.40	2.65	1.60	0

The refinements necessary to obtain truly high still-air performance bring structural problems. The Eppler 385 has a very thin T.E.: the E 59 has in addition a particularly thin profile, so its use is limited to small, light models—outside practical limits for present-day R/C. The E 385 should be a good thermal-flying section. The Benedek sections are not normally used thicker than 10%, and the lower drag thin variants have T.E. problems; the special 7406-f shape is a great help in meeting the strength requirements of R/C work with these successful free-flight sections. The first number is t/c, the second pair are location, the last is camber.

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	2.6	4.6	5.9	7.0	8.5	9.6	10.1	10.5	10.5	9.7	8.3	6.7	4.8	2.7	0.2
Lower y	0	−0.5	−0.6	−0.5	−0.3	+0.2	0.6	1.0	1.3	1.8	3.0	2.0	1.8	1.3	0.6	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	3.0	5.0	6.4	7.6	9.0	9.9	10.2	10.3	10.0	9.2	8.0	6.5	4.6	2.7	0.40
Lower y	0	−0.4	−0.4	0	+0.4	1.2	2.0	2.5	3.0	3.5	3.4	3.0	2.3	1.4	0.4	0

Station x	0	2.5	5	7.5	10	15	20	25	30	40	50	60	70	80	90	100
Upper y	0	3.0	4.6	5.75	6.7	7.7	8.3	8.6	8.7	8.4	7.8	6.6	5.3	3.7	2.0	0.3
Lower y	0	−0.5	−0.4	−0.2	0	0.7	1.2	1.4	1.6	1.8	1.8	1.5	1.2	0.6	0.1	0

The Sigurd Isaacson sections are similar to the Benedek; the numbering system is reversed, so that 73508 has 7% camber at 35% chord, and 8% t/c. The sharp L.E. is particularly intended to suit small slow models, and can easily be rounded off if this suits your application. The use of turbulator strips is common, and might repay careful experiment; enough thickness and no more is the key, otherwise you create more drag.

APPENDIX I

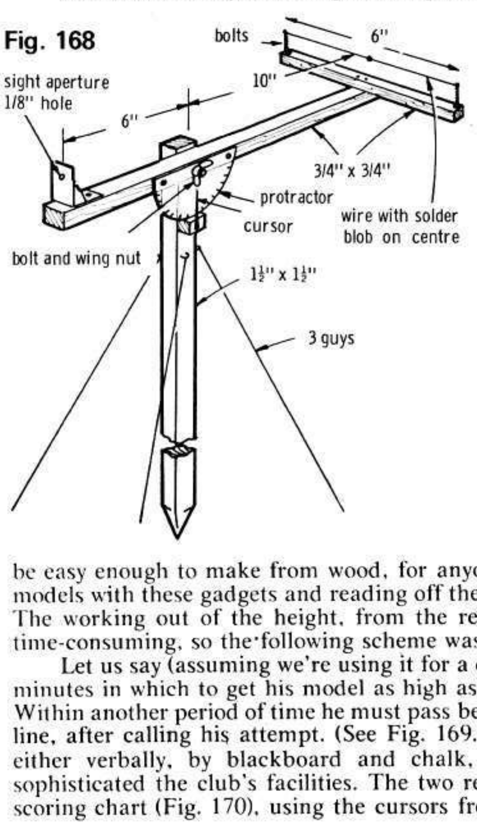
HOW HIGH IS IT?

IN those idyllic days when there is plenty of lift about, and our models suddenly seem very much smaller, as we lie on our backs and watch them circle overhead, we've all found ourselves wondering just exactly how high they really are. Some of the guesses to be heard from fellow modellers, as to the heights of *their* craft are obviously very wild indeed, but the estimates we make about our own are likely to be on the conservative side. Of course.

Why not, then, devise a proper means for computing a model's actual height with a fair degree of accuracy? John Beer has done just this, originally with a view to instituting height-gain competitions and, although the idea has not so far been taken up by any contest organisers, the system in itself was felt to be well worth recording here, even if to be used by groups of individuals for their own enjoyment, rather than for organised contests.

The basis of the system is a pair of sighting devices, as shown in Fig. 168. These should be easy enough to make from wood, for anyone who builds models. And sighting up the models with these gadgets and reading off the angles to the horizontal is easy enough, too. The working out of the height, from the readings, however, is rather more tricky, and time-consuming, so the following scheme was devised.

Fig. 168



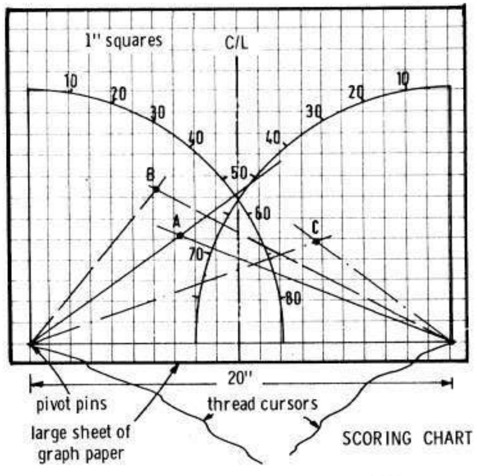


Fig. 170

Let us say (assuming we're using it for a competition) that the competitor is given two minutes in which to get his model as high as he is able, finding lift wherever he chooses. Within another period of time he must pass behind the sighting line and head up across the line, after calling his attempt. (See Fig. 169.) The sighters could transmit their readings either verbally, by blackboard and chalk, or by field telephone—according to how sophisticated the club's facilities. The two readings would then be transferred on to the scoring chart (Fig. 170), using the cursors from each corner to the appropriate quadrant

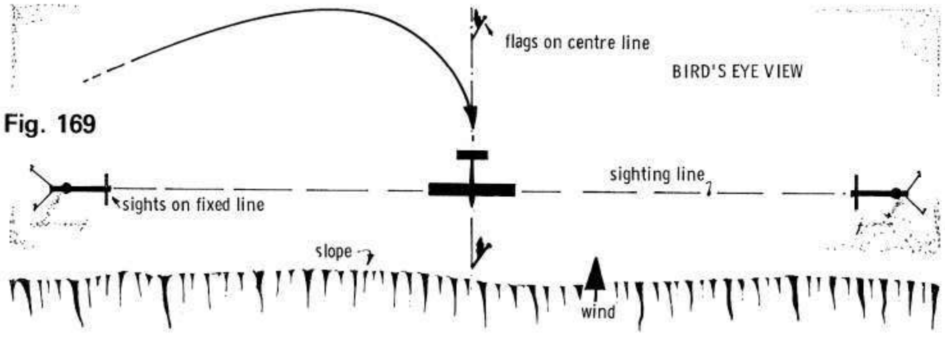
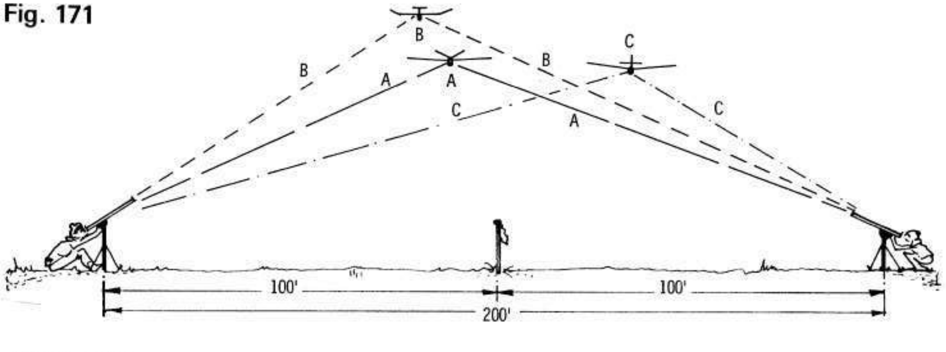


Fig. 169

marked on the chart. The intersection of the cursors could then be pinpointed, marked with the competitor's number or tabulated on a separate sheet.

It will be noted that it is suggested that the sights be placed 200ft. apart. This would give a direct reading of the height in feet. (Fig. 171). A further "task" could be incorporated into the flight, if it were desired to make it more interesting, inasmuch as points could be deducted for the amount by which the model was off the centre-line position.

Fig. 171



More mobile . . .

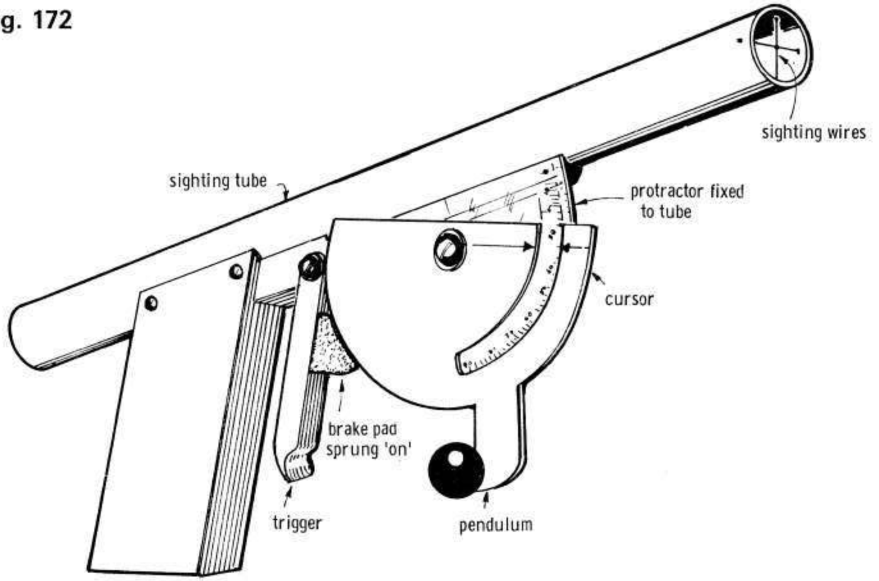
A refinement of the foregoing system involves the fabrication of a pair of portable sighting "guns". (Fig. 172). These take the place of the ground-based devices and avoid the need for the sighting men to lug around poles, tent-pegs and mallet. The guns are perhaps more tricky to make than the wooden sighting devices previously illustrated, but should be within the capabilities of those with a little metalworking ability. They incorporate small celluloid protractors, over which a metal cursor swings. This cursor has a pendulum to keep it vertical and is free to swing while the trigger is held in against its spring.

On sighting the model in the crosswires, the spring-loaded trigger is released and locks the cursor in position, when the angle may be read off the protractor. The two marshals or "sighters" would release their triggers at the sound of a whistle blown by the contest director or—if this is being done by a group merely for their own interest—by whoever is appointed to do the job.

Or airborne—an altimeter.

An entirely different way to find a model's height, of course, is by fitting a recording altimeter. Mention of this will conjure up thoughts of aneroid barometer type devices, tricky to make, to say the least, if not quite beyond the bounds of the less experienced. The device

Fig. 172



described here, however, is very simple indeed, as will be seen. The original idea came from Norman Armstrong and was published in *Radio Modeller* several years ago.

While it is not intended that it should be looked upon as a highly accurate instrument, nevertheless it gives a very good indication of the maximum height achieved by the model to which it is fitted.

The basic principle is this: to an air container is attached a length of transparent pipe, which has been filled with a certain amount of water from its outlet end. As the altimeter is carried upwards, the air in the container expands and drives the water out of the outlet end of the pipe, to waste. As the altimeter comes down again, air in the container is compressed and sucks the water back along the pipe. Now, however, there is a length of water missing from the outlet end and this missing length is a measure of the expansion of the air when the altimeter was at its highest point. The ticklish part is in determining just what height this missing length of water actually represents. (See Fig. 173.)

Calibration

To find out, we hark back to our distant school days and dimly remember something about Boyle's Law and Charles's Law and the expansion of gases. We couldn't care less

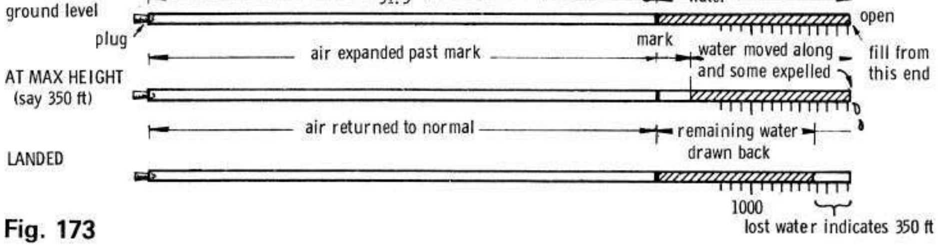


Fig. 173

then—because we hadn't got an application for them, but now we have. Further probing into the cerebral cobwebs reveals the equation:

$$\frac{P1 \times V1}{T1} = \frac{P2 \quad V2}{T2}$$

where P is pressure, V is volume and T is temperature in degrees absolute (Centigrade plus 273).

We can assume P1 (at sea level) to be 14·69lb./sq.in. (we can still use the device from any hilltop we like), and we can assume the temperature, T1, to be 15°C + 273 = 288 Abs. V1 we don't know yet. We want P2, V2 and T2 for greater heights.

If a graph is made of atmospheric pressure against height, the result will be a curve. However, the atmosphere goes up a long way and, if only the bottom 5,000ft. is taken, the curve is so near to a straight line that we can take it to be one and make our height scale linear. So, in the second half of the equation, we will put in the figures for 5,000ft. Thus: P2 = 12·23lb./sq.ft., T2 is ten degrees colder at 278° Abs., and V2 = ?

$$\text{So, } \frac{14.69 \times V1}{288} = \frac{12.23 \times V2}{278}$$

$$\text{Therefore, } 0.051 \times V1 = 0.044$$

$$\times V2 \text{ and the ratio } \frac{V2}{V1} = \frac{0.051}{0.044}$$

$$-1.16 \text{ (by slide rule)}$$

So Volume 1 at sea level becomes 1·16 times bigger when raised to 5,000ft. Owing to the "straightness" of the curve mentioned, V1 at 2,000ft. becomes (nearly) 1·16 times bigger when raised through 5,000ft. to 7,000ft.

For practical purposes, we can cut out the separate air container and use a length of small bore fuel tube instead. (This is the total cost of the device!) The inside volume of 2in. of this is—obviously—twice the volme of 1in., so the comparison of volumes now becomes much easier, in that it is now simply a comparison of lengths.

How long should the tube be made? Let us assume, for the moment, that we should like 1 inch on the scale to read 1,000ft., and, of course, 5in. 5,000ft. Then:—

(1·16 length minus 1 length) = 5in.

so 0·16 length = 5in.

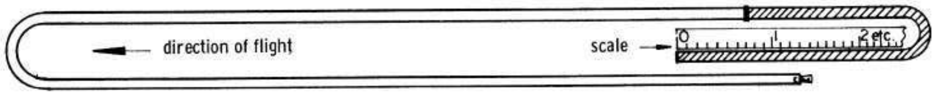
dividing by 16 $0{\cdot}01 \text{ length} = \frac{5\text{in.}}{16}$

Multiplying by 100

$$1 \text{ length} = \frac{500\text{in.}}{16}$$

$$= 31{\cdot}3\text{in.}$$

Fig. 174



This means that the air column part of the tube must be 31·3in. long and an extra length, say, at least 6in. should be added for water. One end of the tube is plugged, but the plug must be removable. If you can drive all the water out of that tube, you've beaten the world record, easily!

Mounting on the model

The length of tube may be mounted inside the fuselage or taped on to the outside, but the plug and water scale must be accessible. If the tube is kept straight, a hard launch or a sudden stop on landing may cause it to show a false height of 1,000ft. or more. The best way to mount the device has been found to be as in Fig. 174 so that sudden starts and stops have little effect on the water. Don't make the bends sharp enough to restrict the bore of the tube. Use the thinnest fuel tube you can get and make the plug really airtight. I use the tip off the shank of a fine painting brush.

The scale may be marked beside the tube, $\frac{1}{10}$ in. = 100ft. The point 31.3in. along from the plug should be well marked with a piece of sticky tape. For pouring water into the tube, a plastic bottle fitted with a suitable nozzle, is convenient. Colour the water with ink or dye for easy reading.

Using the altimeter

Remove the plug and fill from the other end until the water exactly reaches the 31·3in. mark; insert the plug tightly and check that the water is still at the mark. Now fly the model and, when you have brought it down again, measure the length of the water lost. Each tenth of an inch represents 100ft. The inside end of the water should be back on the 31·3in. mark. If it isn't, the plug is evidently leaking and the reading will be false.

If one wants to check the calibration, by taking the altimeter up and down hills in a car, it should be remembered that cars are heated, even when the heater is not in use, and the altimeter will over-read because of lack of temperature variation. Air temperature normally falls about 2°C per thousand feet.

There seems no reason why it would not be possible to arrange competitions for altitude, using commonly calibrated altimeters of this type. It would then be quite feasible to have six models airborne together for, say, a quarter of an hour, each with one fitted, and combined with a spot-time for landing. The models would obviously have to be launched at short intervals, rather than simultaneously, so as to avoid chaos when the time was up!

Even if the idea is not taken up for contests, however, the use of an altimeter on your model can be quite fascinating, and you will eventually become able to judge quite well, by eye, just how high your model really is, instead of hearing all the wild guessing that starts when the models get into really good lift.

THE BEAUFORT WIND SCALE

This is a standard scale for wind speed (expressed in terms of Beaufort Number), based on observed phenomena. The original scale is rendered in terms of the appearance of the sea; but the equivalent land observation is added in the following table, and wind speeds are given in miles per hour rather than knots.

Beaufort Number	*Wind Speed m.p.h.*	*Wind Description*	*Observation, Sea*	*Observation, Land*
0	Less than 1	CALM	Mirror flat.	Smoke rises vertically.
1	1—3·5	LIGHT AIR	Ripples on water.	Wind direction indicated by smoke drift, but wind is not strong enough to give proper indication by weathercocks.
2	4—7	LIGHT BREEZE	Small wavelets, crests have glassy appearance and do not break.	Wind strong enough to be felt on the face; leaves on trees begin to rustle; flags partially extended.
3	8—11	GENTLE BREEZE	Large wavelets with crests beginning to break: some scattered white horses.	A light flag will be fully extended; leaves and twigs on trees in constant motion.
4	12—18	MODERATE BREEZE	Small waves with frequent white horses.	Small branches waving on trees; dust and paper, etc., on ground lifted by the wind.
5	20—24	FRESH BREEZE	Moderate waves or more pronounced form: many white horses.	Small trees begin to sway.
6	25—30	STRONG BREEZE	Large waves begin to form, foam crests more extensive everywhere and probably some spray.	Larger branches on trees in continual movement; telephone wires hum.
7	32—38	NEAR GALE	Sea heaps up and white foam from breaking waves begins to be blown along in streaks with the wind.	Whole trees in motion; considerable resistance felt in walking against the wind.
8	39—45	GALE	Moderately high waves of greater length, with edges breaking up into spindrift. Foam blown in well-marked streaks.	Twigs and small branches broken off trees.
9	46—55	STRONG GALE	High waves with dense streaks of foam and flying spray.	Slates or tiles may be lifted off roofs; other minor structural damage likely.
10	55—65	STORM	Very high waves with long overhanging crests; large patches of foam with the whole sea taking on a white appearance.	Whole trees may be uprooted and houses damaged.
11	65—75	VIOLENT STORM	Exceptionally high waves, sea completely covered with foam.	Damage to trees and houses.
12	Over 75	HURRICANE	Sea completely white with driving spray; air filled with foam and spray.	Extensive damage to trees and buildings.

APPENDIX II

HOW FAST IS IT?

By GEORGE BUSHELL

OVER a number of years I frequently used to hear fellow modellers complaining that the wind was "too strong" but, when I took up slope soaring, the complaint was far more often that it was "too light." I decided that here was a subject on which, if more and positive information could be obtained, might be of invaluable assistance when applied to the design of future soarers.

Basically, the object of my analysis was to determine the percentage windspeed and direction for the months of the year, as applied to my own regular flying sites—Ivinghoe Beacon and the local playing fields. Ivinghoe is best used in west winds, and quite soarable in all but east winds. The local playing fields (for bungee launch, of course) are flyable in all wind directions, but producing best thermal conditions with a little east in the wind.

After close analysis during the winter, I built my new soarers and then attempted, by personal observation and weather forecasts, to assess how many *Sundays* were actually flyable using these models, either as slope or thermal soarers, whether or not I was prepared to venture out. The number of flyable days proved quite remarkable, and those Sundays of heavy rain or threat of rain could be "written off" as negligible. By flyable days I should say "comfortable"—if you take my meaning.

Where does one get the information upon which to make the analysis? There is a book, published by H.M. Stationery Office—ref. Met.0.792—which is the answer. It is called *Table of Surface Windspeeds and Direction over the United Kingdom.* The information used to compile these tables comes from weather stations throughout the U.K. and almost anywhere in the country would be in the same "weather pocket" as one of these stations. Similar tables exist for most other civilised countries, and it was on this basis that I was able accurately to predict that the world record for model glider duration flight would be broken at Sylt, N. Germany, about six months prior to its actually taking place.

The only serious drawback with these tables is that they do not provide information relating to daylight hours only. It is as well to bear in mind the following "rules," therefore, for interpreting them. On coastal sites the winds *tend* to be more on-shore during the day and off-shore towards evening. And, on inland sites, the wind reaches its maximum speed "just after lunch."

From the tables for Dunstable (p. 124-128) given in the book, we can extract the following useful information.

1. Windspeeds in all directions from 8-18 m.p.h. expressed as a percentage:

January	52·5	July	43·3
February	51·2	August	40·5
March	51·9	September	47·2
April	52.5	October	38.7
May	46·4	November	45.4
June	38.5	December	50·6

2. Windspeeds in all directions 18 m.p.h. and over, expressed as a percentage:

January	8·6	July	1·7
February	3·8	August	1·4
March	4·3	September	1·3
April	2·4	October	2·9
May	1.8	November	3·1
June	0.5	December	8·7

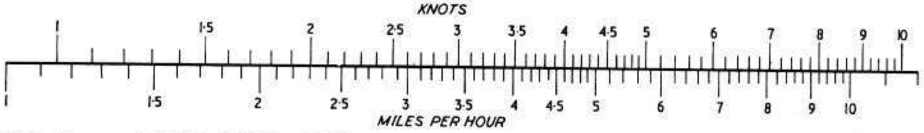
3. Wind direction 020°—160° (the poorest direction for Ivinghoe) expressed as a percentage:

January	17·80	July	23·20
February	25·90	August	20·20
March	40·00	September	29·90
April	31·00	October	18·40
May	33·20	November	23·30
June	20·00	December	19·60

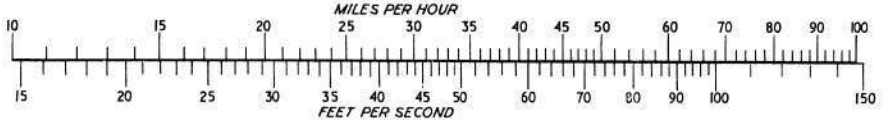
A study of the above figures shows a number of surprising aspects, and will make many modellers revise their ideas of just how many unflyable days there are in the year. Similar figures can be extracted for virtually any site in the United Kingdom, and a study of the book is to be thoroughly recommended. It may be purchased from H.M. Stationery Office, through any bookseller, or may, of course, be studied in your local reference library.

Speed Conversion Scales

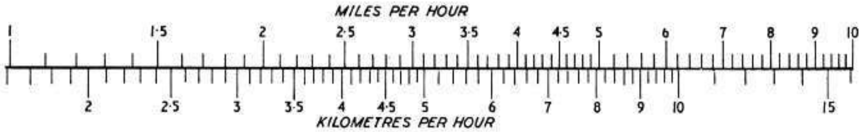
KNOTS to M.P.H.



M.P.H. to FEET PER SEC.



M.P.H. to KILOMETRES PER HOUR



K.P.H. to METRES PER SECOND

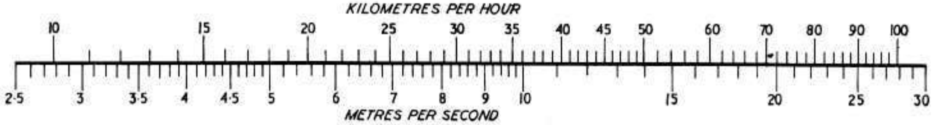
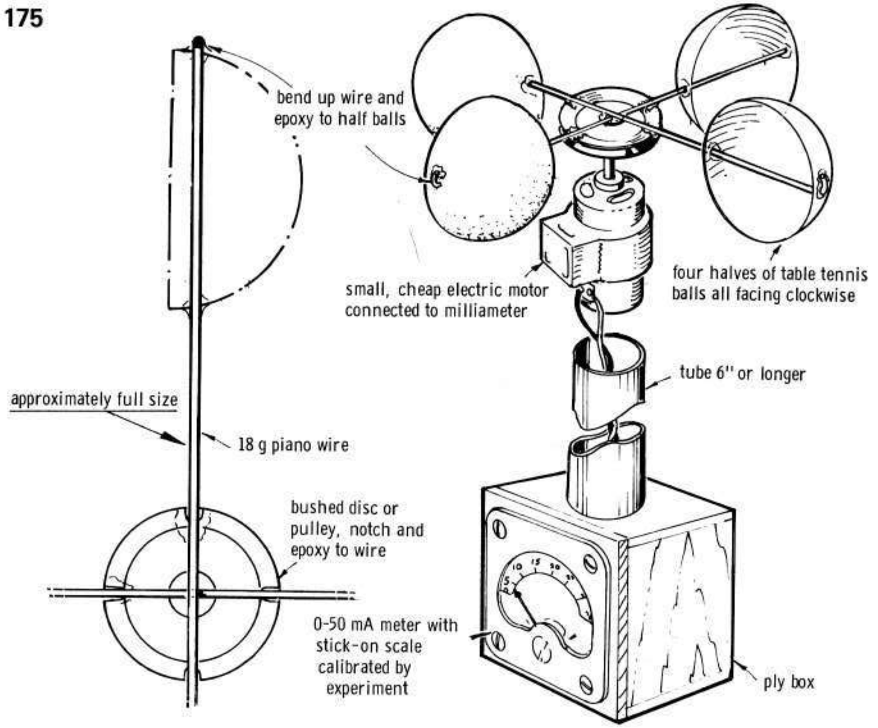


Fig. 175



A HOME-MADE ANEMOMETER

For those who live some distance from their hill-soaring slope, and need to keep a weather-eye on the wind speed, an anemometer will be a boon. Our sketch, Fig. 175, shows how one of these instruments may be easily constructed, using a small electric motor and a milliameter. This type of wind-speed meter is usually fixed to a workshop or shed roof, with the meter itself inside. Not only slope soaring enthusiasts, but also thermal soarers will find it useful to keep a check on wind velocities, and modellers may find it of interest to log weekend wind speeds for themselves, throughout the flying season.

For measuring actual wind speeds when on slope or field, the hand held pocket wind meter is invaluable, and two kinds of these are shown, photographically, elsewhere in this book.

APPENDIX III

CLOTHING AND EQUIPMENT FOR SLOPE SOARERS

WHILE one of the many happy aspects of slope soaring is that one can, in fine weather, wear "civilised" clothes instead of the oil-soaked jeans and sweater favoured by the power flier, one must bear in mind the changeable nature of the climate in these isles. It is essential to have at hand some outer garments for protection against the vagaries of the elements. The slope soaring enthusiast very soon finds that he acquires a special kit for his visits to the hills, and will always take it with him—no matter what the met. men say! To be caught in a thunderstorm, or even a summer squall, at the top of a hill, perhaps a mile or so from one's car, without some form of protection, is not an enviable experience, so don't let it happen to you.

A good set of oilskins, or PVC mack and overtrousers, are a sound investment. Also, even on the hottest day, one cools down very rapidly standing on a hill in a fresh breeze, so you will be glad of an anorak. A popular alternative to this is the lightweight waterproof, fluorescent coloured garment used by sailing enthusiasts. As well as these over-garments, a good thick fisherman's type of pullover with a polo neck is a good thing to have, in addition to whatever woollies you normally wear.

If your "thatch" is getting thin, you will be glad of some warm headgear—perhaps a woollen bobble-hat, but just a word of caution here. If you wear a bobble-hat, either wear the right colour for your radio frequency, or else something like a Paisley or stripe, that could not possibly be mistaken for one of the frequency colours. To wear, say, a red bobble-hat when flying on "blue" could result in your own and someone else's model being "shot down" because others thought you were on "red."

The same applies if you elect to wear one of those lightweight peaked caps, for those hot, almost windless days that always seem to happen when there is a contest! For cooler weather, a Balaclava or a trapper's type of hat, with ear flaps and under-chin fastening, can be very comforting. Have some gloves, or mittens, to be worn between flights if you are one of those who cannot abide wearing gloves of any sort while flying. A sheet of stout polythene, such as may be bought at cycle shops or camping outfitters, will come in very useful for a groundsheet—and may also be used for covering up a model, or several models, should it come on to rain. We have also seen these used as a sort of "personal tent" by mackless soarers who preferred to cocoon themselves to keep dry, and leave their models to the elements.

One usually has plenty of time to unpack the protective clothing and the ground sheet, since, as one is on a hill and looking into the wind, the rain or "precipitation" will often be visible when it is several miles distant. With practice (and you will get this, if slope soaring has really hooked you!) you will find that you will eventually be able to gauge fairly accurately just how many minutes the rain will take to arrive.

If a "personal tent" of polythene, why not a tent proper? This would seem to follow on, but, on many sites—particularly those belonging to the National Trust—the setting up of tents, or even windbreaks, is forbidden by the byelaws. It is as well to ascertain what is permitted, in this respect, before you consider buying one, therefore.

All the other items, plus your thermos flask and sandwiches, will have to be transported up the hill, so a good quality rucksack is a must (unless you have a well-trained wife!!)—and leaves the hands free for model and transmitter. Better still, hang the transmitter on a neck strap and have one hand free in case you should stumble, or need to support the model with both hands in a sudden gust of wind.

Finally, a good stout pair of hiking boots is generally preferable to wellingtons, even in wet weather, especially if there is much walking or climbing to do, from car to launching site. The soles of ordinary shoes will very soon become polished and slippery on the grassy or heather-covered hillside, especially in dry weather, so boots are best whatever the conditions. Don't drive in the boots but change into them, with an extra pair of socks, before you leave your car. In the same way, don't trudge up the hill in your full kit; keep it in the rucksack and don it when you reach the top, as and when you feel the need of it.

If you are one of those lucky ones who has found the kind of site where you can drive right up to the launch point, to "lob off" almost from the car, then you may choose, at first, to disregard all this advice on clothing, and take refuge in the car from the rain, or just to warm up. However, one of the most enjoyable aspects of slope soaring is visiting new and different sites around the country and, if you are going to experience this, then you would do well to be prepared in the way that has been described.

APPENDIX IV

AN AUTOMATIC ELECTRIC WINCH

ALTHOUGH the vast majority of modellers who go thermal soaring do so competitively, there are also those who like to fly this type of model sheerly for its own sake, at their local fields or parks. Some of them do so, probably, because they have no slopes within reasonable distance—others just because they prefer this more relaxed type of glider flying.

Methods of launching the models vary, from the hand-towing and bungee launches described in Section Two, to the use of electric powered, or even petrol-driven, winches. In addition, interest is increasing in the "aerobatics from a flat field" type of contest, for which an electric winch is a definite pre-requisite.

The winch described here was originally published in *Radio Modeller*, and was designed by J. Robertson and I. Barr. The original idea was to produce a launching system capable of launching any model in nil-wind conditions. This was because, being primarily slope soaring enthusiasts, they would go to the hills if there was any wind at all. An electric powered winch was chosen for its ease of control and simplicity of construction, the basis being an ordinary 12v. car starter motor. The original winch was simply a drum coupled to the shaft of the motor, whose speed was regulated by pulsing the current fed to it, by means of a micro-switch. This proved acceptable, but the speed and height of the launch depended too much upon the skill of the operator.

Further thought was put into the design and the system, as it now stands, was conceived. A "jockey wheel" measures the tension of the line and, by means of a reed switch, a transistor switch and the starter motor solenoid, *the motor is pulsed on and off automatically*. Thus, all the operator has to do to give a perfect launch, is to keep the master switch depressed. If it is considered desirable, the line may be run through a pulley, attached to a stake in the ground, so that the winch is at the release point—far better than relying on tiresome and usually ambiguous hand signals—and provision is made for remote operation of the master-switch, making possible even solo operation. Further, a brake drum driven by a bicycle freewheel unit, provides restraint, should the model "kite" up in a gust.

Construction

Construction of the winch is relatively simple, except that access to a lathe is necessary in order to install the bicycle freewheel unit in the metal drum. Very few of the dimensions are critical, but the important points are (1) the inner diameter of the drum which must be as shown, to produce the correct torque, and (2) the strength of the two springs, which have to be found by trial and error, as they are dependent on the leverage of the system.

Operation

Operation of this winch is very simple, and the sequence is as follows. The desired speed is selected on the toothed quadrant; the glider is attached to the line; the master switch is depressed, the glider launched and the master switch released when the model is at the "top" of the launch. The foregoing sequence causes the winch to go through the following

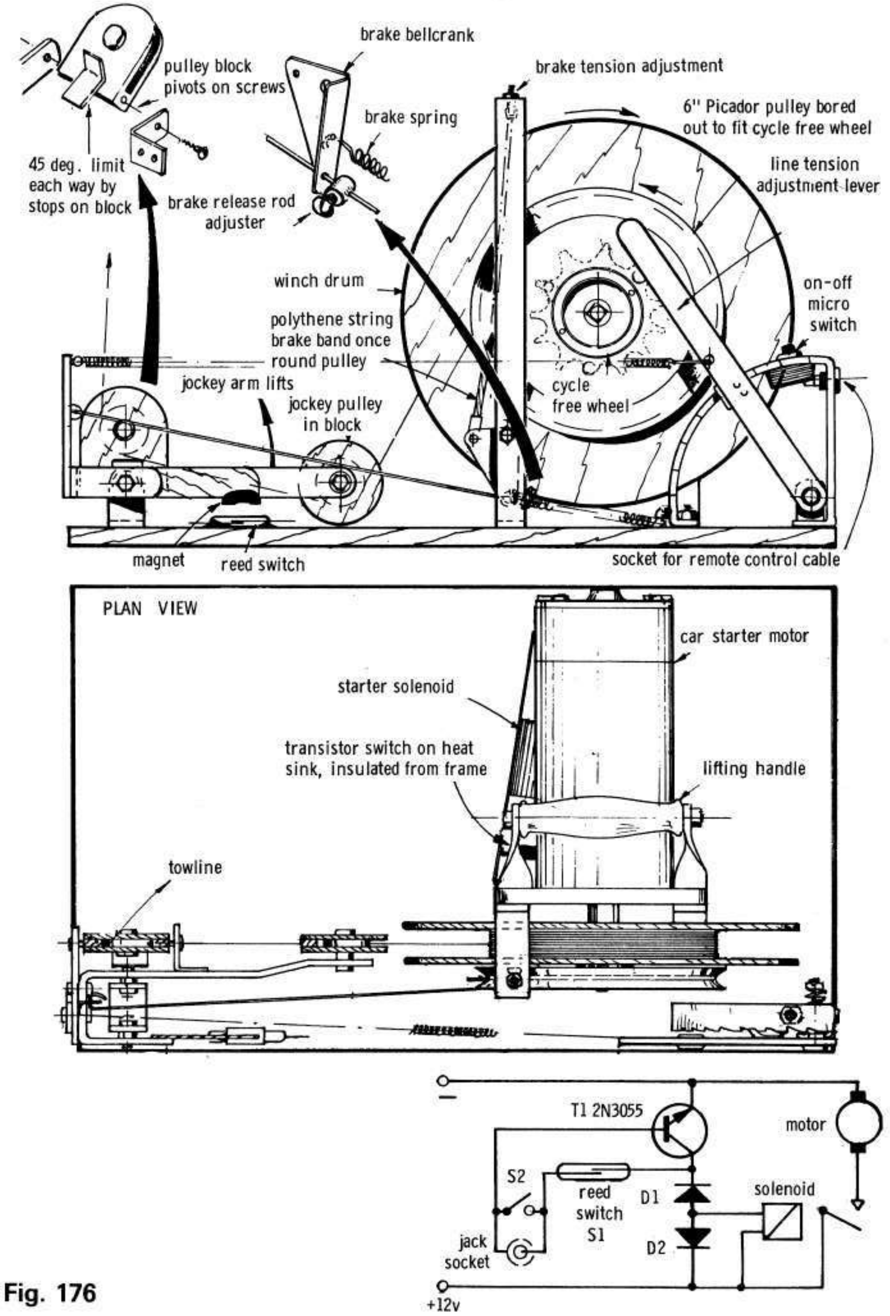
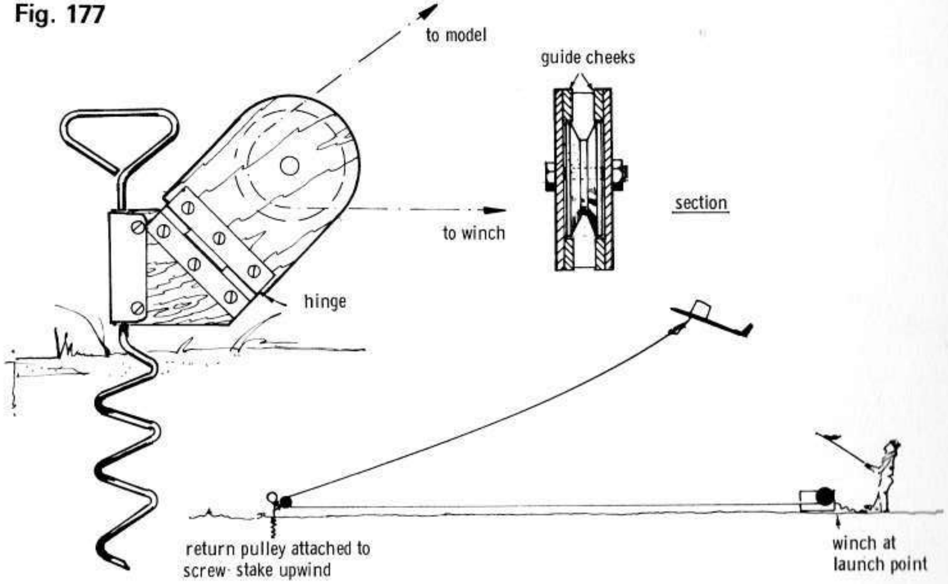


Fig. 176

Fig. 177



actions: the position of the lever on the quadrant sets the line tension (launch speed) that the winch will maintain. Depression of the master switch causes the line to be reeled in until the set tension is reached. The winch will then switch itself off until the model is launched. Initially, the man releasing the model runs forward until the line tension is lowered sufficiently for the motor to start. It will then maintain the correct tension all the way up the tow, by automatically pulsing the motor on and off.

The winch will keep the tension correct, even in strong winds as, in these conditions, it will—again automatically—*pay-out* the line, thus kiting the model. At the top of the launch, the master switch should be released, thus cutting off the power to the winch and releasing the model. If the model does not free itself, the control lever may be set to a lower position.

To pull out the line to the launch point, the quadrant lever is first set at the lowest tension. The initial launch should be made with the lever set at the "average speed" position, and subsequent launches made at faster or slower speeds as is felt desirable for the particular model. Reeling in the line after the last launch calls for some caution, as it comes in surprisingly fast. Power should be switched off when the end of the line (visible by its parachute) is still some 20 yards distant. The parachute used should be similar to that used with the bungee method of launching, described in Chapter 16 (Fig. 123) and may be either home-made or of the commercially available type. A home-made parachute can be quite a simple affair, cut from a square of silk or nylon, about 16in. on a side, with a line at each corner, and bound at the centre, round a "pinch" of the material. There is no need to make an elaborate round 'chute, with its numerous triangular-shaped panels, though this is more elegant, of course.

GOLDEN RULES FOR SLOPE BEGINNERS

by Chris Pullen

(1) Visit a known site and enquire about suitable models for training. (Although many model shops can give good advice, relatively few of them know much about soaring.)

(2) Having built the model (and acquired your r/c licence), ask someone who is obviously a good flier (not the showoff, but a good, consistent flier and lander!) to trim the model out for you. Never attempt to fly it on your own to start with. This could be a risk both to the model (and the radio you've just paid out for)—*and* to bystanders and other fliers.

(3) If the flier who checks out your model is agreeable, get him to teach you the basics of controlling the model and landing—or to recommend someone who will. (It can take quite a lot of a pilot's time up to get a newcomer to the "safe to solo" stage, but there are those who enjoy doing it, reckoning they are putting back into r/c modelling a little of what they've got out of it, over the years.)

Do's and Don'ts

Do check the procedure used at the site concerning frequency control (pegboard, etc?)

Do ascertain the local conditions—*e.g.* turbulent areas to avoid, safe approach areas and any particular hazards of the site.

Do ask for help if you are not sure of your capabilities.

Do always have a high regard for other people and their property (not only modellers and models, but farmers, land-owners and so on, and their walls, gates, fences—and animals).

Don't risk it if you're not *sure.*

Don't switch on your radio before you are ready to fly (*e.g.*—don't check it in the car park!)

Don't "hog" the frequency (*i.e.,* make your flight of reasonable length, if there are others waiting for your "colour").

Don't fly your model over people, unless unavoidable (such as to avoid some sudden hazard).

Don't land your model close to other models, or people. Choose your intended spot well beforehand, and keep a lookout for changes in people's positions, or other models landing, while you're lining up.

Most of the problems arising at well-frequented sites are caused by, (a) people attempting to fly models for the first time and without sufficient knowledge, (b) people not prepared to take advice from experienced fliers, (c) people flying their models too low, and colliding with other models or—worse—people and (d) attempting to land their models alongside parked models, and ending up ploughing into them.

APPENDIX V

READING THE WEATHER

by GEOFF MEAKIN

FURTHER OUTLOOK

WEATHER-WISE, the further outlook may often be determined locally, with some degree of accuracy, by the intelligent use of a moist forefinger held high above the head combined with a keen pair of eyes and a fundamental knowledge of cloud formations.

At first sight, the wide range of strange sounding Latin names used by the meteorologists appears confusing and not immediately meaningful. Put more simply, however, a study of the clouds can prove fascinating when it is realised that all cloud formation is water vapour, which is always present in the atmosphere, condensed into tiny floating globules of liquid water, or crystals of snow or ice, depending on height and therefore temperature.

There are two main types of cloud formation—the *cumulus* or heaped clouds, and the *stratus* or stretched or layered group. *Cumulus* are short termed, developing rapidly, changing shape, sometimes perceptibly and, except in summer, thundery weather producing only heavy showers. *Stratus* clouds are often associated with warm fronts, with streaks of higher cloud banking up into denser formations and later bringing drizzle and sometimes more continuous rain. In the winter they also form in warm moist air, turning into heavy grey sheet type cloud and again bringing drizzle or heavier rain.

There are ten main classifications of cloud formations but, before considering them individually, it will be as well to study some of the more common Latin terms used to describe different combinations of cloud names. . . .

* * *

Cumulus. This means a mound or heap of cloud appearing as cotton-wool like, heavily massed groups resembling small mountains slowly changing shape (Fig. 178).

Fig. 178

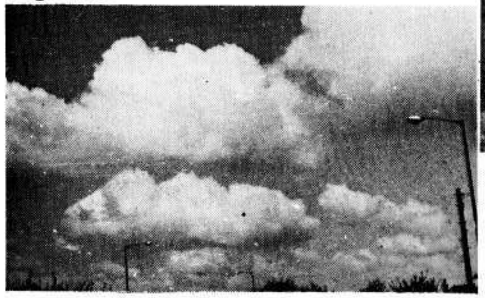


Fig. 179

Stratus means stretched or layered cloud (Figs. 179, 180 and 181).

Cirrus means curled and light and airy—and these clouds are therefore often found

Fig. 180

Fig. 182

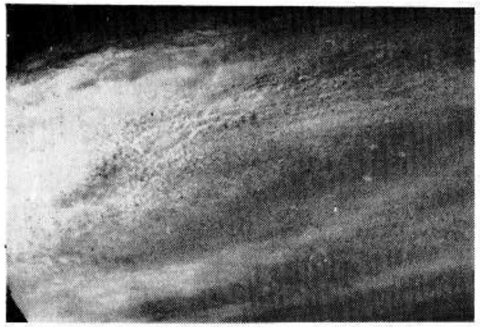


Fig. 181

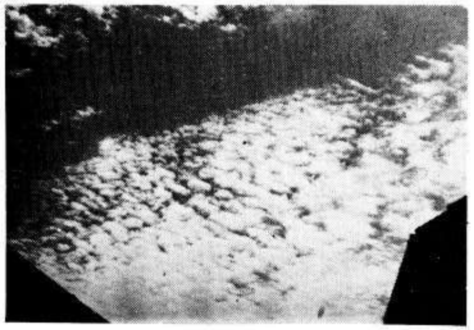


Fig. 183

at the greatest heights—about 30,000ft. above sea level.

Alto stands for "height" which, in the cloud sense, can range from anything below *Cirrus* down to about 5,000ft.

Nimbus means "rain-maker" and generally appears at heights of from 2,000ft. down to 500ft. or perhaps lower, when viewed from the lofty perch of some slope soaring site.

Starting, therefore, at the highest altitude and descending gradually to ground level, let us now look at the ten major classifications of cloud formation. . . .

1. **Cirrus.** Very high. Detached, delicate and fibrous formation, white in colour with no shadow. (Fig. 182).

2. **Cirro-cumulus.** Very high. Small, round, white and flakey. Seen in groups or lines—or ripples rather like sand formations on a beach. (Fig. 183).

3. **Cirro-stratus.** High. Thin and veil-like, with a whitish milky wash effect. (Fig. 180).

Next come the *Alto* group, below the *Cirrus* group. . . .

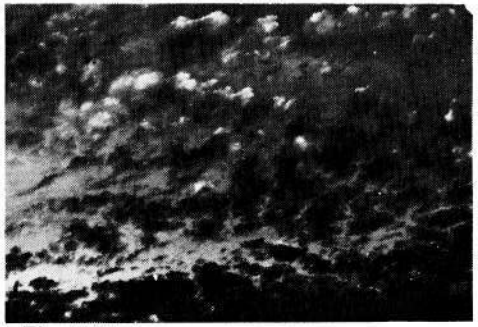


Fig. 184

4. **Alto-cumulus.** Rounded or rolled masses, fairly large, in groups or lines, or rows following one another in one or two clear directions. (Fig. 184).

5. **Alto-stratus.** Greyish white or grey veil with sun showing behind, dimly outlined as if seen through ground glass. (Fig. 181).

Then follow the *Stratus* group, below the *Altos*. . . .

6. **Strato-cumulus.** Large, lumpy, irregular masses forming large grey undulating cloud banks. (Fig. 179).

7. **Stratus.** Uniform layer of fog-like cover but well above ground level. (Figs. 179 and 180).

8. **Nimbo-stratus.** The rain-maker. Lower layer of structureless rain bearing cloud, heavy and sultry grey towards black, with a threatening appearance. (Fig. 185).

And then, finally, the *Cumulus* group. These may vary considerably in both height and size. . . .

9. **Cumulus.** Thick, dense and dome-shaped, with turrets rising rapidly. Form changes, sometimes quite perceptibly. Short term, bringing heavy showers. Base of cloud often flat and horizontal—like lumps of cotton-wool pressed onto a sheet of glass. (Fig. 186).

10. **Cumulo-nimbus.** Great masses of mountainous tower shaped cloud, often with "anvil shaped" tops and dark black centres and bases. Sometimes the centres of electrical storms, bringing heavy rains and thunderstorms. (Fig. 187).

Fig. 185

Fig. 186

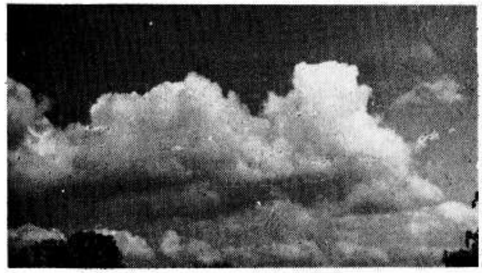


Fig. 187

Fig. 188

Soaring pilots are shrewd judges of the speed and direction of the wind and, from the advantageous heights of the slopes, it is often possible to see approaching and departing weather for several miles around.

Perhaps those who don't already know may, after a study of the foregoing basic information, with its accompanying illustrations, be able to assess the "further outlook" more accurately, and decide either to keep their models aloft or to bring them down before the storm breaks! Normal rain fronts travel, on average, at about 25 mph, and storm fronts sometimes considerably faster, so give yourself time not only to land satisfactorily, but also to get packed up and safely under cover of the car or whatever shelter may be available.

* * *

A CLOSER LOOK AT THERMALS

A CAREFULLY blown smoke-ring, fumes and heat released by a garden bonfire or the dense billowing smoke and searing heat generated by a burning building; all these produce artificial thermals. They differ, however, from natural thermals in that they carry upwards with them tiny, but collectively visible, particles whereby some of their form and movement may be seen, whereas, at source, natural thermals are almost completely invisible. Nevertheless, both types of thermal carry water vapour in varying degrees and this only becomes visible when it condenses out in upper and cooler surroundings.

Air bubbles

Most natural thermals are invisible at source because they are generated by radiant heat from the sun striking local areas of the earth's surface which accumulate the heat received. These "hot-spots", in turn, raise the temperature of the air immediately above them until a type of invisible hot-air-bubble is formed, which may either take off in still air on its own accord, or is assisted by gentle air currents at ground level in finally breaking free.

Depending on the nature of the ground being heated, the strength of the sun's rays and the speed of any wind at ground or the upper levels then, one of two phenomena may occur: either an intermittent series of hot-air-bubbles will be formed which will take off at more or less regular intervals *or*, a fairly continuous stream of air-bubbles will be generated, forming into a kind of processional column rising at a steady speed.

In relatively still air the intermittent series of bubbles will rise almost vertically, as will the processional column but, in light breezes which may be travelling at differing speeds in ascending heights, then both the intermittent bubbles and the continuous stream will rise either in a diagonal line from ground source or in the form of a gentle parabola to something like 500ft. above ground level. (See Figs 189 and 190). At this height, the surrounding air will be less dense and considerably cooler than at ground, and the stream of ascending hot-air-bubbles will start to condense out their contained water-vapour which will show itself, at first in the form of a wispy white mist and then later as the more clearly defined embryo form of the *cumulus* cloud.

In near still air, the intermittent stream may gradually accumulate themselves into one largish cumulus cloud, increasing gradually in both size and buoyancy. Similarly, the more or less continuous stream of bubbles may more quickly form into a cumulus cloud of considerable size and strength.

Alternatively, if the air at the 500ft. altitude is moving directionally faster than the air below it, then the intermittent stream of bubbles will form a horizontal procession of small cumulus clouds travelling at wind speed in what is sometimes known as a "cloud street". Under similar conditions the continuous upward thermal column will tend to generate a series of somewhat larger cumulus clouds, bunched more closely and travelling also in a "cloud street" downwind of the ground thermal source (see Fig. 188, Page 263).

Fig. 189

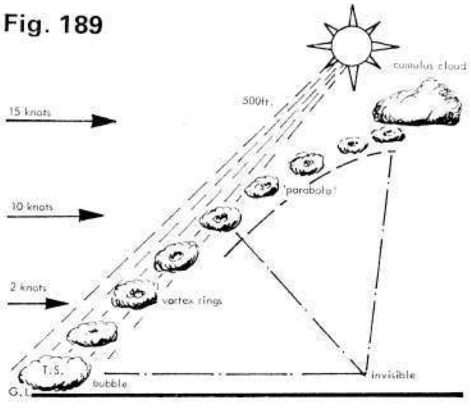
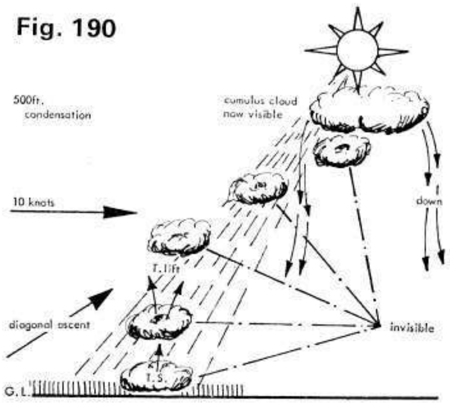


Fig. 190



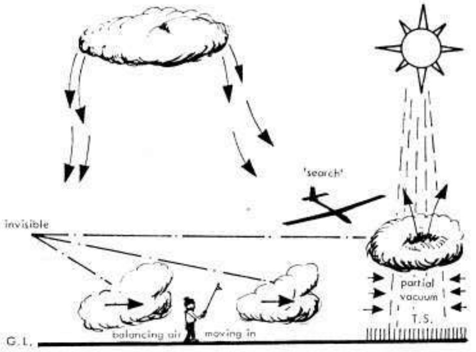


Fig. 191

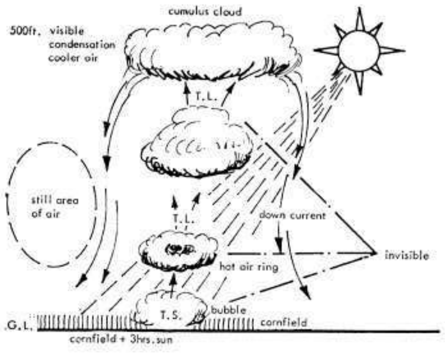


Fig. 192

So, whilst the formation and ascent of the hot-air-bubbles is not generally visible at ground level, the phenomena may be detected by the formation of cumulus clouds at somewhere around 500ft. At the same time, further phenomena are taking place, some of which are partly visible whilst others have to be imagined. As the water vapour in each forming cumulus cloud condenses into minute droplets, these are held in suspense by the hot air beneath them. But every droplet tends to combine with its nearest neighbour forming larger droplets which, being heavier, sink to the bottom of the cloud and then, being denser they appear darker than those above them. Hence the flattish, darker coloured base of almost every cumulus cloud.

Ups and downs

These heavier and now considerably cooler droplets can no longer be fully supported by the up-rising hot-air-bubbles and they therefore fall as a down-current of cooler air, mainly on the outsides of the uprising current, when they travel back towards ground into the generally warmer air below, either completely evaporating or partly arriving as short sharp showers of light rain, on the earth-bound soarer "pilots" below.

One of the first truths about thermals, therefore is that, for every up-current there is a balancing down-current. Looked at more optimistically; if a glider wing is seen to dip suddenly then somewhere, very close by, there is some positive "up-lift" to be found. But, before moving on, and from ground level again, it is necessary to examine two more phenomena. One of these can only be sensed or physically felt. The other only becomes visible in the upper atmosphere—sometimes quite majestically.

Because nature will not tolerate imbalance and since the hot-air-bubbles taking-off from the ground leave a partial vacuum, nearby air moves in sharply sideways to take their places. So, on a relatively still summer day, a hopeful soarer pilot may feel a short-lived brisk cool breeze going past him followed by a more gentle and slightly warmer breeze. He may then know that he has just missed one ascending hot-air-bubble but happily, if he looks in the direction of the breeze travel, he may know that he could be standing very near the centre of a ground thermal source. (See Fig. 191).

But what happens to the hot-air-bubble as it actually leaves the ground and travels upwards? It does not remain in the form of a bubble (see Figs. 190 and 192) but, because its centre is more "active" than the perimeter, the bubble will tend to form into an invisible hot-air-and-vapour ring and, in the same way as a smoke-ring, it will entrain more air as it travels up and so increase in size, gathering strength and speed as it goes into the more rarefied air above.

On encountering the under-side of an embryo cumulus cloud, the "newcomer" will tend to break through the centre part of that existing formation, so creating an even larger aerial vapour-ring which will now become visible as the water vapour condenses.

Additionally, at this point, the latent heat stored within the uprising vapour ring, before it took off from ground level, will be released as the condensation begins and this released heat will add to the general up-lift within the forming cumulus causing a type of secondary thermal which may show itself as a sort of central "crown" on top of the general billowy shape of the cloud. Probably the truly classic example of this may be seen when watching the formation of a cumulo-nimbus or thunder cloud. (See previous article "Further Outlook", Fig. 187).

The centre of such a formation will break out of the top of the cumulus and lift with quite considerable force to form the well-known "anvil" shape at quite some altitude above. "Lift", of this kind, for full-scale gliders searching in such clouds, may vary between 900ft. per minute which is about the same as the rate of climb for a light aircraft and as much as 2,000ft. per minute—which is about 40ft. per second. In any pilot's log book this is certainly going up! (See Fig. 193). Having said that, and using the following symbols to denote certain factors, let us now study a few simple diagrams which illustrate what goes on but cannot always be seen.

Symbols used in illustrations

Thermal Source = T.S. Thermal Lift = T.L. Ground Level = G.L. Sun = *stylised sun drawing* and Wind an *arrow* in appropriate direction.

Example one

This shows a clear morning sky with a strong summer sun striking a standing cornfield. (More about this thermal source later.) Almost still air. After some time, hot air bubbles will break away, turn into vortex type rings entraining more air and eventually reaching the 500ft. ceiling. Condensation will commence. Droplets will combine and then fall to the outer and lower perimeter of the cloud. They will then break away and fall back towards ground, evaporating as they go. (Fig. 192).

Example two

This shows the same basic conditions but with a general 10 knot wind which will move the bubbles and hot air rings downwind of the source from which they ascend, so that a rather weaker cumulus cloud will eventually form up some considerable distance down-wind from the thermal source, but still about 500ft above ground level (Fig. 190).

Example three

This shows the same basic conditions but with varying wind strata sliding along on top of one another in ascending heights. In this case, the travel-line of the ascending hot air vortex rings will not be a straight diagonal, but more of a gentle parabola.

Whilst conditions such as in Figs. 189 and 190 will perhaps be of assistance to the full-scale soaring pilot, they will not greatly assist the r/c model pilot because of the distances travelled downwind. In the case of the first condition, however, the vertical lift and the down-currents will form in the same fairly close area and may be useful indicators of potential thermal power. (Fig. 189).

Example four

This shows the balancing "horizontal" breezes of a short-lived nature restoring the pressure balance left by a departing hot-air-bubble. (Fig. 191).

Example five

This shows the up-thrust of an arriving hot-air-vortex-ring underneath a cumulus

formation with the release of latent heat, the break-through effect and the formation of the upper "anvil" at much higher altitude where the droplets become frozen into ice crystals when they meet the base of the stratosphere. Such formations and heights are of no practical value to the r/c glider pilot from a flying point of view but they are all very positive indications of what is going on above him and, therefore, what may or may not be going on in his immediate vicinity which may be of direct use to him, or her, as the case may be.

From the first three diagrams, however, it will now be realised that ground contours, obstructions such as buildings and banks of tall trees and large wooded areas, the temperature of the sun's rays when they actually strike the ground and the varying wind speeds both at ground and upper levels; all these things will contribute to quite differing conditions governing the formation, speed, durability and actual "lift strength" of any given thermal. It might now be thought that the ideal condition would be a rapid and continuous generation of near-vertical thermal columns, with little wind at ground or above to disturb the lift. Such a condition may well overtake the decay of the individual cumulus clouds, which will then join together and form into a medium dense layer of stratus formation.

This will not only form a barrier to the sun's rays and thereby eventually reduce the rate of thermal formation but it will also produce an artificial "ceiling" through which it will not be possible for subsequent thermal bubble-vortex-rings to pass. The whole thermal generation process will then slow-down and finally stop. This condition is known as "over-development" (Fig. 193).

So much, then, for the physics and the mechanics and what perhaps might mistakenly be called the "hydraulics" of the business but what, now, about the real nitty-gritty of where to look and under what conditions to find thermals and to go on finding them? This is, perhaps, a more crafty business but it is equally fascinating and rewarding.

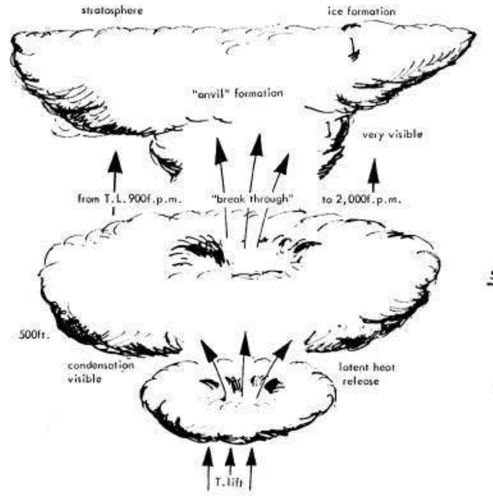


Fig. 193

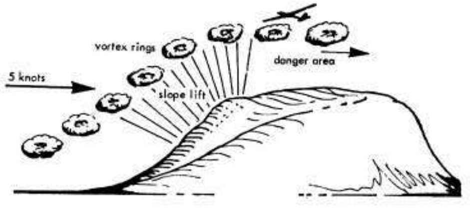


Fig. 194

The best ground "heat reservoirs" are generally thought to be:

(a) Plains or other high clear land with sand or chalk bases.

(b) Similar areas but in the "wind shadow" or lee of much higher sheltering ground which will not produce turbulence conditions.

(c) Dry, tilled ground, preferably with standing crops or other dark and dry surface growth such as heather.

Areas to be avoided are:

(a) All lush green damp areas.

(b) Woodlands (except perhaps in the evening).

(c) Snow and ice covered ground of any kind.
(d) Rivers and lakes or areas crossed by streams.

Woods which have had the strong sun on them all day may release their accumulated heat towards evening time but, in general, all water surfaces and the tops of high banks of trees are possibly the most difficult and damaging areas from which to attempt retrieval of groundward bound sailplanes. Preferably, keep well away at all times.

Thermal "up-lift" may also be found, on occasions, joining company with natural slope lift, particularly if a steady gentle breeze is releasing thermal bubbles from such a source as standing crops well up-wind and well out from the slope base. Thermal bubbles, rather like thistle-down, may then sometimes be detected riding up on the back of the slope lift. (See Fig. 194.) To keep in such a windward travelling thermal for too long, however, may find the sailplane much too far downwind and considerable discretion needs to be used in deciding just when to quit and dive back into the wind and the greater safety of the more constant slope lift.

The following factors must be "permed" with the locales given above in determining the probability of thermal existence.

(a) Angle of incidence of the sun's rays to the ground. Season will affect this.
(b) General clarity of the sky or cloud filter effect between the sun and the flying site.
(c) The heat "absorbability" of different substances and materials. More technically, latent heat.

If some ice in a calorimeter is gently warmed and stirred, and the temperature is noted throughout, the thermometer will remain steady at 0°C. until all the ice has been melted to water. As further heat is supplied, thermometer readings will rise so that the temperature of the water will now be found to rise. The heat absorbed before the temperature rises has been called the hidden or latent heat.

The specific latent heat of fusion of a substance is defined as the "quantity of heat required to change a unit mass from a solid to a liquid at the melting-point". Therefore the sun's rays in the winter striking snow-covered high ground will probably never produce any thermal bubble because all the heat will be absorbed in melting the ice. Put simply, ice and snow will absorb about three-quarters of the sun's radiant heat. Green grass will absorb about one-quarter but tilled ground only about one-eighth and standing crops about one-seventh, leaving a good six-sevenths for thermal bubble formation.

Wind strength has an increasing heat dispersal effect proportional to speed and temperature, as with a car radiator. The angle of thermal bubble climb, as indicated in Figs. 189, 190 and 192, shows that the further downwind a thermal bubble has travelled from source, the more heat it may have lost on the way and therefore the less "lift" it may provide at cumulus cloud height.

Fairly even-surfaced dry grass or heathland over which a gentle breeze is travelling is more likely to produce better thermal effect than broken ground which will provide greater ground turbulence. Correspondingly, a good wide corn or wheat field, in the lee of a large wood or a line of high poplar trees, may not produce such useful thermals as a smaller field or crops in a sheltered valley at the foot of a gentle slope, because of the relative amounts of turbulence produced.

It will now be realised that the permutations of conditions are very many and these have to be constantly watched, for good conditions in the morning may well deteriorate by "over development", or an increase in wind speed or shift in its direction may completely change the type and strength of thermal production. Not to lose heart, however, for herein is the real challenge! The positive and outward signs of thermal lift are quite real. They are:

(a) Largish cumulus cloud formation at about 500ft. altitude. Thermal sources will be some distance upwind depending on wind strength.
(b) Short-lived spurts of cool and then warmer breezes at ground level on a relatively still summer day.
(c) On very hot days "dust-devils" or mini-tornados may be observed. Leaves, small pieces of paper and dust are drawn into the vacuum caused by rapidly ascending thermals, and they themselves are carried upwards in a spiral type of thermal column to quite considerable heights and with great force.

(d) Gulls and swallows are very efficient thermal-seekers and gulls, in particular, may be seen "circling" with motionless outstretched wings riding, it would seem, with enjoyment on the otherwise invisible thermal lift.

When wing movement starts again, the gull has run out of the lift or encountered sink in a nearby down-current. It will then employ the tight-circling thermal seeking technique until more lift is found, when the wings will again become quite still.
(e) Gulls of many sorts may also be seen "ridge-riding" above a line of cliffs on the slope lift generated by an off-sea breeze supplemented by some thermal activity from the hot sands or a bank of heated dunes below. Such r/c soaring is really only for the gulls and the real experts, for the lift here, although sometimes very strong, is strictly limited, both seaward and inland, and it is best enjoyed by watching the ease with which the gulls slide effortlessly to and fro, calling out to one another from time to time in gullish exhilaration.
(f) Strong sink, unless generated by turbulence, should indicate associated lift which some tight circling should find in reasonable time!

Finding and keeping thermals is an art quite apart from slope soaring itself, but one thing is fairly certain. Thermals alone will not last as long as slope lift, and decisions must be made in good time as to when to leave and look for more. One of the many skills in staying aloft is in not being too content, but in "searching" whilst the going is still good and satisfactorily high.

The memorable Sherlock Holmes said of all detection, "It's elementary my dear Watson". The elements, or basic principles of thermal detection are outlined in the foregoing. The art of slope and thermal soaring is, indeed, not elementary—but it is most certainly elemental! The application of the basic principles in using the power of the elements and the development of such skills may best be learned by listening to other very experienced pilots and, as with the gulls, in watching what they do and where they go!